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Global Research on Emerging Digital Technology: A Bibliometric Analysis

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ABSTRACT

Digital technology has become a demand in the Industrial Revolution 4.0 era. This research aimed to explore technological developments globally and comprehensively based on the Scopus database. The method used bibliometric analysis. In recent decades, it has been more common to utilize bibliometric data to perform comprehensive statistical analyses of research progress, trends, and focal points. This study became the first study that used the quantitative and qualitative evidence for examining technological developments. The literature review used the publications on technology studies from 1969 to September 2023. The number of documents found in the Scopus database was 1730. Worldwide, the majority of researchers in this particular field originated from China, the USA, and India. The results of the study showed that the number of papers on technology had continued to increase significantly since the 2000s. Furthermore, this study examined the challenges, problems, and impacts of technology in education. Digital technology areas currently have a great interest and the prospective avenues for future research.

1. Introduction

The use of digital technology, such as the Internet of Things (IoT), is increasing in the Revolution of Industrial Era 4.0, changing the human life and education [1,2]. The industrial revolution 4.0. also relies on educational structures to improve industrial skills [3-6]. The formation of the education sector is a fundamental part of the industrial revolution. The education sector has an opportunity to serve a more significant purpose, especially in the communication, appropriate knowledge, and the spread of understanding aspects [7,8]. With technology, information can be provided freely and easily accessible. Technology changes someone to do something and makes it possible to present information and knowledge in many forms [9].

The philosophy of education does not include a big physical presence of educational facilities, tools, and inventions built on a psychological foundation. In the contemporary environment, learning process and technological use are becoming the primary objectives of education. A person spending time acquiring emerging technologies will be seen as a skilled person. Today abilities may not be useful tomorrow. Future education will be conducted using simple, affordable, and effective digital

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technologies [10]. Because of this, the implementation of education and learning procedures needs to have an aggressive improvement, excellent service system, determination, exclusive talent, ability to lead data and source of information, constant transformation and development, alignment towards excellence, refinement, and confidence. In many parts of the world, the fourth industrial revolution leads to a paradigm shift in the educational policy and reform. Developed nations regularly adjust to technology advancements, bridging essential skill gaps and allowing access to new resources. Technology and educational resources contribute to enhancing the classroom environment and the teaching-learning process. Additionally, they allow educational institutions to be more flexible and customize their curricula to meet the needs of individual students [11,12].

The use of digital technology in the education sector is a transformation process from the conventional learning to the digital-based learning. The process of digitalization transformation in education is complex [13]. The success of digital transformation is greatly influenced by various supporting components, namely cultures, government policies, and the digital competence of teachers and students [14]. A successful transformation will occur if all school components increase their digitalization capacities. It really supports the success of effective integrations in the learning process. Many research results have examined the importance of digital technology in the field of education. Almost all research results show that digital technology has a positive impact [15-17].

Currently, bibliometric analysis is recognized as a valuable tool for mapping identified published records and has gained a widespread recognition as an alternative method for evaluating academically detailed topics in the library and information science [18]. This approach has emerged as one of the most prominent methods for assessing and predicting research trends related to specific topics. To gain a deeper understanding of global digital technology trends, bibliometric analysis is an essential tool. Detailed information for the bibliometric is shown in Table 1.

Table 1

Previous studies on bibliometric

No	Title	Ref.
1	Involving Particle Technology in Computational Fluid Dynamics Research: A Bibliometric Analysis	[19]
2	Bibliometric Computational Mapping Analysis of Trend Metaverse in Education using VOSviewer	[20]
3	The Use of Information Technology and Lifestyle: An Evaluation of Digital Technology Intervention for Improving Physical Activity and Eating Behaviour	[21]
4	Strategies in language education to improve science student understanding during practicum in laboratory: Review and computational bibliometric analysis	[22]
5	How language and technology can improve student learning quality in engineering? definition, factors for enhancing students' comprehension, and computational bibliometric analysis	[23]
6	Mapping of nanotechnology research in animal science: Scientometric analysis	[24]
7	Scientific research trends of flooding stress in plant science and agriculture subject areas (1962-2021)	[25]
8	Introducing ASEAN Journal of Science and Engineering: A bibliometric analysis study	[26]
9	A bibliometric analysis of chemical engineering research using VOSviewer and its correlation with Covid-19 pandemic condition	[27]
10	A bibliometric analysis of materials research in Indonesian journal using VOSviewer	[28]
11	Bibliometric analysis of engineering research using VOSviewer indexed by google scholar	[29]
12	Bibliometric computational mapping analysis of publications on mechanical engineering education using VOSviewer	[30]
13	Research trend on the use of mercury in gold mining: Literature review and bibliometric analysis	[31]
14	Domestic waste (eggshells and banana peels particles) as sustainable and renewable resources for improving resin-based brakepad performance: Bibliometric literature review, techno-economic analysis, dual-sized reinforcing experiments, to comparison with commercial product	[32]
15	Bibliometric analysis of educational research in 2017 to 2021 using VOSviewer: Google scholar indexed research	[33]
16	Corn-cob-derived sulfonated magnetic solid catalyst synthesis as heterogeneous catalyst in the esterification of waste cooking oil and bibliometric analysis.	[34]

17	The compleat lextutor application tool for academic and technological lexical learning: Review and bibliometric approach.	[35]
18	Use of blockchain technology for the exchange and secure transmission of medical images in the cloud: Systematic review with bibliometric analysis.	[36]
19	Computational bibliometric analysis of research on science and Islam with VOSviewer: Scopus database in 2012 to 2022.	[37]
20	Digital transformation in special needs education: Computational bibliometrics.	[38]
21	Particulate matter emission from combustion and non-combustion automotive engine process: review and computational bibliometric analysis on its source, sizes, and health and lung impact	[39]

The novelty of this study is that it employed bibliometric analysis to conduct a comprehensive examination of digital technology, providing references and concepts for future researchers, especially in education. Within the study, social network maps were established via review and analysis of the figures, tendencies, research groups, and citation frequency of references of ascertained records. The concentrated research and prospective tendency on digital technology areas were determined based on keywords and abstracts. This research examined the development of digital technology globally and the use of digital technology in education. Additionally, digital technology and its quandaries were also methodically reviewed and summarized. Furthermore, this study examined the challenges, problems, and impacts of technology in education. This research can be recommendations related to the focal points and perspectives on digital technology in the future research.

2. Methodology

2.1 Data Sources and Eligible Criteria

The study was conducted using the bibliometric analysis [18]. The eligibility criteria included a comprehensive search on the Scopus database starting from 1969 to September 2023, using the keyword “digital technology”. This search was conducted to investigate the articles exploring the emerging digital technology and technology in education.

2.2 Analysis Method

Document analysis used R-Studio software (version R 4.2.2). R-Studio was used to analyse documents, years, citations per year, relevant sources and source impacts, word clouds, trending topics, thematic maps, keyword network maps, and abstracts. Co-cited can be interpreted as an author, journal, or reference that is cited jointly by the researcher. Furthermore, the articles examined the challenges, problems, and impacts in education.

3. Results

3.1 Article Types and Quantity

The literature search on the Scopus database obtained 1730 articles using the keyword digital technology. The analysis of the articles based on the publication year is presented in Table 2. Table 2 provides the number of the last five-year publications.

Table 2
Articles based on keywords

Year	Number of Articles
2019	120
2020	155
2021	204
2022	264
2023	140
Total	882

Table 2 shows the number of articles on the use of digital technology. Annual scientific productions can be seen in Figure 1. It provides the number of articles and the years when researchers started to study the digital technologies. Annual scientific productions on digital technology began to develop in 2000 and the number continued to increase. It shows that digital technology is an important need.

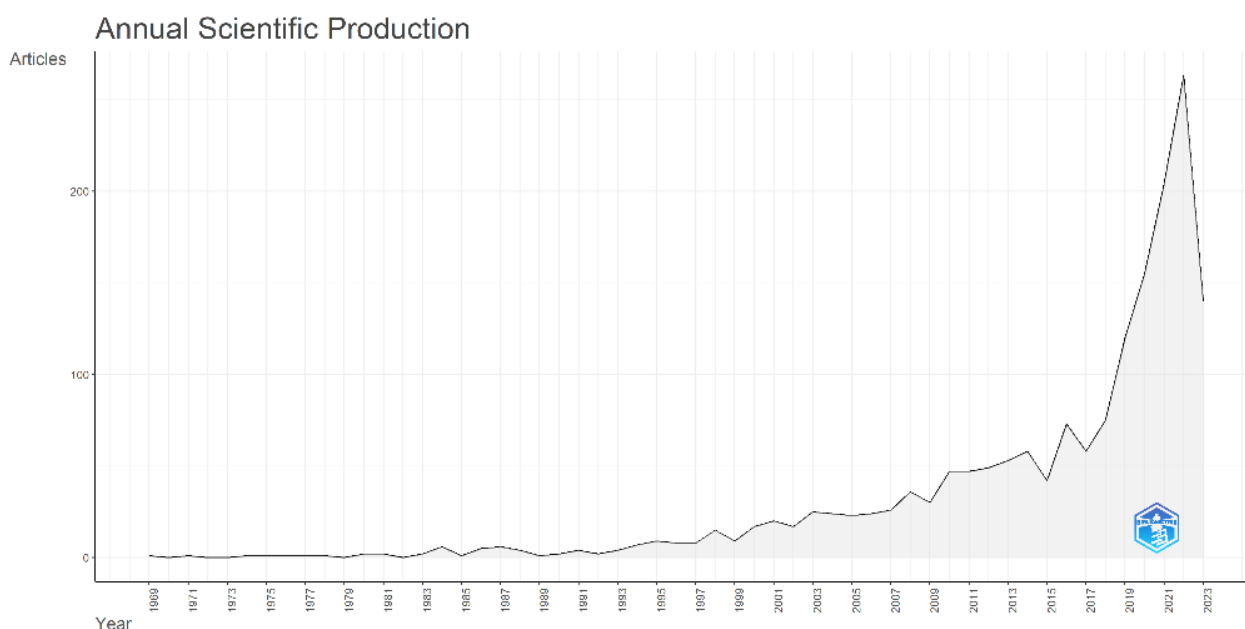


Fig. 1. Number of articles on the use of digital technology

3.2 Citations per Year

Average article citations per year is presented in Figure 2. Article citations fluctuated each year, but there was a significant increase in 2019 and 2023. Article citations in 2023 would continue to increase until the end of December 2023. The increase in the number of citations shows the high interest of researchers in studying the field of digital technology.

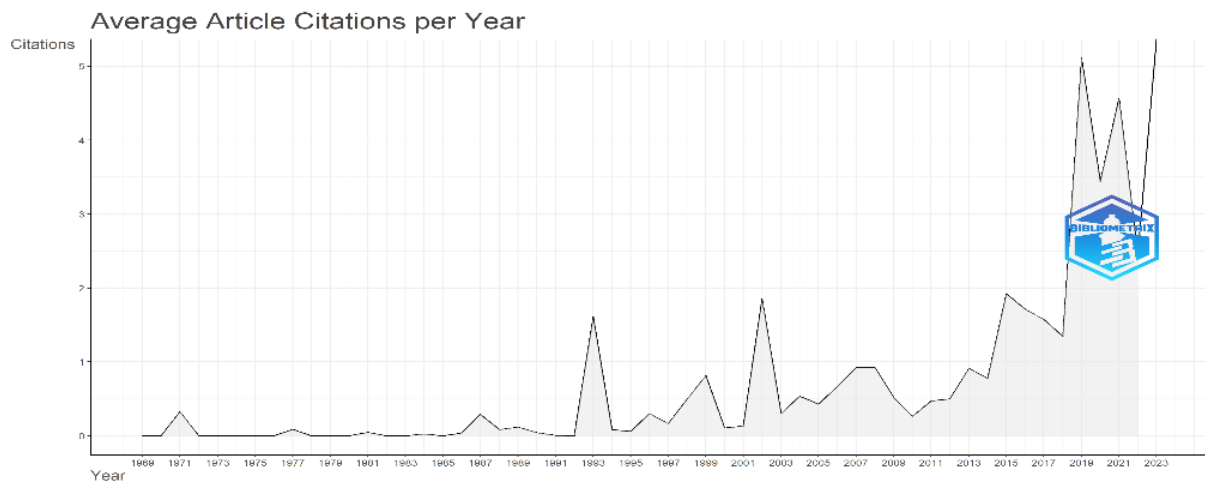


Fig. 2. Average citations per year

3.3 Relevant Sources and Source Impacts

The top ten most relevant sources can be seen in Figure 3. Sources were collected from conferences and journals. The utilization of digital technology, based on the top ten most relevant sources, was generally found in engineering, science, network system, computer, and information technology research. Digital technology research had not been dominant in the education sector.

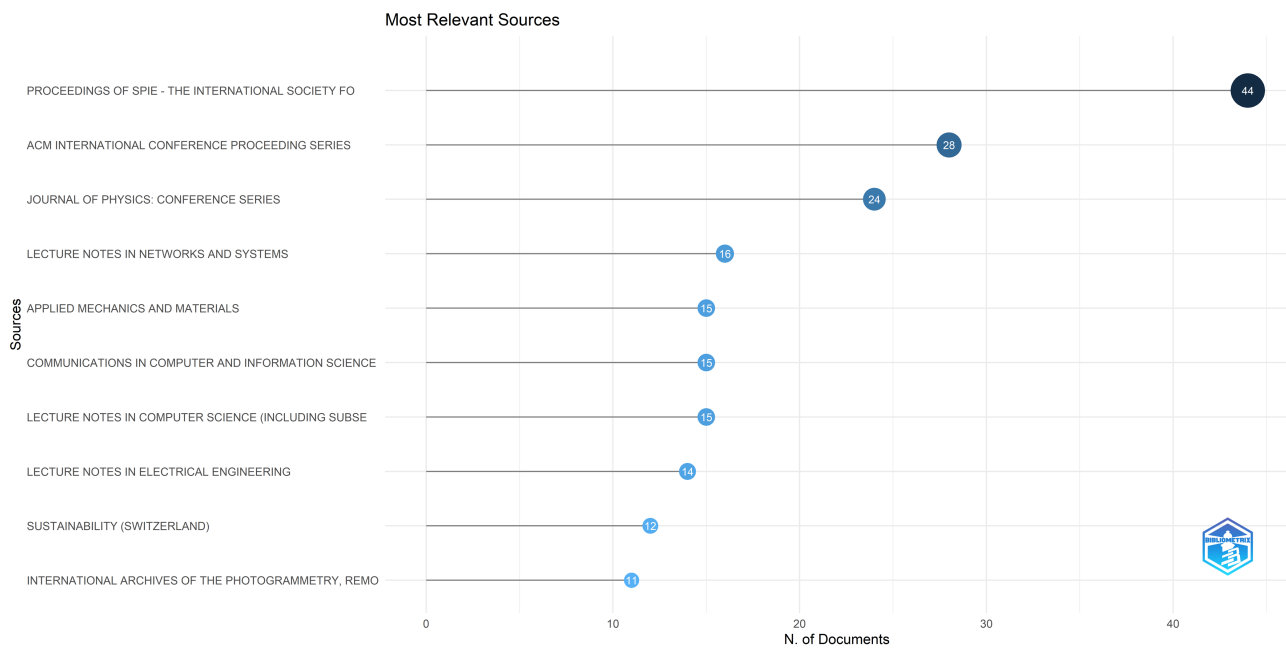


Fig. 3. Most relevant sources

3.4 Word Cloud

This study wanted to find out the frequently appeared words in these articles using the orange application. The result can be seen in Figure 4. In Figure 4, we can see the words that often appear. The bigger the writing, the more the articles examining the keyword.

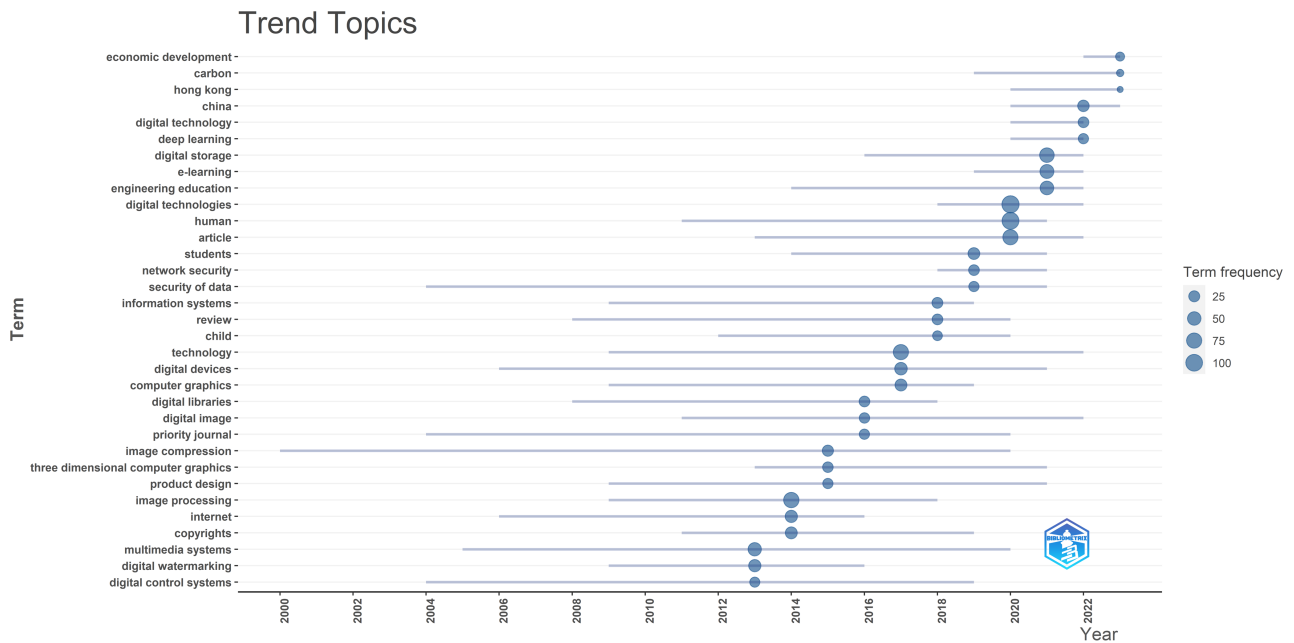


Fig. 6. Trending topics in digital technology

3.6 Thematic Maps and Networks

Next, the analysis was administered based on thematic maps. Thematic maps divide research results into four quadrants, namely motor themes, niche themes, emerging or declining themes, and basic themes. Globally, the motor theme quadrant means research that is developing and can be related to other fields of science. The niche theme quadrant means research themes that are developing in certain fields of science only. The emerging or declining theme quadrant means new themes that are emerging or will disappear. The basic theme means basic themes. Figure 7 shows the digital technology mapping.

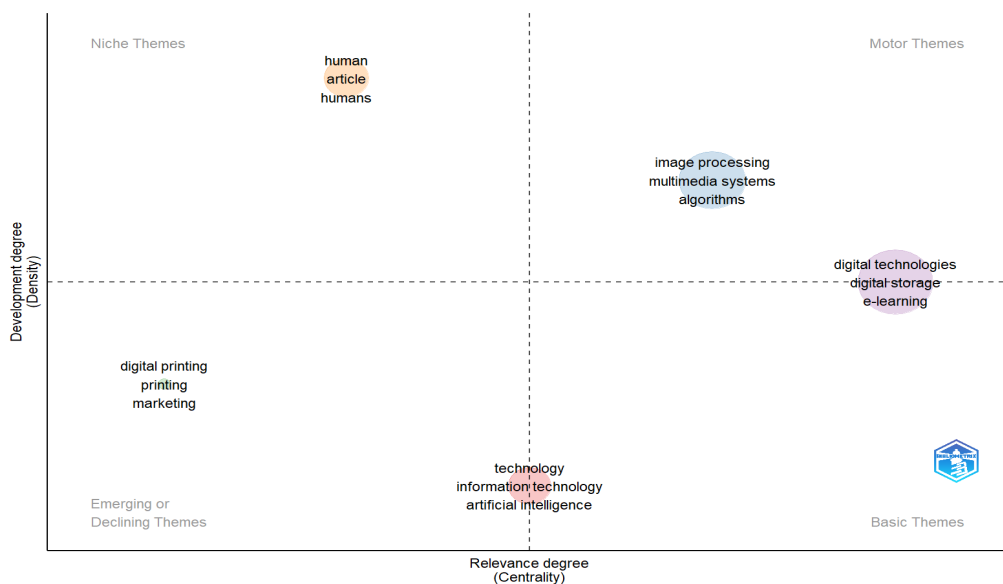


Fig. 7. Thematic maps

Themes in the top-right quadrant are both well-developed and crucial for a study field organization. Given their strong centrality and high density, they are referred to be the motor-themes

of the specialization. The positioning of these topics in this quadrant suggests that they have external connections to ideas that apply to other, conceptually similar subjects. This means that digital technology is a subject that is being developed and is important for other fields.

The co-occurrence matrix social network maps are shown in Figure 8. Each cluster average keyword frequency is reflected in the node size. A higher size denotes a more significant subfield and a stronger citation burst. The conceptual organization revealed by keyword co-occurrence shows variation within the study sub-fields. The thematic map network based on keyword digital technology is shown in Figure 8.

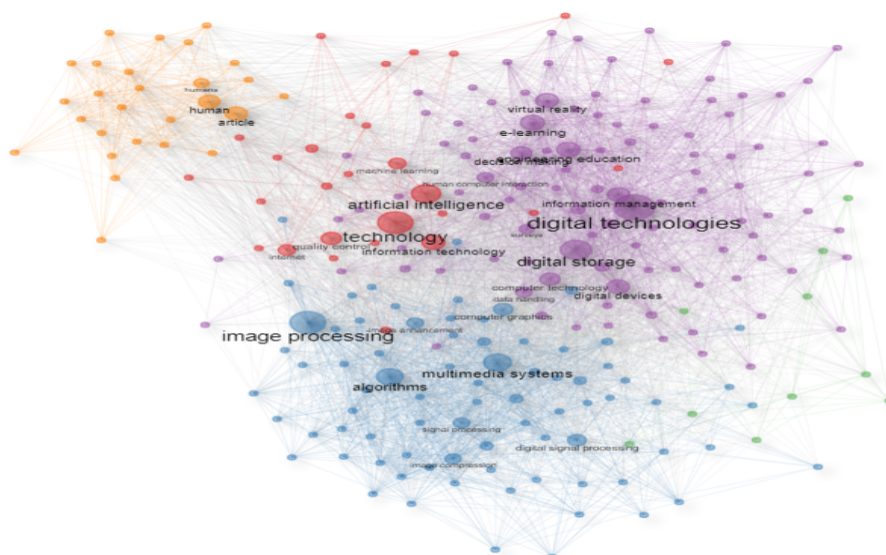


Fig. 8. The network of thematic maps

The network shows clusters in the co-occurrence of keywords. The network represents themes/fields of study in digital technology research. The main themes emerged from the network of co-occurrences include technology, artificial intelligence, digital devices, and various phenomena in digital technology keywords.

3.7 Types of Technology

This research also examined various types of technology. The digital technology can be utilized in the field of education. Types of technology in education can be seen in Table 3.

Furthermore, this research also investigated the problems and challenges of using technology in education. The research results, problems, and challenges based on the results of research [40-49] include the negative impacts of using technology, the readiness to face online learning, internet network problems in some areas, laptop and smartphone facilities, the students understanding of mathematics materials, the limitation in making comprehensive evaluations in online learning, problems in using media applications in online mathematics learning, the difficulty to know the student understanding of the digital platforms used, the tools or technology that were not fully integrated into mathematics learning affecting mathematical results far from what the student wanted although they could use the technology, quality of teachers, the reality of a global society, and the dependence on the effective learning environment. The challenges of using technology include the need of space and time to practice using new digital platforms, the need of training on how to develop a special technology for developing the student mathematical thinking, and the

challenge for the future education environment to improve the technologically competent future teachers.

Table 3

Technologies in education

Technology Findings	Types
Digital Technology	Mobile Learning/Android E-Book/E-Modul Augmented Reality (AR) Artificial Intelligence (AI) Animated Videos/ Digital Videos/Videoscribe
Learning Software	GeoGebra Multimedia/Adobe Flash Macromedia Flash Camtasia Lectora Windows Live Movie Maker Educational Games Prezi/Fokusky Kahoot Quizizz PowerPoint Zenius Meeting App Zoom Google Meet Schoolology Google Classroom WhatsApp Group Moodle Flipbook
Online Learning	WEB YouTube E-Learning/Virtual Learning Remote Learning Blended Learning Hybrid Learning

Qualitative results of the digital technology use had been high since the emergence in 2022. Many of the latest digital platforms intend to support the teaching and learning process. From the exploration results of the technologies studied, the highly used applications include GeoGebra, Zoom, YouTube, and learning videos. The most preferred synchronous learning system is Zoom followed by Google Meet, Google Classroom, and WhatsApp Group, while the most proffered asynchronous learning system is learning using learning videos. The learning system during the pandemic required the use of technology so it provided a new form of learning. In line with the opinion of [50], media and technology create a new hybrid teaching.

Online learning still raises problems, especially in mathematics learning [51]. Before the pandemic, mathematics learning materials were often considered difficult for students [52-54]. Problems arising from online learning in mathematics include difficult and unstable internet networks in certain areas [14,18], the material had not been conveyed properly, few applications focusing on mathematical concepts (such as GeoGebra), the student understanding in learning mathematics, and the need for laptop or smartphone facilities [8]. Other challenges include the obstacles in using the

latest media or applications when learning, the frequent assign of assignments as some teacher had difficulties related to technologies, the need for supporting facilities and infrastructures in the synchronous learning [55], mathematics learning outcomes far from expectations, low student interests in reading (self-regulated learning), the learning loss, and the not fully integrated technologies in mathematics learning.

Based on the problems arising in learning mathematics, it becomes a new challenge for policymakers and mathematics teachers. It challenges the government to provide an equitable internet network for all regions, especially remote areas, and smartphone/laptop facilities for underprivileged families. Other challenges include the integration of pedagogic abilities and currently developing technologies, the development of digital-based math contents, and the construction of up-to-date applications [56]. The technology integrated in mathematics learning, such as GeoGebra, helps understand mathematical concepts and foster self-regulated learning in students [56-59]. These challenges cannot only be solved by a teacher. It needs the cooperation of related parties so that these challenges can be overcome. Thus, expectations of good student understanding and learning outcomes can be achieved.

The learning system starting to be in demand is the blended learning system. It can be seen in the increasing number of research on learning using the blended learning system. The blended learning system is a learning system that combines online learning and offline learning that utilizes technology in the teaching and learning process [58,60]. The latest emerging technologies that can be utilized in learning mathematics are AR and AI [59,61,62]. These technologies provide a new paradigm and innovations in education [60,63,64]. It is the target of the era of society 5.0 to better utilize the development of technology in facilitating human life [61,62,65,66].

4. Conclusions

This study examined and explored emerging digital technologies globally and digital technologies in education. In addition, it examined the problems and challenges faced in using technology in education. The literature review showed that the use of digital technology platforms had increased sharply from 2000s. In the last two years, more and more digital platforms that can support the online learning process emerged. The results of the exploration found the frequently used technologies, including mobile learning, e-books, animated/digital videos, GeoGebra, multimedia, Macromedia flash, Lectora, Camtasia, Windows Live Movie Maker, educational games, presentations with Prezi or Focusky, Kahoot, Quizizz, Zenius, Zoom, Google Meet Schoology, Google Classroom, WhatsApp Group, Moodle, WEB, and YouTube. The learning system includes E-Learning, Remote Learning, Blended Learning, and Hybrid Learning.

Based on the results of the study, several problems in using of technology in education were found, including the support of education infrastructures, Learning Management System (LMS), internet network problems, communication between teachers and students, readiness of teachers and students, and self-regulated learning of students. Furthermore, the challenges in using technology in education are student learning outcomes, teacher and student skills and knowledge in using technology for learning, the ability to link subject concepts with the right technology, the need for supporting facilities and infrastructures for using technology, developments of digital-based learning media to develop student higher order thinking skills.

The limitation of the research is that digital technology data were only generated from the Scopus database. For further research, researchers can examine research developments in the last decade and the urgency of digital technology in supporting education.

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