Bibliometric Computational Mapping Analysis of Trend Metaverse in Education using VOSviewer

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ARTICLE INFO	ABSTRACT
             	This study aims to present a bibliometric analysis of the topic of trend metaverse in education published in the Google Scholar database. The data used in this study totalled 995 published articles from 2013 to 2023. This study used reference management software, namely Publish or Perish for data collection, Microsoft Excel for data analysis, and VOSviewer for data visualization. The results show that Metaverse in Education research has increased from 2013 to 2023. In 2023 the number of Metaverse in Education studies has decreased by 78 publications from the previous year 2021 The results of bibliometric data mapping found 81 relevant items based on co-words and 6 items based on co-authorship. Each item is divided into 5 clusters (based on co-words) and 2 clusters (based on co-authorship). International Journal of Metaverse in Education is a journal that publishes many publications on keywords. It is hoped that the findings of this study can become a reference and provide direction for future researchers with similar themes, for example, the link between Metaverse in Education and digitalization in education.

1. Introduction

Education experiences significant changes from year to year, and the education process adjusts to the speed of technology that is developing very rapidly [1]. This encourages educators to improve and innovate in learning [2]. Education and technology have a reasonably close relationship, education and technology build a pattern of cause and effect. Technology can influence the development of the education system, and vice versa, education will influence technology. The world of education can provide research space for students to continue to develop innovations that are progressive and beneficial to civilization, namely technology. One of the technological trends in education is metaverse integration [3].

Metaverse is one of the focuses in education, which aims to involve students participating in learning activities. *Metaverse* is a design that combines the real world with the digital world [4].

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Metaverse is a virtual space where people worldwide can gather and communicate using virtual and augmented reality technology [5]. *Metaverse* is a social network interconnected between an immersive environment and a multi-purpose platform that allows users to interact dynamically in real-time [6]. In general, the metaverse is part of the internet visualization in a three-dimensional media format [7].

The influence of metaverse technology on the world of education today is considerable, especially in changing methods, techniques, ways, and systems of learning in the world of education. The term metaverse was first discussed in Snow Crash by Neal Stephenson [8], then became famous to the public through a game called Second Life, created by Linden Labs in 2003. Since then, the term metaverse has continued to be known by the public, and from year to year, the interest in the metaverse is increasing [9], especially in education. Metaverse integration in learning is conceptually applied in virtual learning, where students and teachers can interact in cyberspace without having to be in the same physical space [10]. Metaverse integration was growing when the Covid-19 pandemic hit, where the learning process was minimal because everyone had to do social distancing [11]. Technology integration can change and develop teaching and learning activities to be more innovative and creative. The COVID-19 pandemic has highlighted the new role of technology in education [12]. Technologies that are often used are gadgets, one of which is virtual reality (VR), considered a learning tool in the 21st century, augmented reality (AR), and mixed reality (MR). The combination of using virtual reality (VR), augmented reality (AR), and mixed reality (MR) is a combination that refers to the setting of the virtual world and the real world [13,14].

Metaverse is an alternative form of the internet that provides a more accurate and realistic virtual experience [15]. Metaverse was developed with a focus on virtual environments, users in virtual environments can be connected seamlessly to each other in real-time and dynamically through digital technology. Metaverse has free and unlimited characteristics, and students can carry out learning independently by broadly exploring the world of technology without limits. Learners can also get inspiration from the ideas of countless others [8]. The virtual world in education provides innovation in the teaching-learning process, developed as a digital tool supporting teaching [9,16]. That is, the virtual world aims to facilitate and give access to students and teachers to have flexible interactions.

This study aims to determine the trend of a metaverse in education through a literature review and bibliometric analysis. We also describe the image of the metaverse in education. We use VOSviewer mapping to analyze the data. Keywords were obtained from the "metaverse in education" relationship to search for data from 2013 to 2023. Research on the relationship between the metaverse and education is increasing every year. This shows the importance of metaverse bibliometric analysis in the field of education in the hope that it can help and become a reference for determining research topics.

2. Methodology

Blibiometric analysis is a technique which makes it possible to provide a macrospic overview of large amounts of academic literarature [17]. The article literature data is used in this study is based on searched from journal publication on Google Scholar. We chose Google Scholar because Google Scholar is an open source of data. A reference application is used to collect research data namely Publish or Perish. Publish or Perish software was used to conduct a literature review on our chosen topic.

The search for article data in Publish or Perish is used to filter publications to use the keyword "metaverse" AND "education" based on the need for publication titles. The research was published between 2013-2023. All data were collected in February 2023 and 995 articles were found indexed

by Google Scholar. The articles that had been collected and matched for studying analysis were the converted into two data types: research information system (*.ris) and comma separated value format (*.csv). The *.ris format is used as the format for data mapping in the VOSviewer application, while the *.csv is used as the format for data analysis in Ms. Excel.

Microsoft Excel is used to analyze development data every year and sort articles based on the highest number of citations. VOSviewer is used to visualize and evaluate trends using bibliometric maps. The article data from the source database is mapped. VOSviewer is used to generate three variations of mapping publications, namely network visualization, density visualization, and overlay visualization based on the relationship between items.

3. Results

3.1 Metaverse in Education Publication Development

The search results for publication data regarding metaverse in education found 994 article data. The title and abstract are used as a reference for adjusting the data with the research topic chosen, namely "Metaverse", and "Education". The research matrix concerns the number of citations for metaverse in education research indexed in Google Scholar. The research year taken is 10 years, from 2013 to 2023. The number of research citations is 7194 citations. The average citation per article regarding this research is 7.23 and the average citation per year is 719.40. Articles about metaverse in education have an h-index of 45 and a g-index of 71. Table 1 shows the articles with the most significant number of citations. The article with the most citations is " 3D virtual worlds and the metaverse: Current status and future possibilities," with 400 citations.

Table 1
Publications on Metaverse in Education with the highest number of citations

No	Cites	Title	Year	Ref
1	400	3D virtual worlds and the metaverse: Current status and future possibilities	2013	JDN Dionisio *et al.*, [18]
2	347	All one needs to know about metaverse: A complete survey on technological singularity, virtual ecosystem, and research agenda	2021	LH Lee *et al.*, [19]
3	298	A Metaverse: Taxonomy, components, applications, and open challenges	2022	SM Park *et al.*, [20]
4	269	Metaverse for social good: A university campus prototype	2021	H Duan *et al.*, [21]
5	251	Metaverse	2022	S Mystakidis [22]
6	185	Data-driven operations management: organisational implications of the digital transformation in industrial practice	2017	P Gölzer and A Fritzsche [23]
7	147	A Survey on Metaverse: The State-of-the-art, Technologies, Applications, and Challenges	2021	H Ning *et al.*, [24]
8	146	Educational applications of metaverse: possibilities and limitations	2021	B Kye *et al.*, [8]
9	138	A content service deployment plan for metaverse museum exhibitions—Centering on the combination of beacons and HMDs	2017	H Choi and S Kim [25]
10	137	The digital transformation of human identity: Towards a conceptual model of virtual identity in virtual worlds	2014	P Nagy and B Koles [26]

Figure 1 shows the development of published research in Google Scholar-indexed journals regarding metaverse in education. Metaverse in education research have increased from year to year, from 2013 to 2023 it has experienced a significant increase. The significance of the number of publications can be seen in Figure 1. The highest number of the metaverse in education publications was in 2022 with 589 articles. In 2023 the number of publications was 145 articles. The development of metaverse in education research can be considered for research on metaverse in education, which

will be carried out in the future. The consideration that can be made is whether the research trend regarding metaverse in education is still relevant.
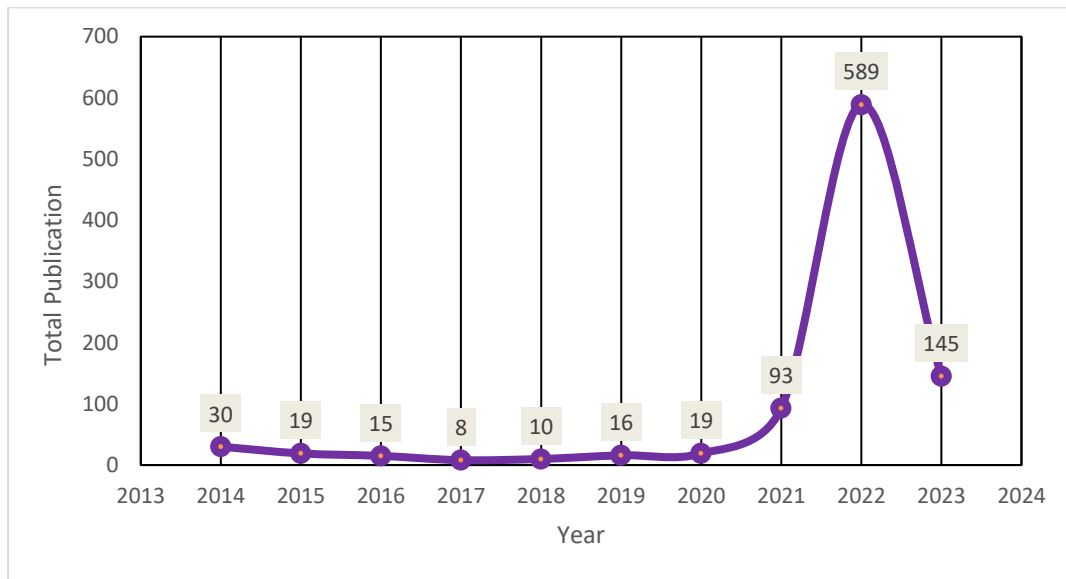

Fig. 1. Metaverse in Education Publication Development

3.2 Metaverse in Education Publication Mapping Visualization

Based on the mapping results, 5376 related terms were found in the metaverse in education research. We determined the number of occurrences of the term at least 5 times so that 276 terms were found. We selected 60% most relevant terms, resulting in 276 terms found. We verified the selection of terms so that 160 terms were found for mapping visualization by paying attention to their relationship with metaverse in education research.

Figure 2 shows a visualization of the publication network regarding metaverse in education from 2013 to 2023. The network visualization shows the linkages and the strength of the relationship through the value of the term link strength [27]. The colour size of the nodes in the visualization network represents the number of occurrences of terms [28]. The larger the nodes in the network visualization image, the larger the terms appear [28]. The thicker the links between nodes, the stronger the relationship between terms [28,29]. Network visualization divides each term into several groups or clusters. Terms regarding research on metaverse in education are divided into 4 clusters.
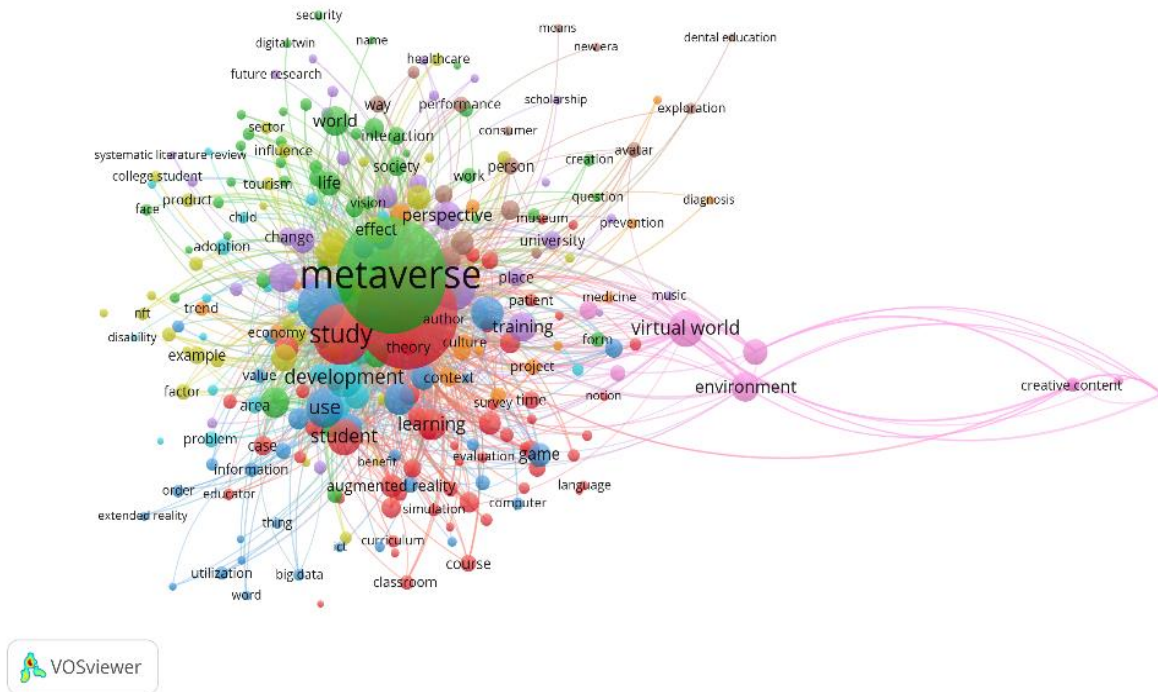
Fig. 2. Network visualization of Metaverse in Education Publication

Table 2 shows the distribution of clusters in the research analysis mapping regarding metaverse in education.

Table 2
Clusters based on the results of the keyword visualization

Cluster	Figure	Items
1	Figure 5	Addition, approach, article, augmented reality, case, classroom, college, combination, course, current study, curriculum, direction, distance, education, education field, education system, educator, evaluation, formal education, future education, generation, group, health education, higher education, implication, importance, Indonesia, language, learning, level, metaverse education, metaverse platform, metaverse technology, ministry, museum, need, notion, past, patient, perception, possibility, post covid, practice, program, reflection, response, school, simulation, step, student, study, survey, teacher, teaching, theory, time, transformation.
2	Figure 6	Advancement, analysis, brand, communication, company, creation, digital, digital twin, digitalization, distance education, education program, effectiveness, era, face, facebook, form, human, ide, interaction, interest, lack, learner, life, literature review, meta, metaverse, metaverse concept, metaverse era, metaverse world, name, online education, part, platform, question, real world, risk, security, society, systematic review, term metaverse, topic, transition, type, user experience, vision, work, world.
3	Figure 7	Application, art, artificial intelligence, big data, computer, design education, emergence, entertainment, extended reality, fourth industrial revolution, game, growth, ICT, information, internet, literature, medical education, metaverse application, metaverse experience, order, reality, relationship, researcher, rise, role, solution, space, surgical education, system, technology, thing, use, utilization, value, virtual reality, word.
4	Figure 8	Community, creative content, creative output, environment, inquiry, metaverse creativity, primary focus, user, virtual environment, virtual world.

Figure 3 shows a publication overlay visualization regarding metaverse in education. The visualization overlay shows the distribution of research years to see updates on using terms in related research [27].
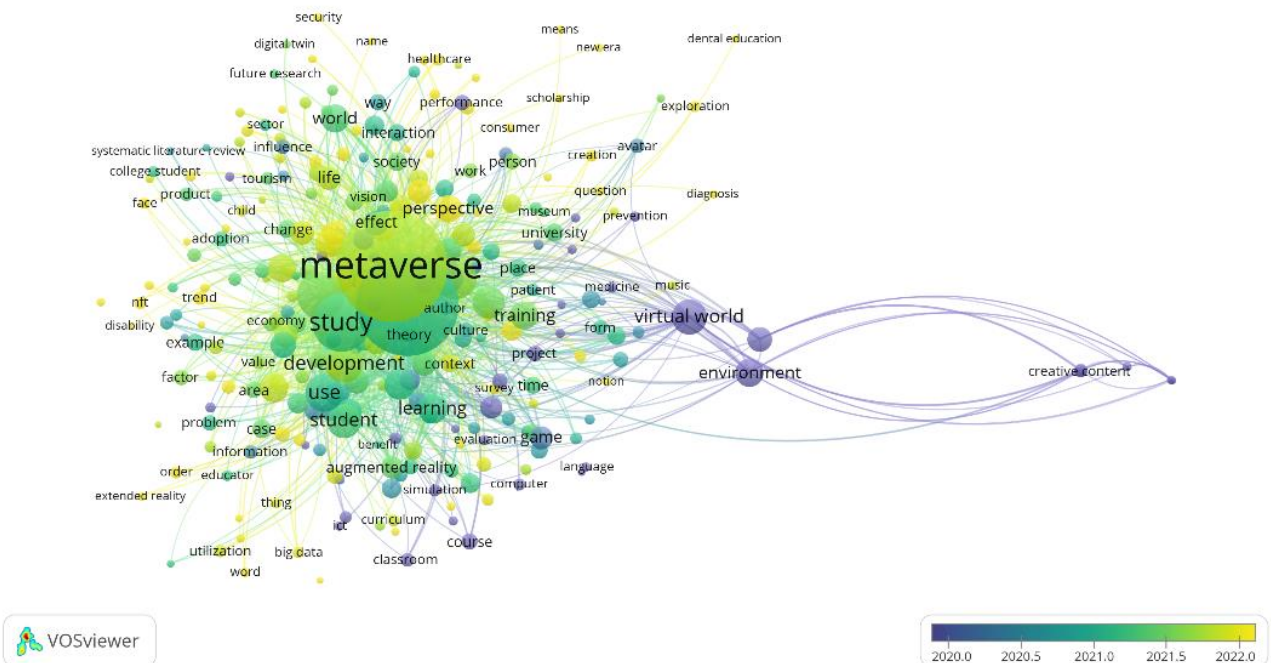

Fig. 3. Overlay visualization of Metaverse in Education Publication

Figure 4 shows that most digitalization and transformation in technical and vocational education research were carried out in 2022. As can be seen, the dominant colour of the nodes in Figure 4 is a gradient colour from green to yellow.
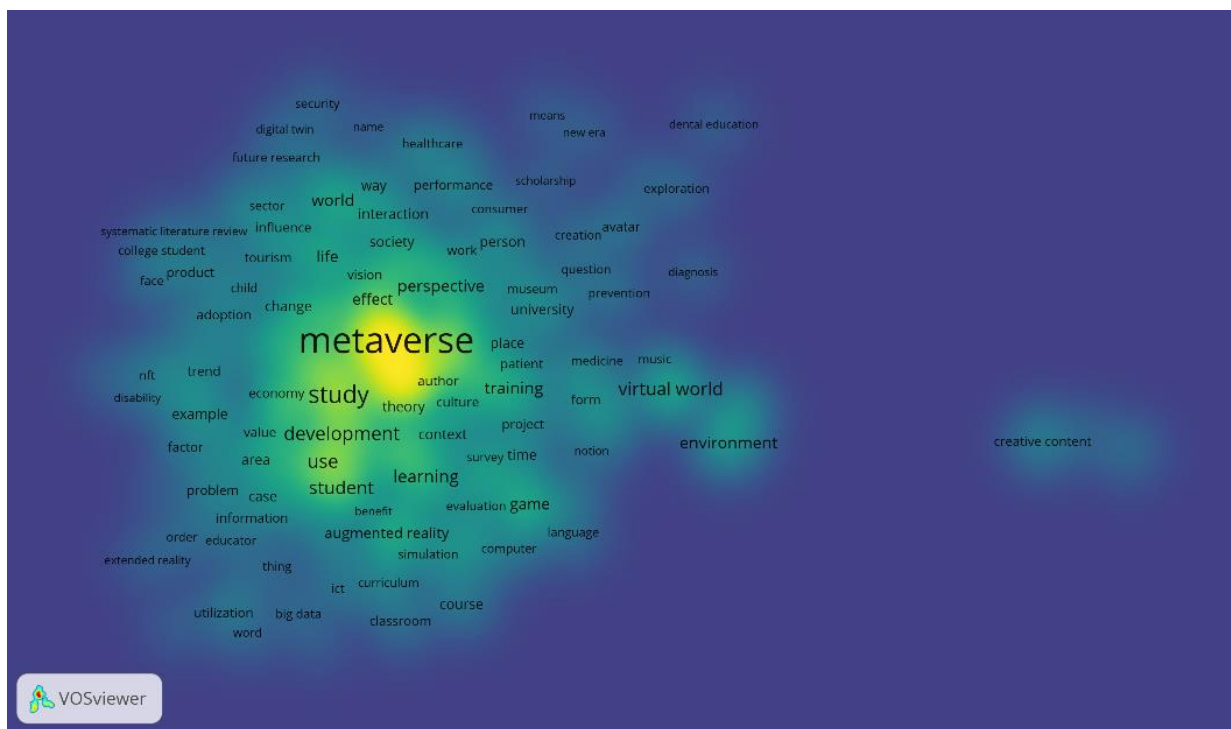

Fig. 4. Density visualization

The visualization of research density on metaverse in education is shown in Figure 4. Density visualization is a form of visualization that can identify how often the term is examined. The keyword font size and density (background colour) are used to represent the total link strength (TLS). Larger font sizes indicate larger TLS, while the distance between each keyword indicates the relevance of this research topic [30].

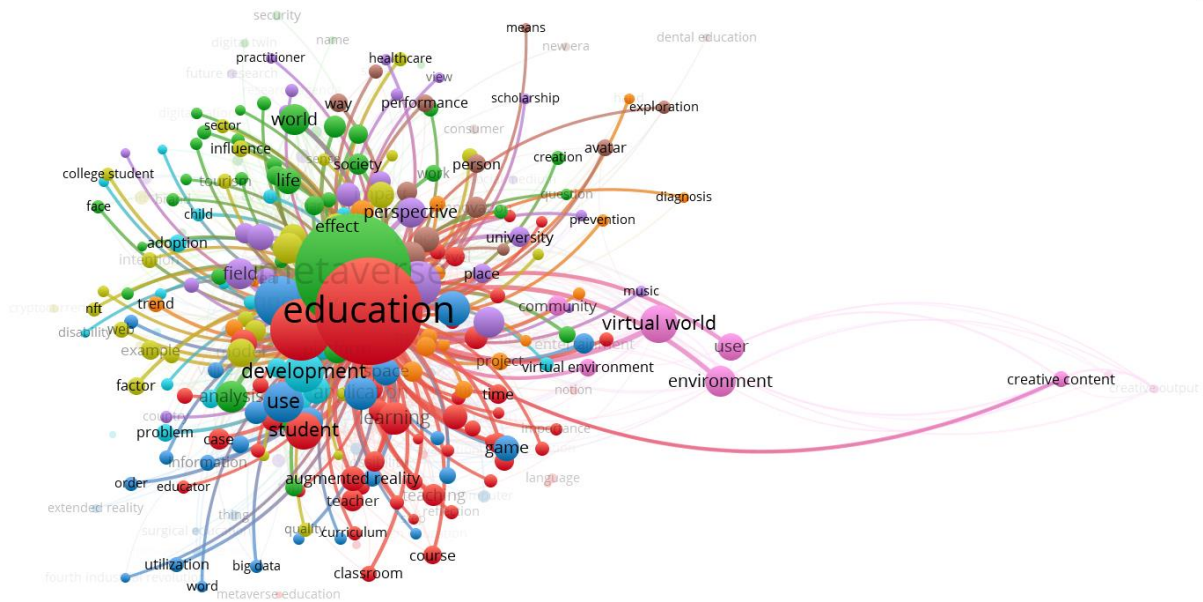Figure 5 only shows terms related to the topic, namely metaverse.

Fig. 5. Network visualization of the term metaverse education (cluster 1)

Based on Figure 6, the term "education" is in cluster 1. "Education" is connected to 57 other terms with a total link strength of 3212 and an accuracy of 532. Furthermore, in Figure 6, the keywords in the bright zones show the latest investigative trends [31]. The term "education" was heavily scrutinized on February 2019. Meanwhile, keywords in the dark zone show investigative trends that have been researched for a long time (not the latest). Figure 6 only displays terms related to the topic, namely "metaverse". Based on Figure 7, the term " metaverse " is in cluster 2. "Metaverse" is associated with 33 other terms with a total link strength of 3502 and an accuracy of 612.
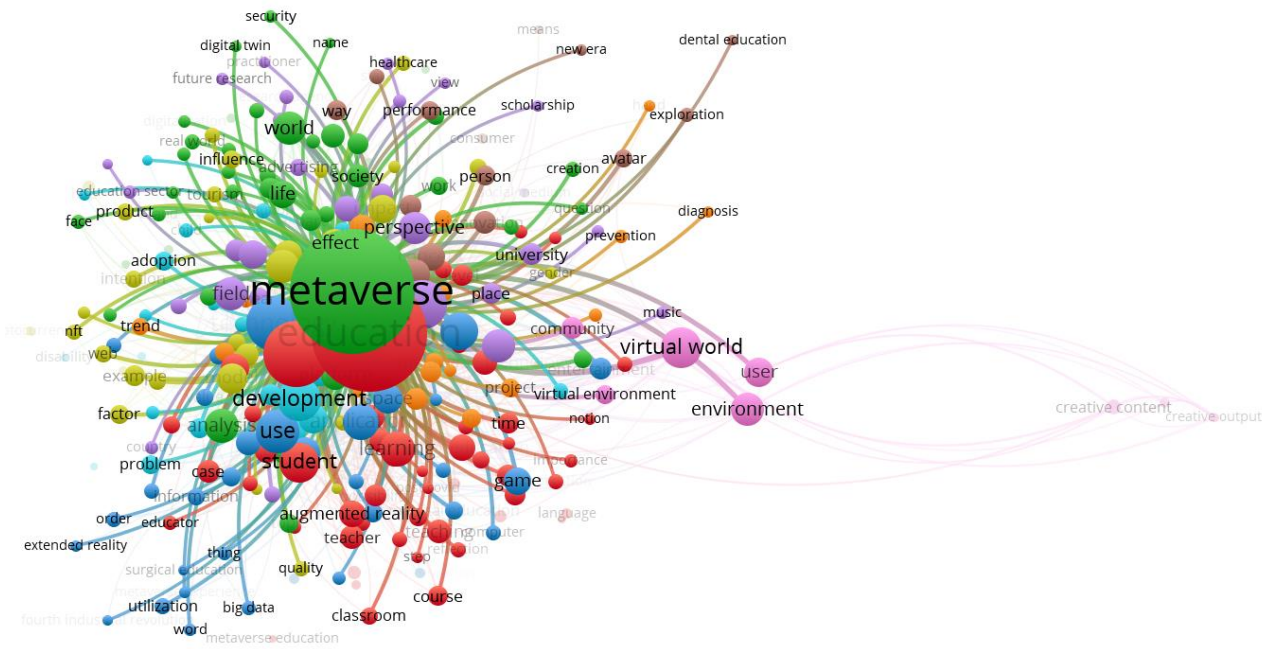
Fig. 6. Network visualization of the term metaverse education (cluster 2)

Figure 7 only displays terms related to the topic, namely "virtual reality".
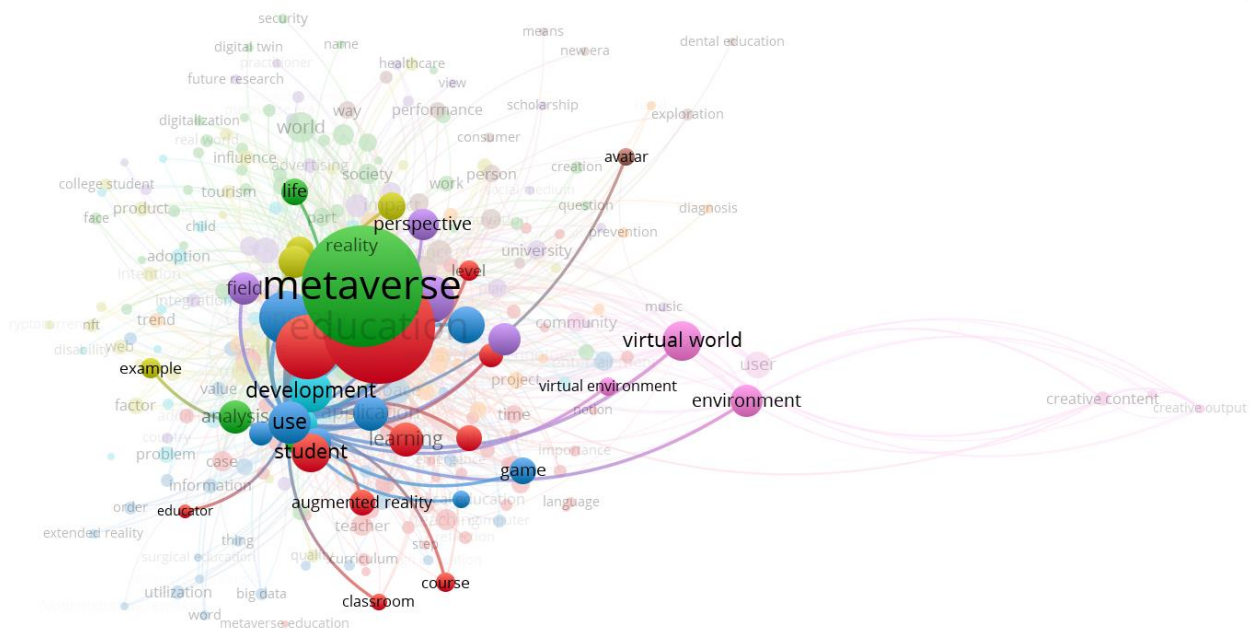
Fig. 7. Network visualization of the term metaverse education (cluster 3)

Based on Figure 8, the term "virtual reality" is in cluster 3. "Virtual reality" is associated with 27 other terms with a total link strength of 30 and an accuracy of 16. Figure 8 only displays terms related to the topic, namely "virtual world". Based on Figure 8, the term "virtual world" is in cluster 4. "Virtual word" is associated with 25 other terms with a total link strength of 27 and an accuracy of 14.

Fig. 8. Network visualization of the term metaverse education (cluster 4)
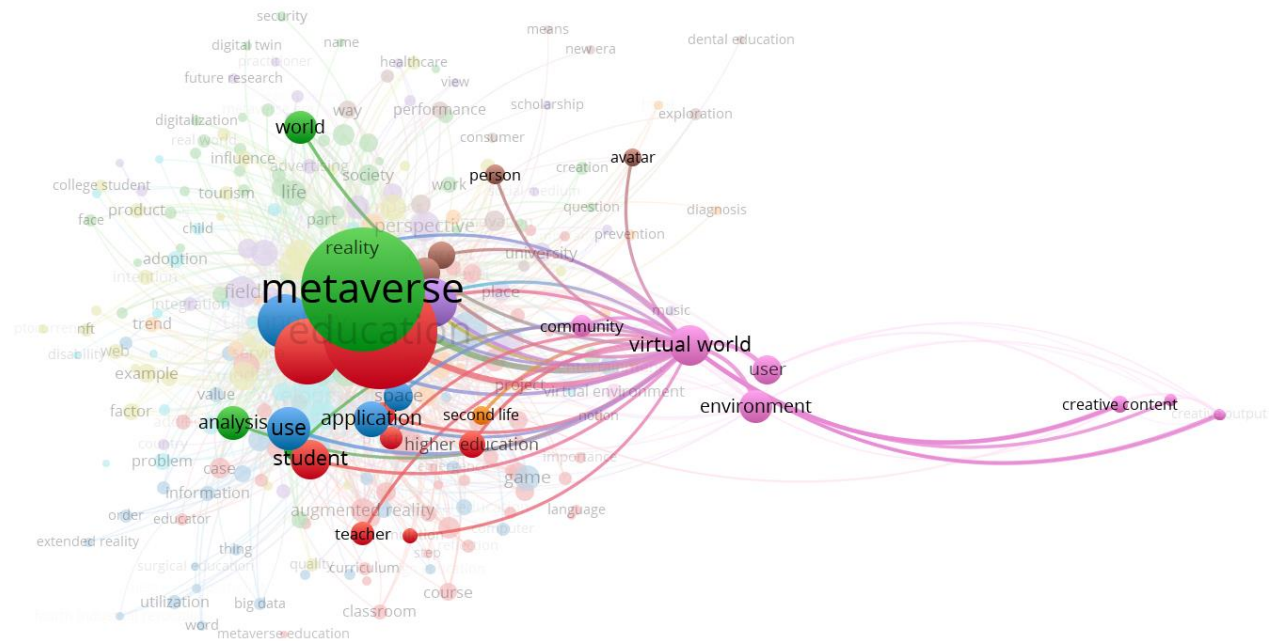
Metaverse is a trending research topic in education, metaverse is a medium that provides convenience and innovation in education. The study results show that the metaverse has a good influence and impact on educational development. Education is easier to reach various groups, not limited by space and time. Research on metaverse in education continues to increase from year to year. This shows that the metaverse continues to be developed and integrated into education. This has a significant impact that the metaverse will occur on a large scale and affect the application of education. This study can give additional information for understanding research trend using bibliometric analysis, as reported in previous reports [32-48].

4. Conclusions

This study provides the results of a bibliometric analysis of the topic of Trends Metaverse in Education published in the Google Scholar database. The article data taken is data from articles published in 2013-2023. The result of the analysis of trends metaverse in education publications in the last 10 years show an increasing data, although still fluctuating. This study aims to discuss metaverse and digital transformation from literature review and bibliometric analysis. The VOSviewer capture method analyses metaverse and digital transformation bibliometric data. Data was taken from 2013 to 2022. The results showed that the highest guidance and counselling research was in 2022. From the results, research analysis of metaverse and digital transformation has a significant influence. This can be seen from the data presented in VOSviewer. The results of this study are expected to be a consideration for scientists and other researchers to examine more deeply research related to metaverse and digital transformation.

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