



ARTIFICIAL INTELLIGENCE RESEARCH TRENDS IN EDUCATION: BIBLIOMETRIC ANALYSIS USING BIBLIOSHINY

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Abstract

ICT which is growing rapidly in the digital era has succeeded in creating an artificial intelligence called Artificial Intelligence for the benefit of various fields of life, especially education. The purpose of this study is to see the development of research on the topic of Artificial Intelligence trends in bibliometric-based education. This research method is using bibliometric methods regarding the production, growth, maturation, and consumption of scientific publications with a descriptive approach using data derived from Scopus regarding Artificial Intelligence in education published in various academic journals, books, patents, proceedings, and so on from 1999 to 2024. The results of this study, namely bibliometric analysis based on Scopus data with 1646 documents on Artificial Intelligence in education, have provided a comprehensive view of the current domain status. The results of the analysis of 21 aspects contained in the overall Scopus data have provided new findings about Artificial Intelligence in education including: Artificial Intelligence in education gave rise to the words augmented reality, student, and learning systems which continues to evolve along with the emergence of new research words or themes and the growing popularity of certain topics; It finds many of the studies that are frequently cited, and several articles, authors, and journals play an important role in it. This means that Artificial Intelligence in education today is very dynamic with a steady growth of publications.

Keywords :Artificial Intelligence, Bibliometrics, Biblioshiny, Education

I. Introduction

The rapid development of ICT in the current digital era has succeeded in creating an automation called Artificial Intelligence (AI). Artificial Intelligence (AI) is a branch of computer science that creates intelligent machines that can work and react like the human brain with the use of processing data, patterns, and models to understand, reason, plan, solve problems, make predictions, and manipulate objects (Karsenti, 2019). This now makes Artificial Intelligence (AI) a buzzword in the 21st century and has many important roles and impacts on everyday life (Alwi, 2023). Therefore, Artificial Intelligence is currently the main technology that attracts a lot of attention to become a trend in the digital era.

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The emergence of the Artificial Intelligence (AI) trend is seen from its use which has always increased rapidly in recent decades. One field that widely uses Artificial Intelligence is education (Khan et al., 2023; Fitriyani et al; Sardi, 2022). This is in line with what was expressed by Fitriani, Rosidah, & Zafrullah (2023), that in the future learning will use more Artificial Intelligence. Artificial Intelligence in education is believed to be able to have a major impact on the future of humans in the form of solutions when experiencing chronic challenges related to equality, future learning, and real-world relevance (Srinivasan, 2022). Therefore, currently, in the field of education itself, Artificial Intelligence is considered a breath of fresh air that can contribute to the progress of education in Indonesia.

According to Karsenti (2019) Artificial Intelligence has 26 contributions to education, namely: 1) personalized learning; 2) greater academic success; 3) automatic correction of certain school assignments, thus freeing up time for teachers to work on other tasks, but in this regard human contribution remains important; 4) ongoing assessment of learners; 5) teachers can customize their courses to the limit; 6) intelligent tutoring platforms for distance learning; 7) new ways to interact with information; 8) educational feedback; 9) customized teaching content; 10) expanded opportunities for learners to communicate and collaborate with each other; 11) greater interaction between learners and academic content; 12) better teaching through facilitation rather than content transformation i.e. as a teacher's helper; 13) homework help; 14) more learning, as AI can personalize exercises to make learning more meaningful and fun; 15) immersive or virtual reality environments; 16) dropout prevention; 17) distance learning more accessible and engaging; 18) learner autonomy, a key mission for educators, 19) better classroom management; 20) vast gamification potential and games contribute directly to learner engagement; 21) more efficient administrative processing; 22) to some extent AI can detect learners' moods which is useful for customizing teaching practices; 23) data collection, storage, and security which can address ethical and educational concerns; 24) special contributing learners will benefit from AI; 25) automated tasks; and 26) humanoid robots (teacher assistants in the classroom). In addition, based on research conducted by Tejawiani, Sucahyo, & Sopian (2023); Maufidhoh & Maghfirah (2023); Pardamean, Suparyanto, Anugrahana, Anugraheni, & Sudigyo (2022) Artificial Intelligence (AI) has been proven to be able to increase students' enthusiasm in teaching and learning activities, increase students' creativity, and improve students' learning outcomes.

Based on the above, it is important to look further into the development of Artificial Intelligence research trends in education. One of the ways that can be used is to conduct a scientometric analysis, which combines bibliometric analysis with the Bibliometrix Biblioshiny R package application. Bibliometrics is a study that uses a qualitative research approach by using several scientific articles to obtain information on the development of research topics. (Rusliana et al., 2022). Bibliometric mapping is research included in the realm of bibliometric studies and can be used in various scientific studies. The purpose of this study is to see the development of research on Artificial Intelligence trends in education with a bibliometric-based research approach.

II. Research Methods

This research is a quantitative study research that uses bibliometric methods regarding the production, growth, maturation, and consumption of scientific publications with a descriptive approach using data derived from Scopus regarding *Artificial Intelligence* in education published in various academic journals, books, patents, proceedings, and so on from 1999 to 2024. The software used is R Bibliometrix Biblioshiny, which is Java-based software developed to conduct functional combination research using the bibliometrix package with the web application used as a package in R-studio. (Khan et al., 2023). The results obtained after using R Bibliometrics are datasets in the form of key information, years of scientific production, and three-field plots. This scientometric approach combines the performance of analytical tools and mapping tools in bibliometrics to analyze research fields, generalize and visualize conceptual subdomains, and develop a specific thematic evolution of research topics (Muñoz-Leiva et al., 2012). In forming research with a bibliometric approach, 2 aspects need to be completed, namely bibliometric mapping of bibliometric findings explanation and graphical presentation (Taqi et al., 2021). Bibliometrics that combine mapping and graphics can be converted into scientometry-based research, namely the analysis of publications in a scientific field through various points of view and mapping with a general approach in that field (Makkizadeh & Sa'adat, 2017). The flow in this research is in Figure 1.

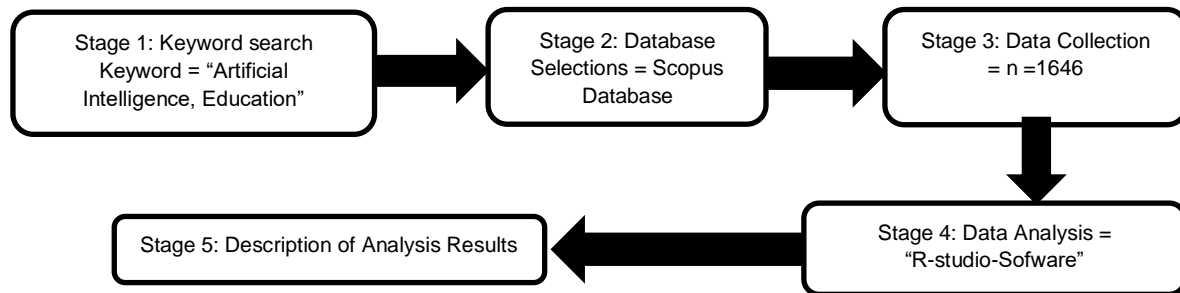


Figure 1: Research flow

III. Results and Discussion

Main Information, Annual Scientific Production, and Average Citations per Year

The first output needed in conducting scientometric research is to identify the main information (main features of the dataset) which contains basic information about all articles with the theme of Artificial Intelligence in education. All basic information is presented in Table 1. Table 1 shows that the documents used totaled 1646. The time range of the documents found is from 1999 to 2024 which comes from various sources, namely 835 journals, proceedings, and books that have been registered in the Scopus database. The annual growth rate is 0%.

In addition, the bibliometric analysis also contains information about author contributions and international collaborations in this study. Based on the analysis, there were 4739 authors involved and 109 were single authors. From this, it can be seen that

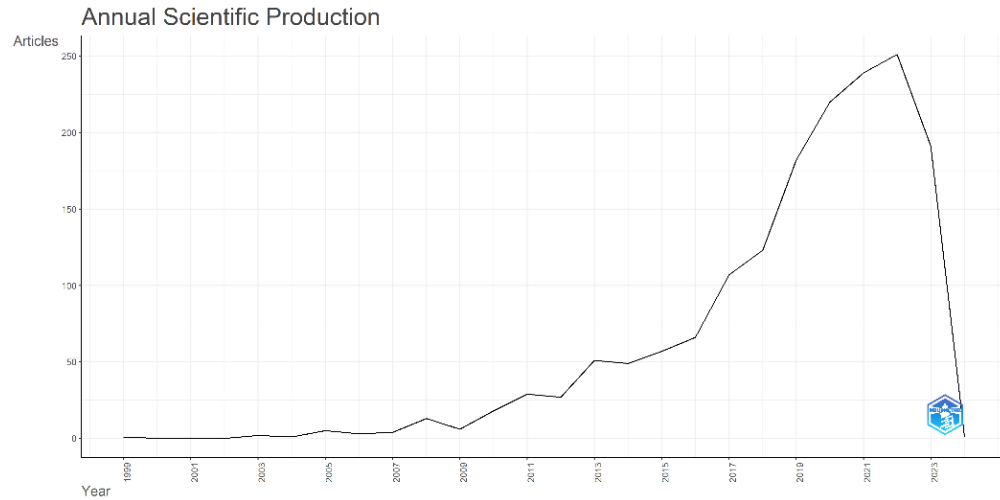
there is diversity in the writing of this article. However, when viewed from the collaboration of international authors, only 12.82% with an average of 3.66 authors per document. Therefore, it can be seen that most research in the field of Artificial Intelligence is carried out at the national level. In addition, there are 2923 keywords and 43846 references corresponding to this topic, thus illustrating the diversity in the field of Artificial Intelligence in education. These documents also have a significant impact with an average of 13.2 citations per document which has broad relevance in the scientific literature.

Table.1 The key information about Artificial intelligence in education

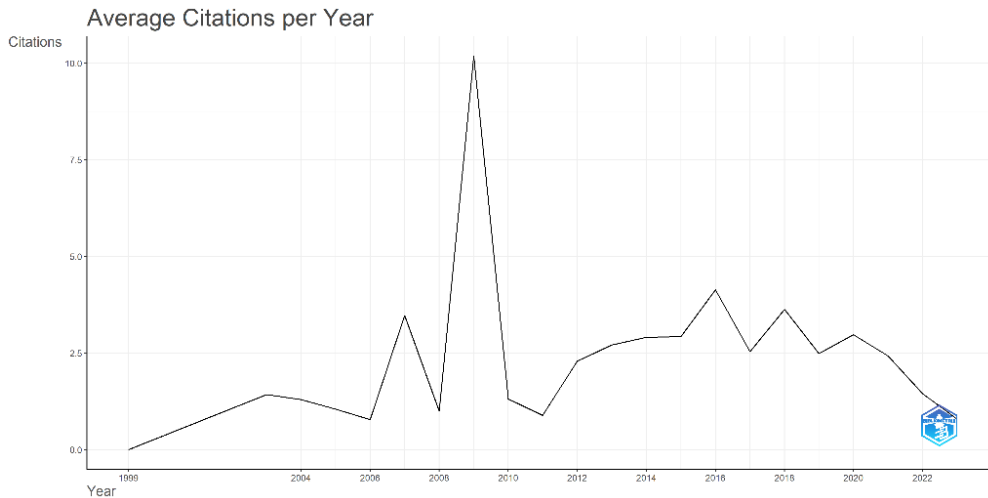
Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	1999:2024
Sources (Journals, Books, etc.)	835
Documents	1646
Annual Growth Rate %	0
Document Average Age	4,06
Average citations per doc	13,2
References	43846
DOCUMENT CONTENTS	
Keywords Plus (ID)	5332
Author's Keywords (DE)	2923
AUTHORS	
Authors	4739
Authors of single-authored docs	109
AUTHORS COLLABORATION	
Single-authored docs	126
Co-Authors per Doc	3,66
International co-authorships %	12,82
DOCUMENT TYPES	
article	745
conference paper	901

Source: R-Studio

Referring to the annual production (Figure 2a), it can be seen that the most publications are in 2022 as many as 251 articles published or 15.25%. Regarding the increase, in 2020 there was an increase of 220 publications and the following year to 239. Of the 1646 publications, most came from journals and also from proceedings. The average citations per year (Figure 2b) shows that from 1999 to 2023 the most citations were in 2009 with an average of 10.2. This shows the large number of citations in 2009. Meanwhile, in 2023 there was a drastic decrease with an average of 1.4. Therefore, it should be noted that a large number of citations does not always reflect the quality of a study. This is because there are other factors such as the popularity of a topic or the availability of research.



(a)



(b)

Source: R-Studio

Figure 2. (a). Annual Scientific Article Production, (b). Average Citation per Year

Three-Field Plot

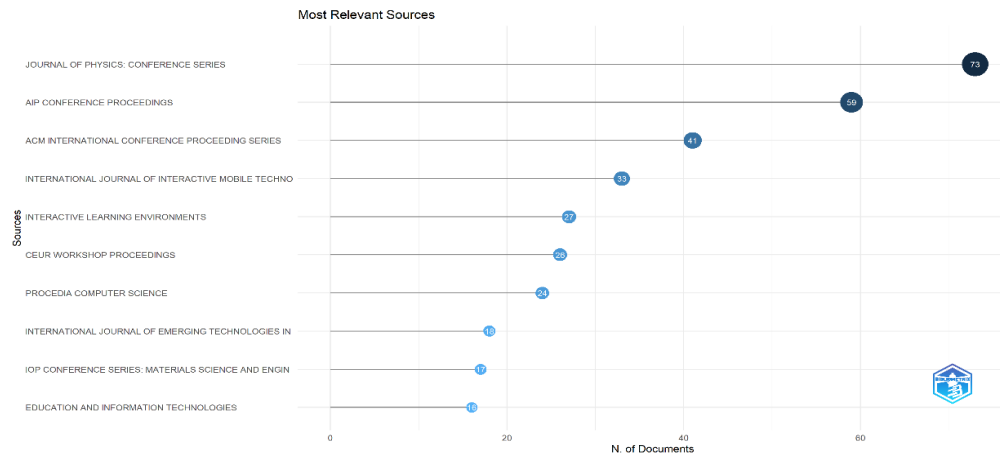
The Three-Field Plot (Sankey diagram) is part of the dataset results in the form of linkages between authors, sources, and keywords. According to Khan, Ahmad, Javed, & Nasir (2023), Sankey diagrams aim to reveal and assess the flow between *authors*, sources, and keywords. The Sankey diagram in this study shows that there is a strong relationship between the three. Based on Figure 3, the strong relationship between the source, author, and main keywords is Dunleavy M, Dede C, and Mitchell R who mostly discuss the affordances and limitations of immersive participatory *Augmented Reality* simulations in science education teaching and learning journals.



Figure 3. Three-Field Plot

Most Relevant Sources

Most Relevant Sources in Figure 4 presents information about the most relevant sources. Based on the figure, it can be seen that there are five journals with the most relevant sources, namely Journal of Physics: Conference Series (73 papers), Aip Conference Proceedings (59 papers), Acm International Conference Proceeding Series (41 papers), International Journal of Interactive Mobile Techno (33 papers), and Interactive Learning Environments (27 papers). This shows that the publication of research with the theme of Artificial Intelligence in education can be used as a suggestion for the best place to publish. However, it does not rule out the possibility of publishing in other reputable and non-reputable journals.

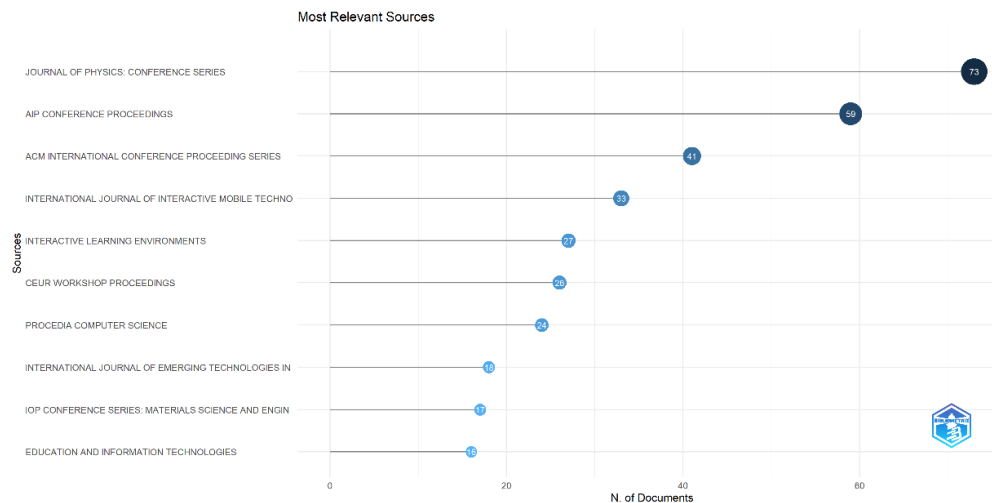


Source: R-Studio

Figure 4. Most Relevant Sources

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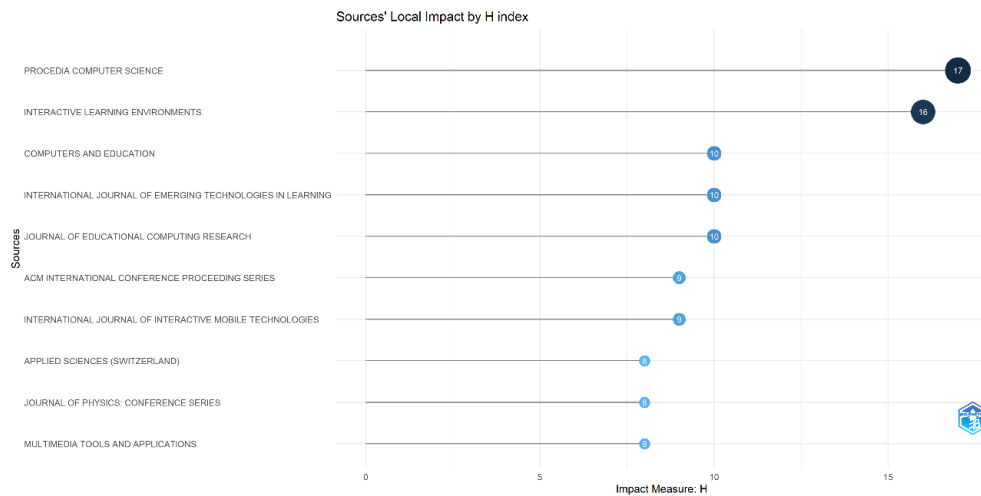
Source: R-Studio

Figure 4. *Most Relevant Sources*

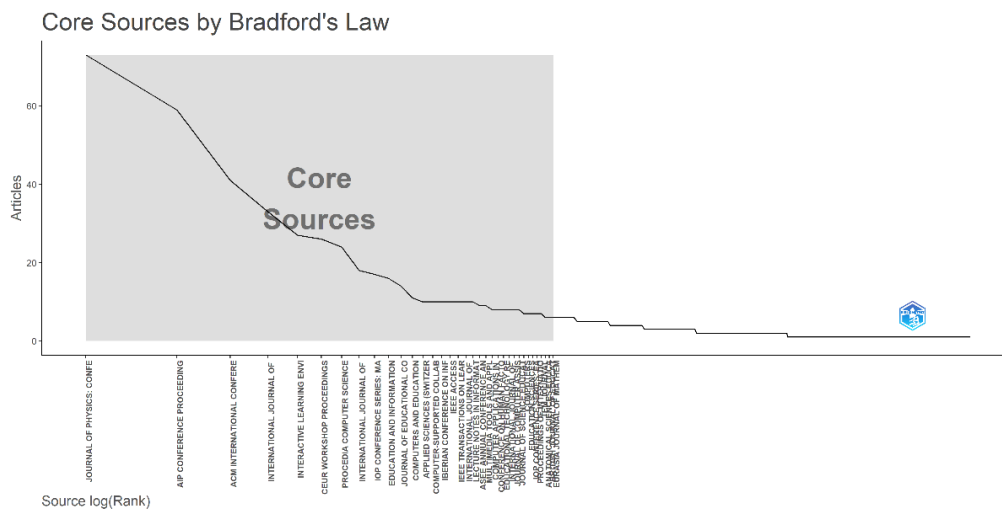
Sources Local Impact, Bradford's Law and Source Growth

This section will analyze the impact of local sources that can measure how much influence publishers have on the theme of Artificial Intelligence in education using the h-index. In addition, Bradford's law is also analyzed to show a number of core sources that show a number of major publishers in the development of Artificial Intelligence in education and also growth sources that show data on a number of publisher developments from year to year in the development of Artificial Intelligence themes in education. In this study, the processing results on the impact of local sources (Figure 5a) show that *Procedia Computer Science* occupies the top position with an h-index value of 17 and *Interactive Learning Environments* occupies the second top position with an h-index value of 16. The other journals have a low h-index including *Computers and Education*, *International Journal of Emerging Technologies and Learning*, and *Journal of Educational Computing Research* have an h-index of 10, *Acm International Conference Proceeding Series* and *International Journal of Interactive Mobile Technologies* have an h-Index of 9, and *Applied Sciences (Switzerland)*, *Journal of Physics: Conference Series* and *Multimedia Tools and Applications* have an h-index of

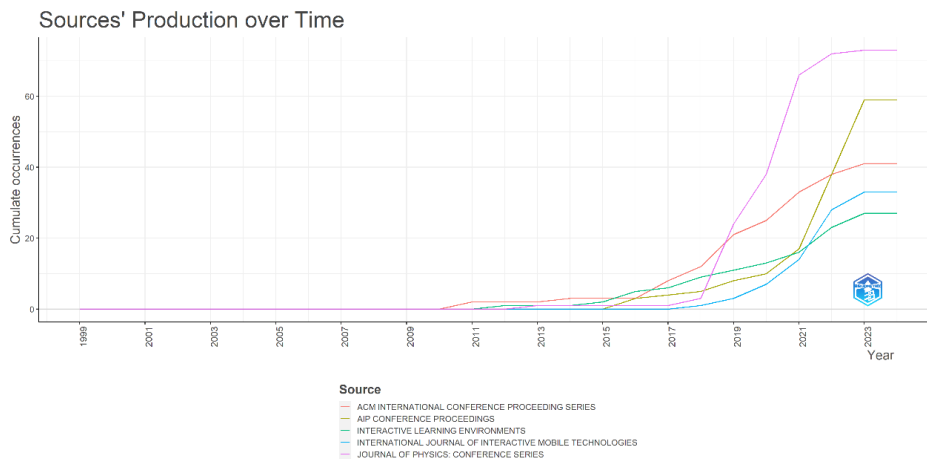
8. Meanwhile, based on the results of Bradford's law (Figure 5b), the journal with the highest number of publications is Journal of Physisc: Conference Series as many as 73 documents. This shows that the journal is a publisher that is the main, dominant, and impactful publication site on the theme of Artificial Intelligence research in education. This study also discusses the source of journal production from year to year which is the source of research on Artificial Intelligence in education. Based on the curve (Figure 5c), it can be seen that there is a cumulative development in each journal from 1999 to 2024. The first journal to develop in Artificial Intelligence research in education is Journal of Physics: Conference Series since 1999. It can also be seen that in the figure there is an increase in the first journal in 2010 that published Artificial Intelligence research in education, namely Acn international Conference Proceeding Series. Furthermore, from 2018 to 2024 there began to be developments in other journals that publish Artificial Intelligence in education.



(a)



(b)



(c)

Source: R-Studio

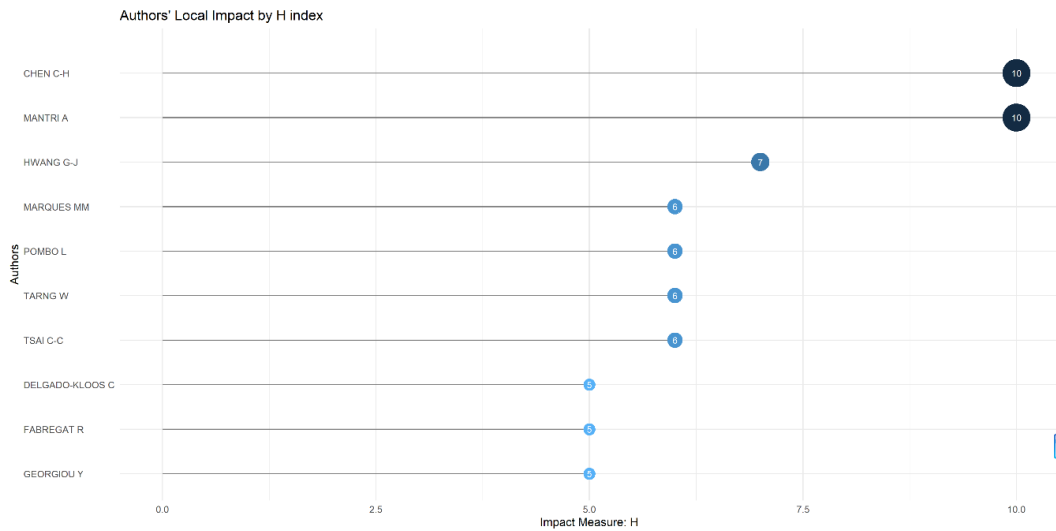
Figure 5. (a). Sources Local Impact, (b). Bradford's Law, (c). Source Growth

Authors' Local Impact by H-Index, Top Authors Production Over the Time, dan Corresponding Author's Countries

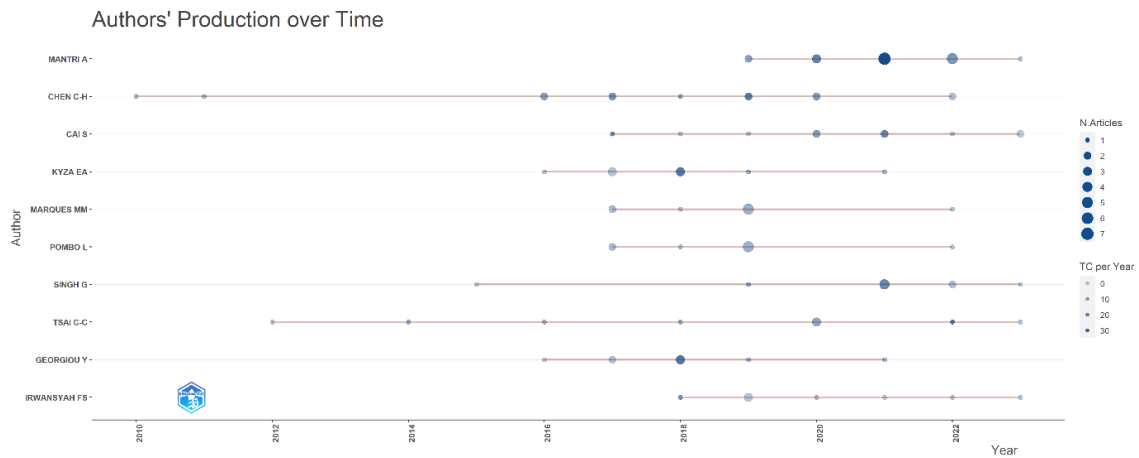
The order of authors who have published their papers can be sorted by the impact generated based on the h-index. In this study, the h-index obtained ranges from 0 to 10. The author impact in this study (Figure 6a) shows that Chen C-H and Mantri A as the authors who have the highest h-index which is worth 10 and Hwang G-J has an h-index of 7 and 4 authors below have an h-index of 6 and 3 authors below have an h-index of 5. The data output from Biblioshiny also displays author production over time. In this case, the researchers with the top writing productivity are indicated by a red line since the author published their research and accompanied by a circle above the red line as a sign of the number of papers or articles published according to the applicable year. In this study, author production over time spans from 2010 to 2023 (Figure 6b). Based on the figure, the first author and the one who has long written research on Artificial Intelligence in education is Chen C-H, from 2010 to 2022. In addition, the author who has a long track record is Tsai C-C, writing from 2012 to 2023. With these findings, it has been proven that research on Artificial Intelligence in education has been around for a long time (2010) and developed until 2023.

Corresponding Author's Countries (Figure 6c) is part of the dataset that shows the country of origin of each article author obtained through calculating the total collaboration between SCP (single country cooperation) or single country collaboration, instead of MCP (Multiple country collaboration) or collaboration between several countries. In this research data, there are 5 top countries. The document quantity interval in this study is between 0 and 155 published with the theme of Artificial Intelligence in education. Based on this, the results obtained are that China is in the first position as the country with the highest number of authors, namely 155 published articles. The second position is Indonesia with 148 articles published. The third position is Malaysia with 63 articles published. The fourth position is USA with 65 articles published. The fifth

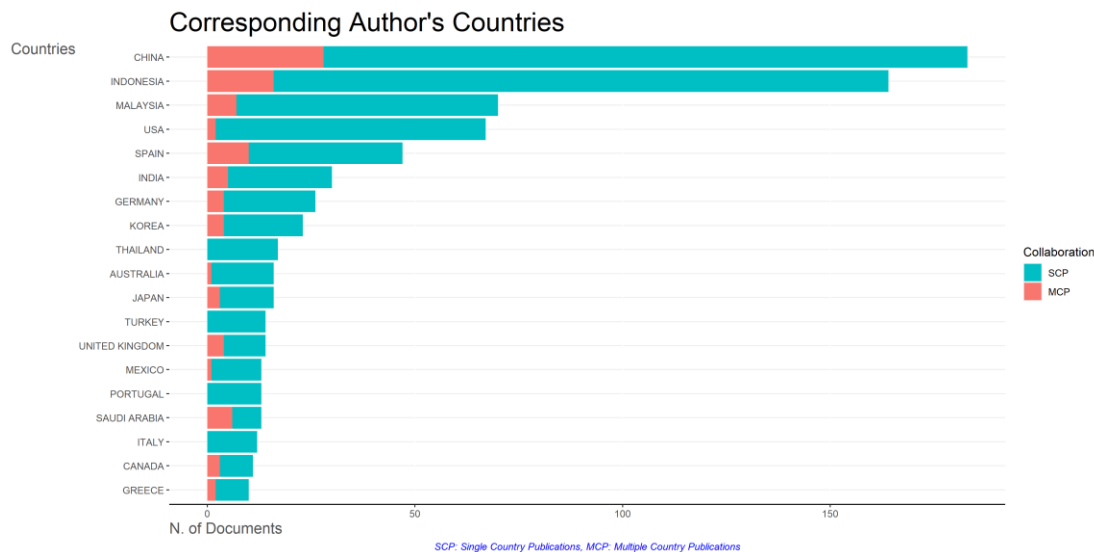
position is Spain with 37 articles published. From this data, it can be seen that an increase in the number of articles with the theme of Artificial Intelligence in education is needed in other countries that occupy a ranking position below 5.



(a)



(b)



(c)

Source: R-Studio

Figure 6. (a). Authors' Local Impact by H-Index, (b). Top Authors Production Over The Time, (c). Corresponding Author's Countries

Most Global Cited Documents, Most Relevant Word, Word cloud, Word TreeMap, Clustering, and Words' Frequency Over Time

Most globally cited is the part of the dataset that shows the most globally cited documents. Based on this, in the research conducted (Figure 7a), it can be seen that Dunleavy M. published in 2009 was cited by 821, which is the most cited. The Most Relevant Words in this study (Figure 7b), namely augmented reality, experienced appearances from 0 to 1050 times. This means that this research is closely related to Artificial Intelligence in education which often appears in research with this theme. Furthermore, in the second position is the word student with a total of 385 occurrences.

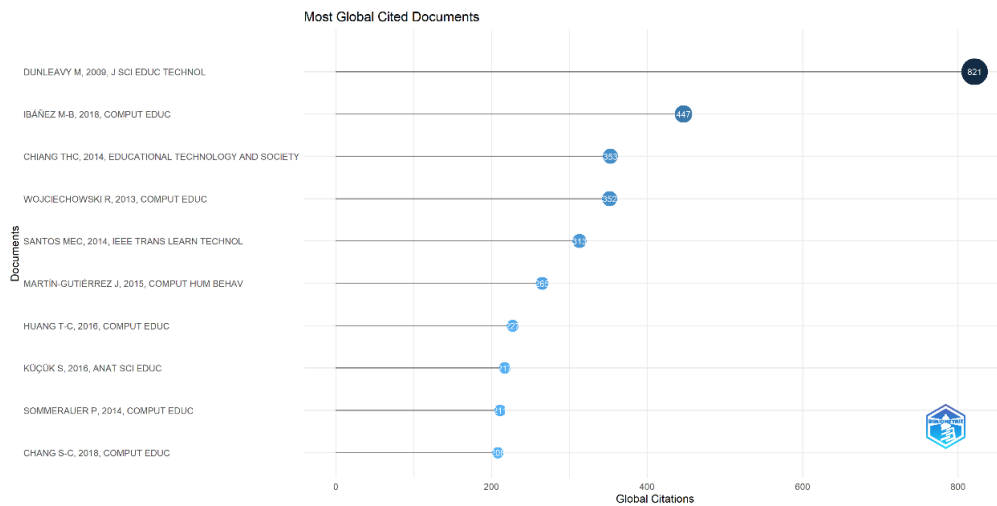
Word cloud, Word TreeMap, and Clustering are part of the dataset that brings up the description of words in the data collection of articles studied with the theme of Artificial Intelligence in education. Based on these three aspects, the words that often appear are generally the same, namely the first augmented reality, second student and third learning systems.

The word cloud in this study (Figure 7c) shows a word digest display with illustrations using words in various sizes according to the number of words that appear. Word cloud placement tends to be random, but the dominating word is often positioned in the center to be more visible with a large size. As for the TreeMap section (Figure 8d), it shows words that frequently appear in boxes that are similar to the regions on the map. In this case, the more words that appear, the larger the area and the grouping is done by displaying words in the form of colored groups by considering the relationship between

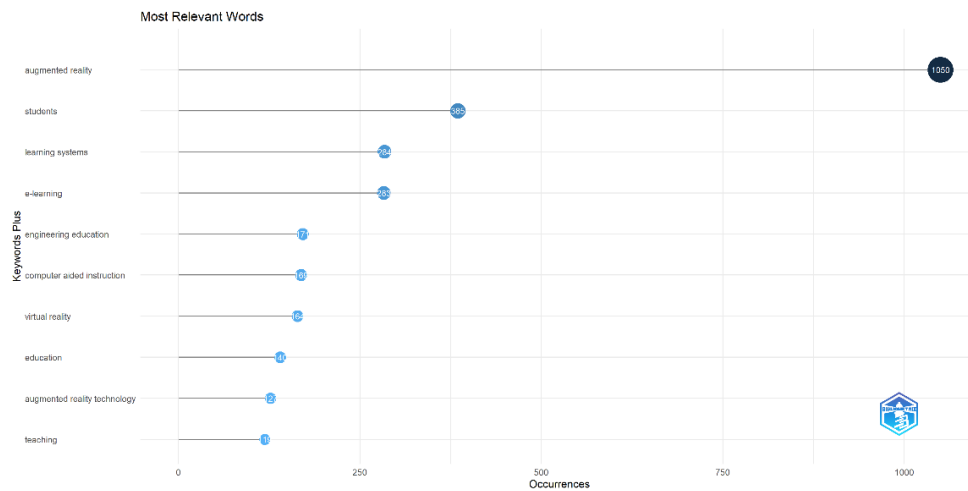
one word and another. Based on this, the word augmented reality is a word that often appears because it displays the largest square box among other words.

Based on the clustering contained in the research results (Figure 7e), it can be seen that the words that often appear are in the middle cluster, namely augmented reality, students, and learning systems. The words education, deep learning, and machine are in the bottom right cluster, which means that the word is fundamental with high centrality but low density, while the words learning and human are specific and rare words, but highly developed with high density and low centrality (Amin et al., 2023).

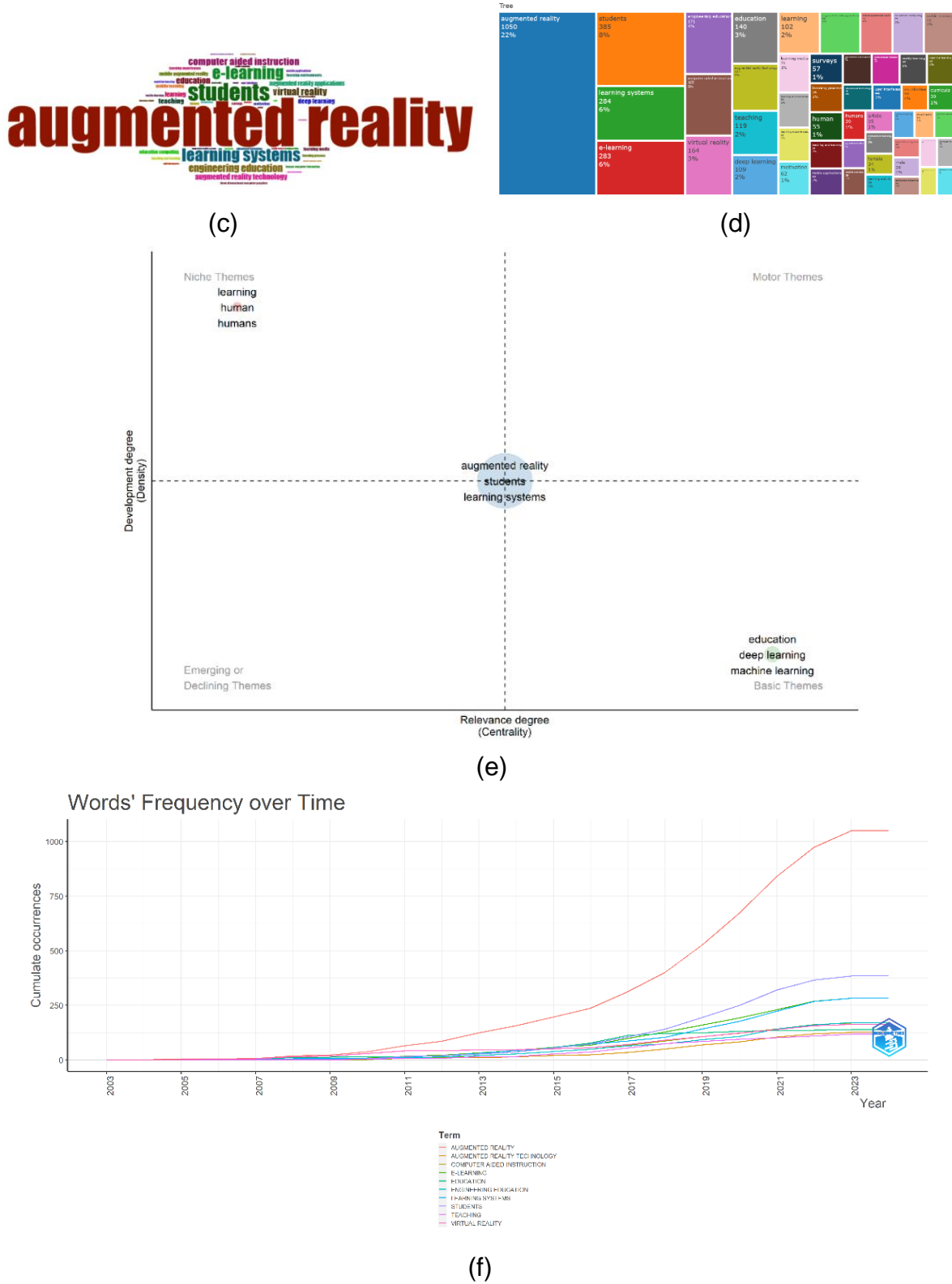
Frequently occurring words are also presented in a progression curve by year. The results of the curve (Figure 7f) in this study show that the words that frequently appear and are used have basically been since 2003 which then developed to increase until 2024. Referring to the year, 2005 saw the highest increase in the word Augmented Reality and 2018 also saw an increase in the word Student. Based on this, the two words continue to increase every year and the same thing also happens with other words.



(a)



(b)

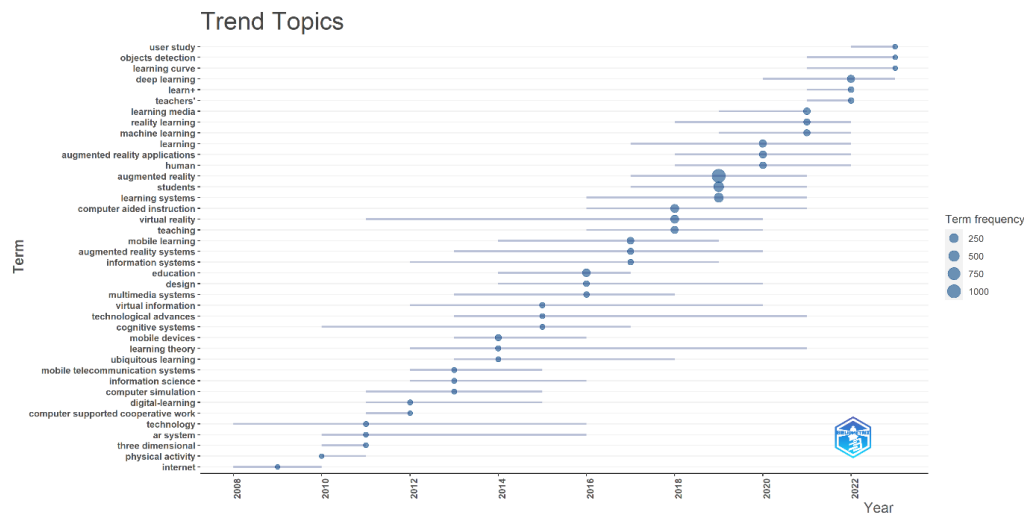


Source: R-Studio

Figure 7. (a). Most Global Cited Documents, (b). Most Relevant Words, (c). Word TreeMap, (d). Word cloud, (e). Clustering, (f). Words' Frequency Over Time

Trend Topics

The topic trend in this study shows the development of a topic from year to year. Based on the diagram in Figure 8, it can be seen that topics that have been used for a long period of time and topics used recently. Topics that appear also correspond to the frequency of the number of words that appear in research on the theme of Artificial Intelligence in education. If more words are used, it will be higher and if more recent words are used, it will be more to the right. Based on this, the trending topics are augmented reality with a frequency of 1000, students with a frequency of 750, and learning systems with a frequency of 500. The development of a topic in this study has increased significantly every year, starting in 2009 and continuing to increase until 2023 today.

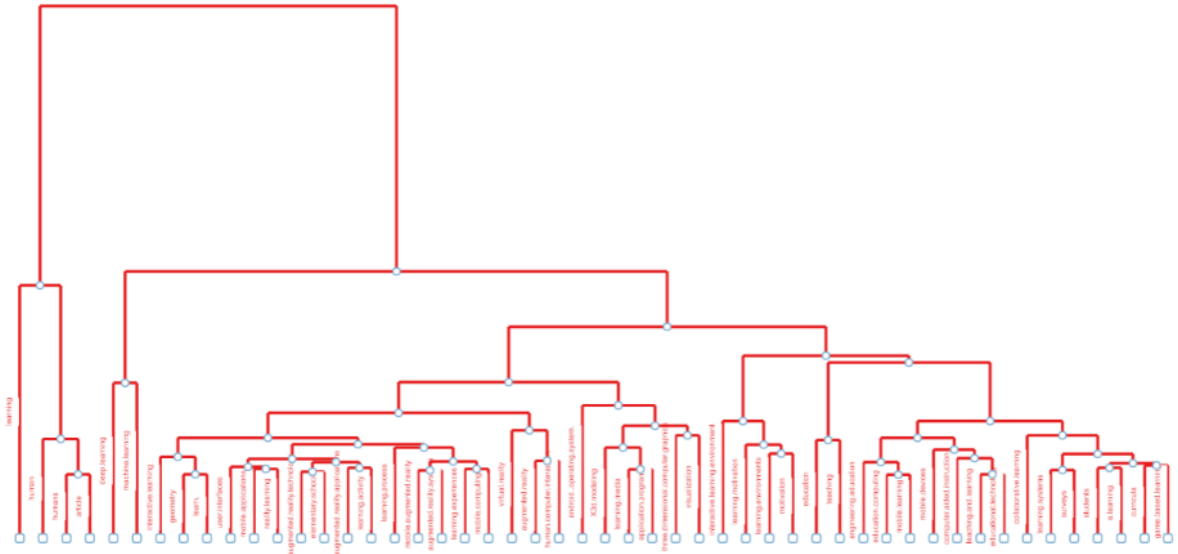


Source: R-Studio

Figure 8. *Trend Topics*

Topic Dendrogram

Cluster analysis is performed to determine the similarities and dissimilarities that occur between objects in the dendrogram. A dendrogram or distance tree is a clustering done to determine the rank order of a keyword. The vertical axis on the dendrogram shows the discipline of a theme, while the horizontal axis shows the difference between a group (cluster) (Khan et al., 2023). The purpose of the dendrogram is to assess the expected number of clusters rather than determining the ideal number of clusters (Akhsan et al., 2021; Lim et al., 2022; Yang et al., 2022). The dendrogram in this study (Figure 9) shows a red area, which means that there are more words that are related to each other. In other words, many research articles have interconnected words. Therefore, with the presence of dendrogram we can know the relationship between various clusters (Ezugwu et al., 2022).

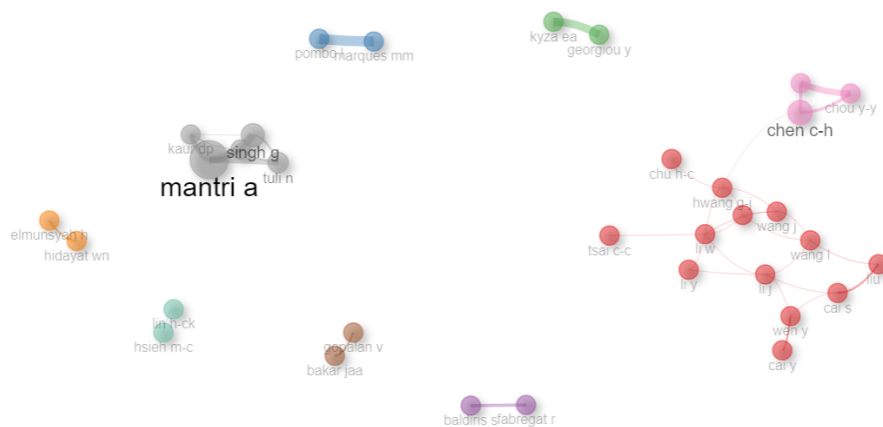


Source: R-Studio

Figure 9. *Topic Dendrogram*

Collaboration Network

Collaboration Network in this research is listed in Figure 10. Collaboration Network is a network of cooperation or network between authors with the theme of Artificial Intelligence in education. In the figure, it can be seen that some authors' names are interconnected or have connections. The relationship is indicated by the similarity of colors or lines between one name and another. Each circle has a size that indicates the number of articles that have been published in this theme. The figure shows the cooperation that occurs between 9 groups of authors. Within the 9 groups of authors, there are 3 largest groups or those that collaborate with more than 2 authors.



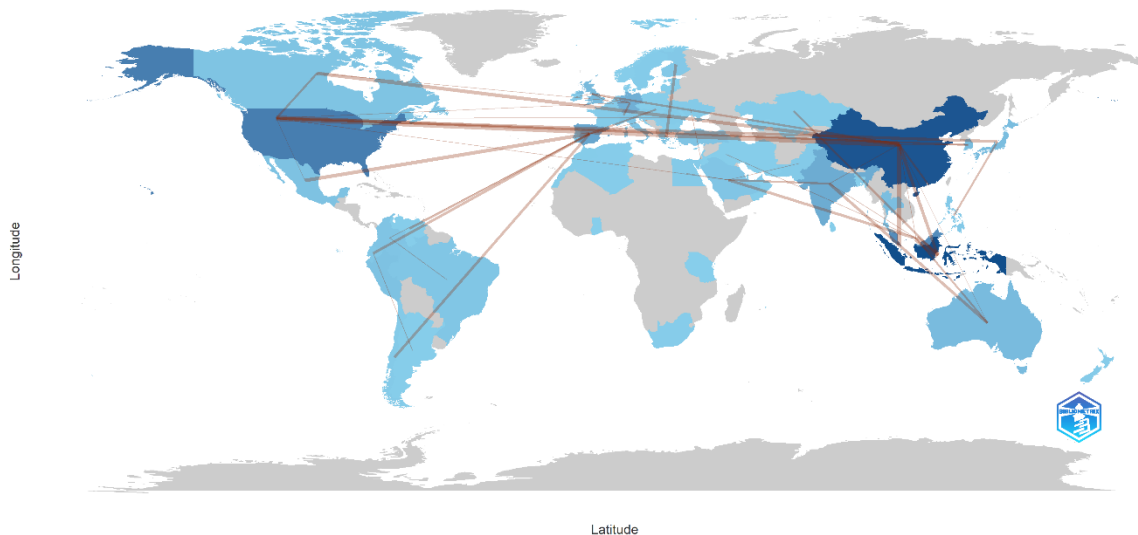
Source: R-Studio

Figure 10. *Collaboration Network*

Analysis Country Collaboration Map

International collaborations from various countries are also visible in the R-Studio software dataset. According to Gu, Meng, & Farrukh (2021), international collaboration aims to explore how authors collaborate in knowledge transfer research and a country's relationship with other countries. In this study, the units of analysis are countries and collaboration documents based on 1646 Scopus documents that have been inputted with the results as in Figure 11. The dark blue color in the figure indicates that a country collaborates with other countries in a broad scope. The lighter blue color indicates less collaboration and the lighter gray color indicates no collaboration or affiliation made with other countries. Based on this, it can be seen that there is extensive cooperation between Indonesia and Malaysia (frequency 14), followed by China and the USA (frequency 11). While various other countries have fewer collaborations and there are even countries that do not collaborate.

Country Collaboration Map



Source: R-Studio

Figure 11. *Country Collaboration Map*

IV. Conclusion

Bibliometric analysis based on Scopus data with 1646 documents on Artificial Intelligence in education has provided a comprehensive view of the current status of the domain. The results of the analysis of Main information, Annual Scientific Production, Average Citations per Year, Three-Field Plot, Most Relevant Sources, Sources Local Impact, Bradford's Law, Source Growth, Authors' Local Impact by H-Index, Top Authors Production Over The Time, Corresponding Author's Countries, Most Global Cited Documents, Most Relevant Word, Word cloud, Word TreeMap, Clustering, Words' Frequency Over Time, Trend Topics, Topic Dendogram, Collaboration Network, and Analysis Country Collaboration Map as a whole have provided new findings regarding Artificial Intelligence in education including: Artificial Intelligence in education brings up

the words augmented reality, student, and learning systems that continue to grow along with the emergence of new words or research themes and the increasing popularity of certain topics; many of the researches are often cited, and several articles, authors, and journals play an important role in it. This implies that Artificial Intelligence in education is currently very dynamic with a steady growth of publications.

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