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Computational Bibliometric Analysis of Research On Bloom Digital Taxonomy and Critical Thinking

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ABSTRACT

This research was conducted to perform a bibliometric analysis on the digital Bloom's taxonomy and critical thinking. The research method employed was bibliometric analysis, utilizing machine learning to map the data. The research comprised four stages of bibliometric analysis, namely: (a) data retrieval through the application of Publish or Perish, (b) data processing, (c) data mapping using machine learning, and (d) data analysis of the mapping using the R programming language. The research materials were published between 2015 and collected from the Google Scholar database in 2023. The search process involved the usage of keywords "Taxonomy Bloom Digital" and "Critical Thinking." The results demonstrated that bibliometric analysis and mapping of 500 publications using machine learning enabled a deeper understanding of the development, trends, and crucial aspects of research in this field. By employing a bibliometric analysis approach and implementing machine learning, this study contributes to the comprehension of digital Bloom's taxonomy and critical thinking while providing an overview of research trends.

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1. INTRODUCTION

Bibliometric analysis or bibliometric methods, also known as scientometrics, is a part of research evaluation methodology that focuses on the analysis of scholarly literature produced. This analysis is facilitated through the use of proprietary methods (Donthu, Kumar, Mukherjee, Pandey, & Lim, 2021). Bibliometric methods refer to measurement techniques in literature using a statistical approach that involves the application of quantitative analysis. These methods are employed to analyze various aspects of scholarly literature, such as publication patterns, citation networks, author productivity, and research impact. By utilizing quantitative measures and statistical analysis, bibliometric methods provide valuable insights into the quantitative characteristics and trends within

a specific field of research (M. Iqbal Firmansyah, Myrna, & Widianingsih, 2021). Bibliometric analysis can uncover the fact that only a small number of studies remain uncited after several years, as citations reflect the impact of research conducted. The findings of research also indicate that this journal is highly effective in selecting meaningful research. Therefore, researchers are encouraged to consider these characteristics when making their decisions (Pendlebury, 2008). Bibliometric search can analyze bibliographic metadata, including citations (impact factor), publication trends, author collaborations, agency collaborations, trending term titles, trending term abstracts, trending term author keywords, country statistics, research trends, journals, and publishers (Singleton, 2010); (Husaeni & Husaeni, 2022).

There are various types of research conducted utilizing bibliometrics with the aid of mapping tool VOSviewer, including in the field of Educational Technology. Bibliometric analysis using VOSviewer can help researchers identify key research areas, influential authors, co-authorship networks, citation patterns, and emerging trends within the domain of Educational Technology. It enables a visual representation of the research landscape, facilitating a better understanding of the field's structure and dynamics. Researchers can leverage these insights to inform their own studies, collaborations, and decision-making processes (Gunes, 2023), STEM Education (Zhan, Shen, Xu, Niu, & You, 2022), Teacher Professional Development (Hoang, 2023), Pedagogical Approaches (del Arco, Mercadé-Melé, Ramos-Pla, & Flores-Alarcia, 2022), Teacher leadership scholarship (Hui-Ling Wendy Pan, 2023), Internet of Things (Leong, 2021), Big Data analytics (Ardito, Scuotto, Del Giudice, & Petruzzelli, 2019), E-Learning (Deti & Mandasari, 2021), supply chain management (Kumar & Kushwaha, 2015), Scholarly Journals Proquest Dengan (Prasetyo, 2021), Government Program Coordination (Utami, & Karlina, 2022), Human Resources (Wedhatama, Hanoum, & Prihananto, 2021), Marine Research in Indonesia (Royani & Idhani, 2018), COVID-19 (Nurfauzan & Faizatunnisa, 2021).

The development of the curriculum refers to the progression of time, scientific knowledge, technology, and the adaptation to the needs of the 21st-century job market, which necessitates changes in the global order of human life, demanding the advancement of critical thinking skills. (Nugraha, 2022). The learning process, as a platform for enhancing critical thinking skills, needs to continuously innovate and adapt to evolving patterns of development (Saputra & Salim, 2020). The changes occurring in the field of education can be observed through the emergence of various innovations, both in terms of educational systems (B. Rahayu & Fitriyani, 2021), One visible aspect of these changes is the curriculum reform in Indonesia, which is carried out as a response to the developments and needs of the 21st century. These changes encompass not only the implementation of teaching and learning processes but also instructional media and other aspects related to the educational domain. The curriculum reform serves as an anticipation to align education with the demands and requirements of the rapidly evolving 21st-century landscape (Shavelson, Zlatkin-Troitschanskaia, Beck, Schmidt, & Marino, 2019) This represents an enhancement of the curriculum, which is based on both character and competency (Achmad, Ratnasari, Amin, Yuliani, & Liandara, 2022).

The new paradigm of education (Achmad et al., 2022) emphasizes the student as a learner and individual who has the potential to learn and develop according to their personal growth (Atris Yuliarti Mulyani, 2022). Students are encouraged to actively seek and develop knowledge (Saputra & Salim, 2020). The truth of knowledge is not solely limited to technological advancements; rather, it involves a shift in the role of teachers. Teachers are no longer seen as the ultimate authority on knowledge or indoctrinators but rather as facilitators who guide students towards constructing knowledge on their own (Florentina Turnip & Karyono, 2021).

Critical and creative thinking skills are specific aspects of higher-order thinking skills (Putera, Harti, & Sakti, 2021). The National Strategies Secondary emphasizes the need to prioritize the development of critical thinking skills as they are linked to data analysis and evaluation (Pramesswari, Widodo, & Qosyim, 2016). Critical thinking is characterized by a willingness to deeply analyze problems and issues within one's range of experience (Susilowati & Sumaji, 2021). It involves

knowledge of examination methods and logical reasoning, serving as a skill to apply these methods (Wahyuningsih, Kurniawan, Maison, & Aziz, 2021).

Based on several studies related to critical thinking conducted by (Sutanto, Irwan Koto, & Endang Widi Winarni, 2022) it is stated that initially, the achievement of student learning outcomes below the Minimum Mastery Criteria (KKM) was 66% out of 15 students. One possible cause is that the teacher's activities predominantly involve providing explanations of the learning material, which leads to students being expected to copy information from their textbooks. As a result, students are not trained to think critically. A similar issue was expressed by (Pramesswari et al., 2016) who stated that the low ability of students to think critically was evident from a test consisting of five critical thinking questions. The test was conducted to assess the students' initial critical thinking abilities, and the average result was 39.20%, falling into the category of poor performance. Furthermore, a study conducted by (Wahyuningsih et al., 2021) ndicated that the critical thinking skills of students in XA class at SMK BIM Ngawi were still low and needed further improvement. In order for students to think critically, they need to learn various aspects that can enhance their performance, including understanding other people's arguments and opinions, critically evaluating those arguments, and developing and defending well-supported arguments based on their understanding (Kurniyasari, Hidayat, & Harfian, 2019).

The principles of digital Bloom's taxonomy are an extension of the original Bloom's taxonomy, encompassing skills and activities related to digital technology (Lim, 2021). Digital Bloom's taxonomy introduces three new levels to the existing levels of the original Bloom's taxonomy, namely creating, evaluating, and analyzing within the context of digital technology (Goranova, 2019). The application of the principles of digital Bloom's taxonomy in instructional material development can assist teachers in integrating digital technology into teaching and enhancing students' technological skills (Matore, 2021). By considering the higher levels of digital Bloom's taxonomy in instructional material development, students will become more proficient in using digital technology to create, evaluate, and analyze information, thereby enhancing their critical thinking skills in problem-solving (Sumartini & Pawarti, 2022).

In the field of education, Bloom Digital Taxonomy (BDT) and critical thinking are collaborative aspects that garner attention from educators. BDT is an innovation of the original Bloom's taxonomy, incorporating skills and activities related to digital technology. Additionally, critical thinking is highly regarded for the development of higher-order thinking skills. However, there are still gaps in understanding and research on BDT and critical thinking that need to be addressed. Firstly, while research trends related to BDT and critical thinking have been explored in bibliometric studies, there is still a lack of comprehensive bibliometric analysis that incorporates computational approaches. This gap encompasses the development of innovative methods and tools to analyze large and complex datasets in this field. Secondly, previous bibliometric studies may not have thoroughly examined author collaborations, top publishing journals, or current publication trends in the context of BDT and critical thinking. Closing this gap requires a more in-depth and detailed bibliometric analysis to understand patterns of author collaboration, influential journals, and publication trends related to these subjects. Addressing these gaps will necessitate comprehensive bibliometric analyses that integrate computational approaches, as well as conducting more detailed investigations to uncover patterns of author collaboration, influential journals, and current publication trends in the realm of BDT and critical thinking.

This research focuses on the application of computational approaches in bibliometric analysis and critical thinking within the context of BDT. To address these gaps, the study utilizes the latest computational tools and techniques, specifically machine learning, using the R Studio programming language, to analyze large and complex datasets related to BDT and critical thinking. Additionally, this research aims to contribute to innovation by providing a deeper understanding of author collaborations, influential journals, and current publication trends in the context of BDT and critical thinking. By analyzing relevant data, this study offers new insights into the structure of author

collaborations, influential journals in the field, and current trends. The use of machine learning and computational techniques allows for a comprehensive analysis of a vast amount of data, providing a more nuanced understanding of the research landscape and shedding light on emerging patterns and trends.

2. METHODS

Bibliometric analysis research using machine learning consists of eight stages, namely defining the research question, identifying literature sources, utilizing applications such as Publish or Perish for data retrieval, collecting data, importing and cleaning the data, text processing, literature analysis, data visualization, and interpretation of the results (Maria, 2018) For a clearer understanding, the methodology can be described as follows:

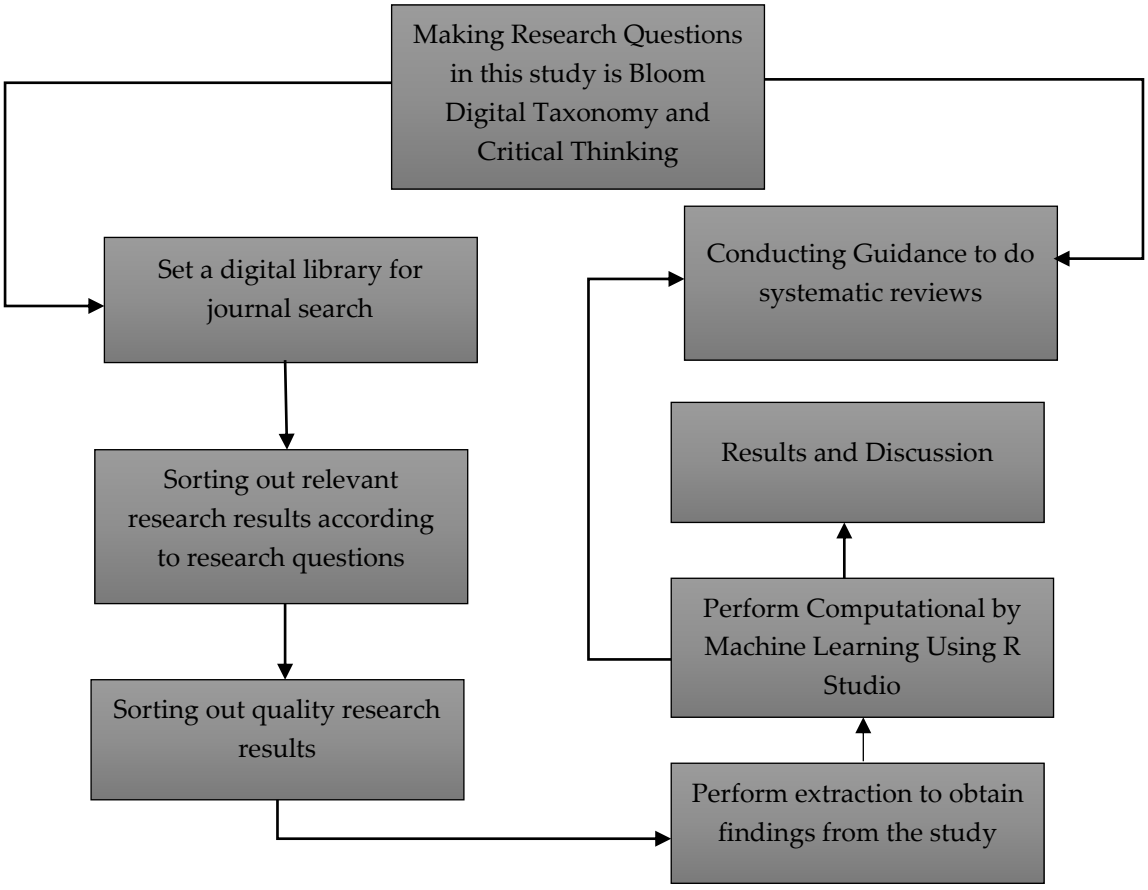


Figure 1 Stages of bibliometric analysis.

3. FINDINGS AND DISCUSSION

3.1 Analisis Citasi

In the academic and scientific realm, the quality of scholarly publications is assessed, among other factors, by measuring the number of times a work is cited by other researchers. A cited work indicates its significance and impact in its respective field. In this study, a total of 200 articles were found with the predetermined keywords from the years 2015 to 2022. Subsequently, a citation analysis was conducted, revealing that the total number of citations per year from 2015 to 2022 was 6,906, with an average citation of 34.35. The H-Index of all papers related to the theme was found to be 33, while the g-index was 81.

Table 1 Publications on taxonomy blooms digital and critical thinking with the highest number of citations.

No	Cites	Author	Title	Years	Source
1	2932	JC Bean, D Melzer	Engaging ideas: The professor's guide to integrating writing, critical thinking, and active learning in the classroom	2021	Books.google.com
2	316	CM Tang, LY Chaw	Digital Literacy: A Prerequisite for Effective Learning in a Blended Learning Environment?	2016	Electronic Journal of E-learning
3	317	A Khan, O Egbue, B Palkie	Active learning: Engaging students to maximize learning in an online course	2017	Electronic Journal
4	240	GS Pratama, H Retnawati	Urgency of higher order thinking skills (HOTS) content analysis in mathematics textbook	2018	Journal of Physics
5	239	RJ Sternberg, DF Halpern	Critical thinking in psychology	2020	Canadian Center of Science and Education
6	235	EA Van Vliet, JC Winnips	Flipped-class pedagogy enhances student metacognition and collaborative-learning strategies in higher education but effect does not persist	2015	CBE—Life Sciences
7	202	SY Rieh, K Collins-Thompson	Towards searching as a learning process: A review of current perspectives and future directions	2016	journals.sagepub
8	178	MT Munir, S Baroutian, BR Young, S Carter	Flipped classroom with cooperative learning as a cornerstone	2018	Education for chemical
9	176	CM Klinge	A conceptual framework for mentoring in a learning organization	2015	Adult learning
10	176	T Keane, WF Keane, AS Blicblau	Beyond traditional literacy: Learning and transformative practices using ICT	2016	Education and Information

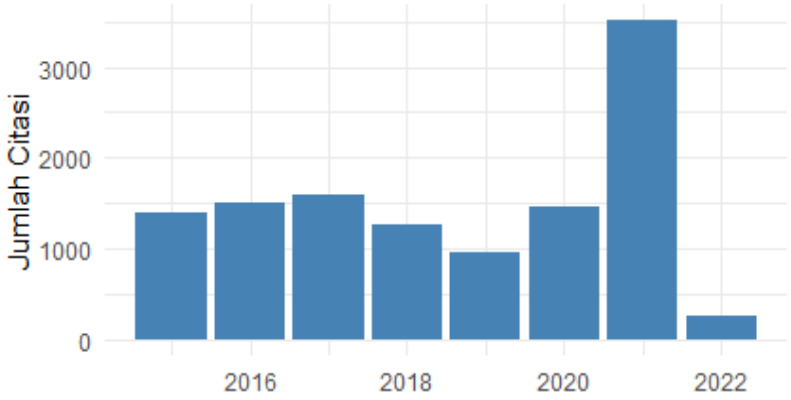


Figure 2 The highest number of citations

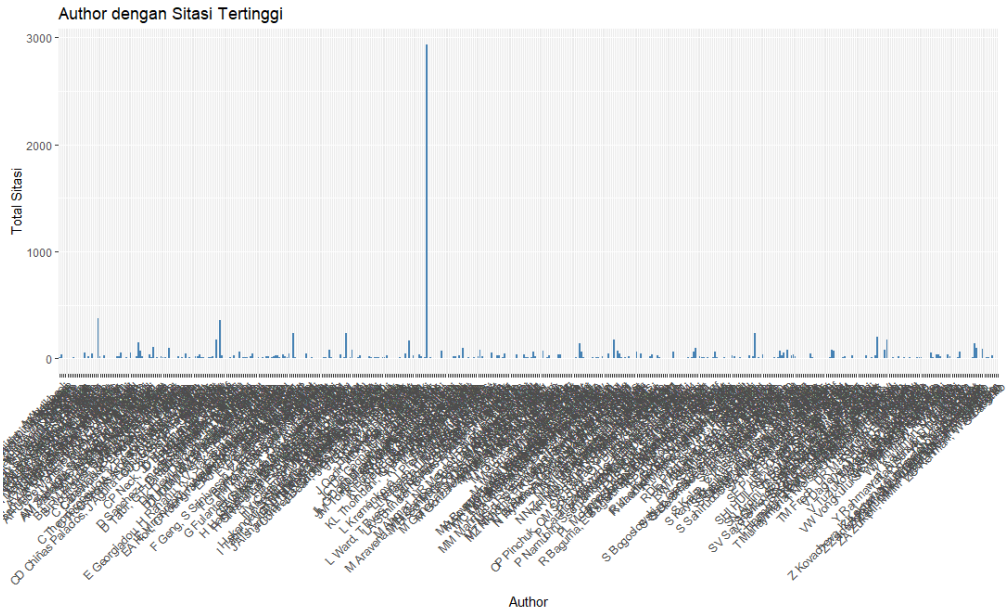


Figure 3 The author with the highest citation

3.2 Publication Trend Analysis

To find out how much research has been carried out by productive researchers in scientific studies in a predetermined period of time (S. Rahayu & Saleh, 2017). In Figure 4, it illustrates the trend of research development related to Taxonomy Blooms Digital and Critical Thinking in journals indexed by Google Scholar from 2015 to 2023. The research indicates that the highest number of publications occurred in the year 2020 with 88 publications. There was a decrease in the number of publications in 2021 with 83 publications. In 2022, there were 57 publications, and there were no publications in 2023.

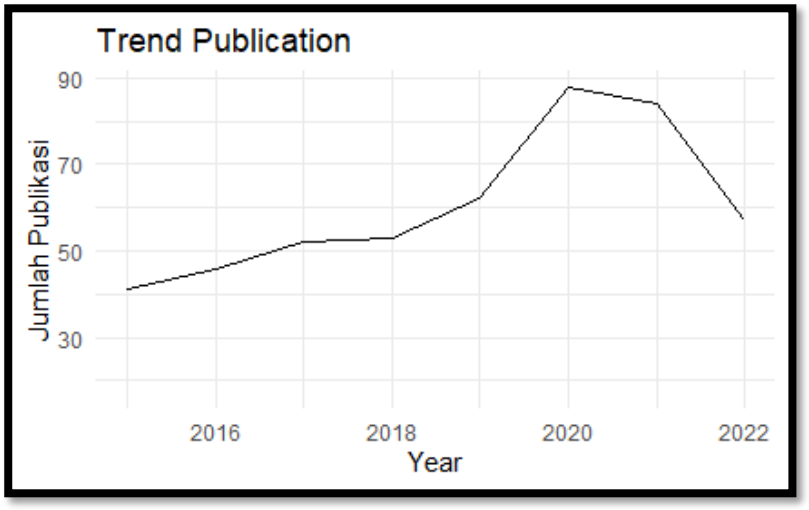


Figure 4 The development of publications on Taxonomy Blooms Digital and Critical Thinking

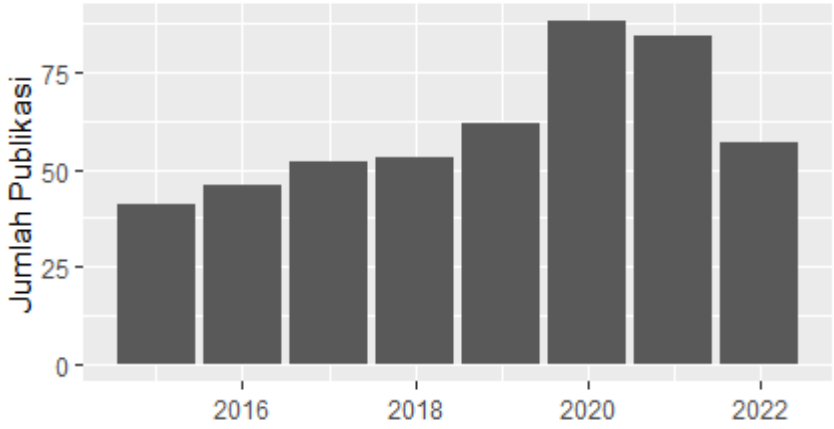


Figure 5 Number Of Publications With The Keywords Taxonomy Blooms Digital And Critical Thinking

3.3 Trend of Publication Development Based on Keywords

To determine publication trends based on keywords, the most common and frequently used keywords are employed. The objective of this analysis is to provide readers with an overview of the current trends and to gain deeper knowledge regarding the keywords used, reflecting interests and relevant research areas.

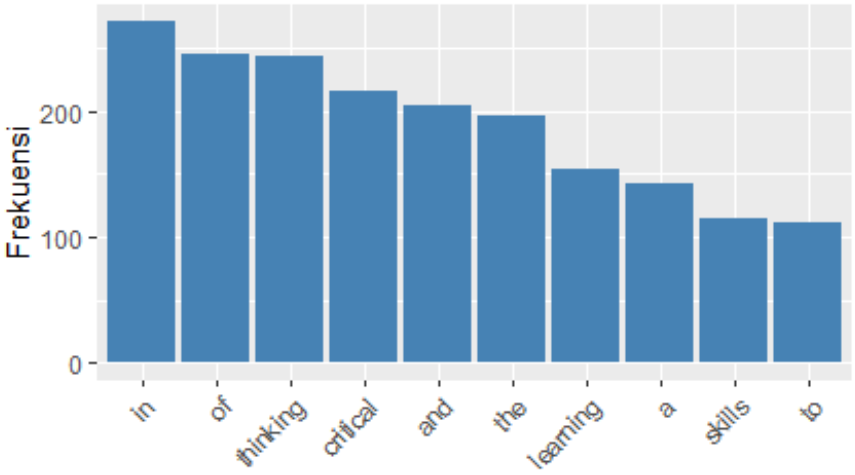


Figure 6 Development of Publications Based on General Keywords

From Figure 6, it can be concluded that the analysis of common keywords related to Taxonomy Blooms Digital and Critical Thinking reveals several findings. Based on the positive sentiment analysis, there is a strong correlation between critical thinking and learning skills, which have been widely implemented in education and have a positive influence on students' ability to engage in higher-order thinking (HOTs). In this regard, critical thinking can enhance students' problem-solving abilities. On the other hand, the negative sentiment analysis indicates that the use of Taxonomy Blooms Digital in supporting the learning process has not been widely implemented. This suggests a gap in utilizing digital tools and technologies to enhance the learning experience. From the results of this analysis, it can be inferred that critical thinking and learning skills are essential in fostering students' ability to engage in higher-order thinking (HOTs). However, there is a need to incorporate the use of Taxonomy Blooms Digital to effectively measure and assess the achievement of the learning process. This integration can provide a framework for evaluating the effectiveness of instructional strategies and ensuring the alignment of educational practices with the desired learning outcomes.

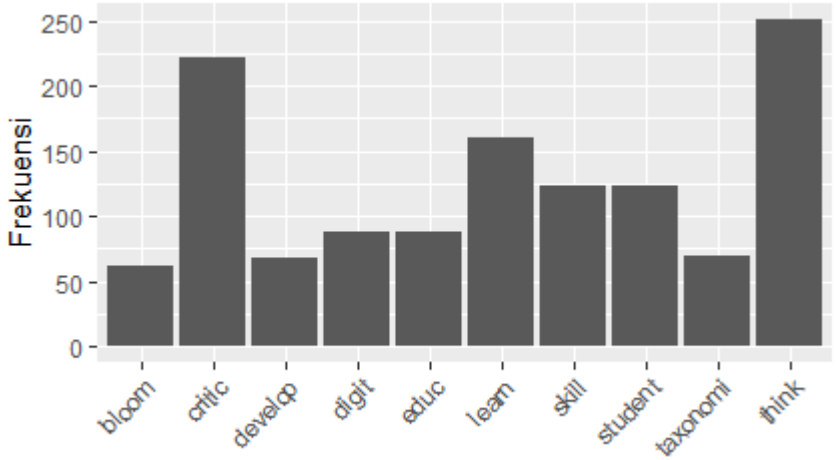


Figure 7 Filter based on the keywords "taxonomy", "bloom", and "digital"

After filtering the common and frequently used keywords, it can be concluded from Figure 7 that the term "taxonomy" appears 70 times after filtering, the term "bloom" appears 60 times after filtering, and the term "digital" appears 90 times after filtering. This analysis highlights the importance of these words in the context of the relationship between taxonomy bloom digital and critical thinking. Furthermore, the bar chart presented provides a clear comparison for each term, which is relevant to the given data. This visual representation offers an easier-to-understand overview of the frequency of

occurrence for these words and allows for a more comprehensive understanding of their relative appearances.

3.4 Trend Analysis of Title Terms

The objective of this analysis is to examine the content, patterns, and tendencies of the document collection by measuring the strength of terms and counting the occurrence of research article keywords appearing together in the studied articles (Chen, 2003, Russell, J.M., Rousseau, 2015). Out of the 500 publications, using at least thirteen conditions, the results indicate that 420 show correlations. The term "thinking skill" appears most frequently in the article titles, occurring 133 times. Meanwhile, the term "taxonomy blooms digital" appears 34 times in the article titles.

Table 2 mapping cluster distribution term title

Cluster	Item	Link/Strange Link
1	Critcal Thinking, Higher Level, Hight Other Thinking Skill, Critical Thinking, Creative Thinking	34/202
2	Bloom, Digital Taxonomy, Critical Thinking Ability, Higher Other Thinking, Collaboration, Communication	32/152
3	Bloom Digital Taxonomy, Cognitive Domain, Framwork, Critical Reflection, Creativity, Knowlage	29/92
4	Example, Higher Level, Strategy, Impact	14/23

3.5 Trend Analysis Based on Abstracts

Based on the analysis of frequently used terms in the abstracts of articles related to Taxonomy Bloom Digital and Critical Thinking, a total of 1349 terms were analyzed across 21 articles. Among these, the term "thinking" appeared the most frequently, with 690 occurrences. The most commonly used terms in the abstracts that are relevant to the topic are as follows: "critical" with 600 occurrences, "taxonomy" with 510 occurrences, "bloom" with 480 occurrences, "skill" with 200 occurrences, and "digital" with 180 occurrences. These findings provide insights into the prominent themes and concepts discussed in the analyzed articles, emphasizing the significance of critical thinking in the context of taxonomy, Bloom's taxonomy, digital technologies, and skill development.

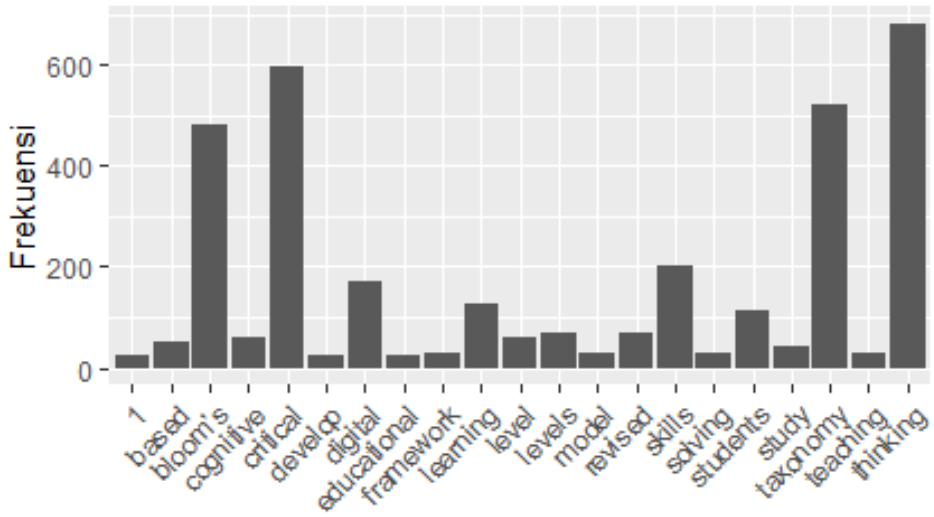


Figure 8 Trend analysis based on the abstract

From the analyzed abstract data, it was found that the length of the abstracts ranged around 150 words, with a minimum length of approximately 50 words and a maximum length of around 300 words. Based on these findings, it can be concluded that the abstract information in the processed data is both detailed and concise. The frequently occurring keywords in the dataset are "thinking," "taxonomy," "critical," "Bloom's," "skills," and "digital." These topics serve as the primary focus of the research in the utilized dataset. Examining Figure 8, it can be inferred that there is a connection between each keyword within the abstracts. "Critical thinking" is associated with "cognitive problem-solving skills." However, the integration of "Bloom's digital taxonomy" with "critical thinking" appears to be less explored. This demonstrates the relationships and connections between concepts in research focused on Bloom's taxonomy and critical thinking. Overall, these findings shed light on the interplay and interrelationships between the concepts discussed in research papers that center around Bloom's taxonomy and critical thinking.

Table 3 mapping cluster distribution Abstract

Cluster	Item	Link/Strange Link
1	Blooms Digital Taxonomy, Cognitive Domain, Higher Order Thinking Skill, Critical Reflection.	8/52
2	Blooms Taxonomy, Digital Taxonomy, Critical Thinking, Communication.	9/262
3	Thinking Skill, , Higher Order Thinking Skill, Creative Thinking, Communication	32/415

3.6 Analysis of Articles Based on Country

This analysis was conducted using the publisher addresses listed in the articles obtained from the Publish or Perish application. Based on the results, it can be concluded that authors of articles related to Taxonomy Bloom Digital and Critical Thinking are from various countries, with varying citation counts. The countries with the highest to lowest citation counts include: United States (41 citations), United Kingdom (36 citations), Germany (28 citations), Italy (21 citations), Canada (20 citations), France (19 citations), Netherlands (13 citations), Indonesia (8 citations). These findings suggest that researchers from different countries have made significant contributions to the literature on Taxonomy Bloom Digital and Critical Thinking, with the United States, the United Kingdom, and

Germany being the most prominent in terms of citation counts. It highlights the international interest and collaboration in the field, as well as the impact of research conducted in these countries.

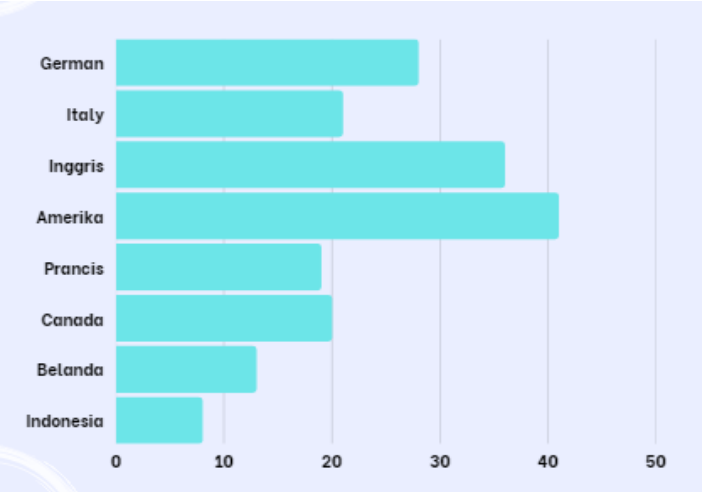


Figure 9 Articles based on countries with high citations

4. CONCLUSION

Bibliometric analysis was conducted on research related to Taxonomy Bloom Digital and Critical Thinking, utilizing data visualization with VOSviewer. A total of 500 highly relevant articles were obtained from the search results. This research aimed to identify various research trends related to the predetermined keywords and analyze them from different perspectives. From the total number of identified articles spanning from 2015 to 2023, it was found that the articles related to Taxonomy Bloom Digital and Critical Thinking received an average of 1465.25 citations per year, with an average of 23.44 citations per article. Through the analysis of these 500 publications, the results indicate that bibliometric analysis and data mapping using machine learning enable a deeper understanding of the developments, trends, and significant aspects of research in this field. By employing bibliometric analysis and applying machine learning approaches, this study contributes to the understanding of Digital Bloom taxonomy and critical thinking, while also providing an overview of research trends.

Conflicts of Interest: The authors declare that there are no conflicts of interest regarding the publication of this article. They affirm that the article is free from plagiarism.

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