EDUMASPUL
JURNAL PENDIDIKAN
Vol. 7 – No. 1, year (2023), page 92-101
| ISSN 2548-8201 (Print) | 2580-0469) (Online) |

Learning Media In Mathematics Education: A Bibliometric Analysis

Awal Kurnia Putra Nasution[1]*, Leni Agustina Daulay [2], Nurul Qomariyah Ahmad [3]

[1, 2, 3] *(Department of Tarbiyah, IAIN Takengon, Indonesia).*

* Corresponding Author. E-mail: [1]awalkpn@gmail.com

Receive: 18/01/2023	Accepted: 28/02/2023	Published: 01/03/2023

Abstract

This bibliometric analysis investigates the development of instructional media in mathematics education. As mathematics education is crucial for various fields, including science, technology, economics, and business, identifying effective learning media is essential to improve the quality of mathematics learning. This bibliometric analysis examines the trends, subject areas, and types of documents related to the use of instructional media in mathematics education. Results show an increasing trend in publications, with conference papers and scientific journal articles being the most common document types. The study highlights the importance of considering factors related to the learning environment, student involvement, and achievement when developing effective learning media, especially online learning during the Covid-19 pandemic. The findings provide insights for mathematics educators, researchers, and policymakers to improve mathematics learning quality and suggest further research directions.

Keywords: *Learning Media; Mathematics Education; Bibliometric Analysis*

Introduction

Mathematics education is important in developing the skills and understanding of mathematics needed in various professions and everyday life. Mathematics education is considered an important academic discipline because mathematics is a universal language used to describe and explain natural phenomena. Mathematics education is highly regarded as it provides a crucial foundation for many other academic fields (Williams & Choudry, 2016). Additionally, mathematics provides a powerful tool for solving practical problems in everyday life. It also plays a significant role in shaping critical thinking skills and logical reasoning abilities. As a result, a good understanding of mathematics is necessary for many aspects of life, including science, technology, economics and business (van Langen & Dekkers, 2005; Yadav, 2019). In mathematics education, instructional media is an important factor that can help students better understand mathematical concepts (Borba, 2021; Capuno et al., 2019). Learning media that can be used include concrete objects, mathematical models, textbooks, multimedia, and digital technology. Using instructional media in mathematics education helps students gain diverse learning experiences (İbili et al., 2020) and facilitates understanding abstract mathematical concepts. In this case, the teacher's role becomes very important in selecting and using appropriate learning media for students.

Using instructional media in mathematics education helps students better understand mathematical concepts but can also increase students' motivation to learn mathematics. Learning media also allows students to learn more interactively and supports student-centred

learning (Moradoff et al., 2021). In this case, the learning media used must be able to attract students' attention and present mathematical information in an interesting and challenging way. Therefore, using instructional media in mathematics education can help improve learning effectiveness and enrich students' learning experiences (Attard & Holmes, 2022). Although instructional media has many advantages in mathematics education, their use must also be managed properly not to reduce the quality of learning. Several factors that must be considered in the use of learning media are the suitability of the media with learning objectives, the availability of resources, and the level of technical skills of students and teachers (Attard & Holmes, 2022). In addition, evaluation of the use of learning media also needs to be carried out regularly to evaluate the effectiveness of these learning media in improving the quality of learning mathematics. In this case, instructional media can be used to improve the quality of mathematics learning more innovatively and effectively.

Mathematics education is a field of education that continues to grow and requires effective learning media to increase students' understanding of mathematical concepts. Many previous studies have been conducted to study instructional media in mathematics education and its impact on student learning outcomes. Various learning media such as textbooks, videos, animations, simulations, and digital technology have been used in teaching mathematics and have been effective media in increasing students' understanding of mathematical concepts. For example, research by Attard & Holmes shows that using instructional videos can help improve student learning outcomes in mathematics (Attard & Holmes, 2022). In addition, research by Arifin et al., found that multimedia technology can improve students' math problem-solving skills (Arifin et al., 2021). Another study by Hallifax et al., found that using math games in teaching can increase students' learning motivation and learning outcomes (Hallifax et al., 2020) .

This study will use the bibliometric method to analyse the literature on instructional media in mathematics education. This research aims to examine the frequency of publications and trends, subject area of research, types of documents, and research topics most widely discussed in the literature on instructional media in mathematics education. Through bibliometric analysis, we hope to provide insight into the development of learning media research in mathematics education. The results of our research can help teachers, researchers, or policymakers understand research trends in the development of instructional media in the field of mathematics education and improve the quality of mathematics learning. In addition, this research can also provide direction for further research in this field.

Method

The bibliometric research method is a science mapping methodology that examines how different fields, academics, and individual papers relate to one another (Fauzi, 2022). Scholars are interested in this technique since it integrates categorisation and visualisation to map the field's structure (van Eck & Waltman, 2014). It is regarded as one of the effective techniques for analysing literature using scientometric database networks. The study concludes a complete publication on learning media in mathematics education based on the bibliometric approach. As shown in Fig. 1, this review was structured using a study design framework influenced by (Djeki et al., 2022; Li et al., 2019).

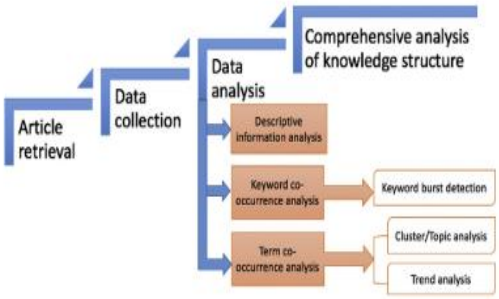

Fig. 1. Research design framework.

We specifically carried out the actions listed below: 1) Finding pertinent research publications between the years 2013 and 2022 by searching for "learning media in mathematics education"; 2) gathering information from Scopus on research titles, authors, keywords, and abstracts; 3) specific descriptive data, including a breakdown of publications by year, disciplinary focus, source, and authors, as well as an example of the most widely referenced works; 4) using co-occurrence studies for keywords and terms with the aid of the visualisation tool VOSviewer; 5) identifying spikes in the frequency of certain keywords over an extended period; 6) employing a cluster analysis of phrases from particular article titles and abstracts to identify research themes and trends.

A search string was developed consisting of three main sub-keywords and related keywords found in synonyms, thesaurus, and past research 1) Learning Media, and 2) Mathematics Education. The search database used in this bibliometric analysis is Scopus. Searches were carried out on article titles, abstracts, and keywords. The search period for manuscripts was limited in the last ten years, namely in 2013-2022, and 1179 articles were found. The search was carried out in February 2023. Search keywords used: ("mathematics education" OR "mathematics teaching" OR "mathematics instruction" OR "mathematics learning" OR "mathematics curriculum" OR "mathematics pedagogy" OR "mathematics classroom" OR "mathematics assessment" OR "mathematics training" OR "mathematics program") AND ("learning media" OR "educational technology" OR "multimedia" OR "digital media" OR "computer-assisted instruction" OR "e-learning" OR "visual aids" OR "interactive media" OR "educational games" OR "teaching materials").

Result and Discussion

1. Frequency of publication

The trend of an increasing number of publications, The data in table 1 shows that the number of publications continues to increase yearly, except in 2015, which showed a slight decrease from the previous year. This shows that the topic under study is increasingly in demand and has become a concern of researchers in recent years.

Year	Frequency
2013	58
2014	61
2015	58
2016	78
2017	102
2018	123
2019	148
2020	197
2021	190
2022	164

Table 1. Publication Frequency

The trend of an increasing number of publications, The data provided shows that the number of publications continues to increase yearly, except in 2015, which showed a slight decrease from the previous year. This shows that the topic under study is increasingly in demand and has become a concern of researchers in recent years. Trends in the fluctuation of the number of publications, Although there has been an increase overall, there have also been significant fluctuations in the number of publications over the years. As in 2015, which showed a decrease compared to the previous year, but in the following year, namely 2016, there was a significant increase compared to the previous year. Likewise, 2022 shows a decrease in publications compared to the previous year. Decrease in the number of publications in 2022; in general, the number of publications continues to increase; in 2022, there will be a decrease compared to the previous year. This can be caused by various factors such as a decrease in the interest of researchers in the same topic, external factors that affect research, or limitations in conducting research due to the Covid-19 pandemic.

2. Subject Areas

Based on the data, the subject areas with the most frequency are Social Sciences, with 582 articles, Computer Science, with 504 articles and Physics and Astronomy, with 282 articles. Meanwhile, the subject areas with the least frequency were Economics, Econometrics and Finance, with only two articles, followed by Biochemistry, Genetics and Molecular Biology and Agricultural and Biological Sciences, with six articles each.

Subject area	frekuensi
Social Sciences	582
Computer Science	504
Physics and Astronomy	282
Engineering	216
Mathematics	153
Psychology	49
Business, Management and Accounting	41
Decision Sciences	35
Arts and Humanities	17
Materials Science	16
Environmental Science	16
Energy	14
Neuroscience	13
Health Professions	10
Medicine	9

Earth and Planetary Sciences	9
Multidisciplinary	7
Chemistry	6
Agricultural and Biological Sciences	6
Chemical Engineering	5
Biochemistry, Genetics and Molecular Biology	5
Economics, Econometrics and Finance	2

Table 2. Subject Area

It can be seen that the most widely used subject area for research topics is the Social field, which includes social sciences such as sociology, anthropology, politics, psychology, etc. This can be caused by the interest in understanding social phenomena that exist in society, such as social change, public policy, political dynamics, etc. In addition, Computer Science is also one of the subject areas that is widely used as a research topic. This can be caused by the rapid advances in information and communication technology, giving rise to many innovations in this field, such as artificial intelligence, big data, computer networks, etc. There are only 153 articles on mathematics, even though mathematics is a very important basic science related to many other disciplines. Therefore, much research is still needed in mathematics to develop knowledge and understanding of mathematical concepts and their application in various other fields.

3. Document Type

Based on the data provided, this bibliometric analysis includes eight documents: conference papers, articles, conference reviews, book chapters, books, notes, and short surveys. The total number of documents analysed was 1,179. The following is an analysis for each document type:

Document Type	**Frequency**
Conference paper	648
Article	427
Conference review	38
Book chapter	32
Review	22
Book	9
Note	2
Short survey	1

Tabel 3. Document Type

Conference papers: 648 conference paper-type documents were found in this bibliometric search, or around 54.9% of the total documents. This type of document was probably chosen because of the many academic conferences in various fields of study, including mathematics, which are held annually and are the venue for the presentation of the latest research results. Article document type is the most common type found after conference papers, namely 427 or around 36.2% of the total documents. Articles are common in scientific publications and focus on specific research results or topics in a particular field. In conference review, 38 conference review-type documents were found in this bibliometric search or about 3.2% of the documents. This document type may be chosen to summarise various presentations or papers at a particular conference. Book chapter: 32 book chapter-type documents were found in this bibliometric search, or about 2.7% of the documents. This document type may have been chosen because some authors prefer to publish their research results as chapters in a collective book. Reviews, There were 22 review-type documents found in this bibliometric search or about 1.9% of the total documents. This document type may provide a critical review or analysis of previous work in a particular field. Book: 9 book-type documents were found in this bibliometric search, or about 0.8% of the total documents. This type of document may have been chosen because some authors prefer to publish their research results in book form, especially if they wish to explore broader or more complex issues in a particular field of study. Note: 2 note types of documents were found in this bibliometric search, or about 0.2% of the total documents. This document may briefly report an interesting discovery or research result in a particular field. Short survey: One short survey-type document is found in this bibliometric search, or about 0.1% of the documents. This document type may provide a summary or survey results on a particular topic.

Based on the data above, eight documents are in the Scopus database with different frequencies. The most common document type is a Conference paper with a frequency of 648, followed by an Article type of document with 427. Meanwhile, the document type with the lowest frequency is a Short survey with only one frequency. Based on these results, it can be concluded that most of the publications on this

subject are conference papers and articles published in scientific journals. The conference review, book chapter, and review-type documents have many frequencies, although not as many as conference papers and articles. This shows that the subject has active academic activities in producing and reviewing published scientific work.

Meanwhile, Book, Note, and Short survey document types have a low frequency. This shows that scientific works in the form of books and notes are less popular in this subject. The short survey document type only has one frequency, indicating that this document type is not used in this subject.

4. Keyword co-occurrence

The following is shown in table 4, as many as 40 of the most used keywords.

Keyword	**Frequency**
E-learning	458
Students	452
Mathematics Education	339
Mathematics Learning	258
Teaching	203
Education Computing	151
Learning Systems	137
Education	127
Educational Technology	109
Mathematics Teachings	103
Mathematics	103
Engineering Education	97
Curricula	96
Computer Aided Instruction	92
Surveys	78
Teaching Materials	68
Learning Mathematics	52
Mathematical Techniques	49
Junior High Schools	49
Problem-Solving	44
Teaching And Learning	43
Mathematics Teacher	43
Elementary Schools	43
Learning Media	41
Online Learning	36
Teachers	35
Mathematics Teaching	35
Game-based Learning	31
Learning Process	30
Blended Learning	29
Augmented Reality	29
Educational Game	28
Geometry	26
Virtual Reality	25
Multimedia Systems	25
Motivation	25
Mathematical Concepts	25
Mathematics Curricula	24
Computer Games	24
Collaborative Learning	24
Algebra	24

Table 4. Keyword

From the data above, it can be seen that the keywords that appear the most are "E-learning" with a frequency of 458, followed by "Students" with a frequency of 452, and "Mathematics Education" with a frequency of 339. This shows that the topics being widely discussed are the use of technology in learning (E-learning) and mathematics education. In addition, the keywords "Mathematics Learning" and "Teaching" also appear quite frequently, with a frequency of 258 and 203, respectively, indicating a focus on learning and teaching mathematics. Regarding technology, "Educational Computing" and "Educational Technology" also appear with a fairly high frequency, namely 151 and 109, indicating an emphasis on using technology in learning and education.

Several other keywords that appear with high frequency include "Curricula" (96), "Online Learning" (36), "Blended Learning" (29), "Augmented Reality" (29), and "Virtual Reality" (25), which shows an emphasis on curriculum development and the use of new technologies in learning. Overall, these data indicate a focus on the use of technology in mathematics learning and education, emphasising curriculum development and the use of new technologies such as augmented reality and virtual reality.

The use of technology in learning mathematics has a positive impact. The tools have encouraging positive impact on student learning of mathematics in Singapore schools (Ng et al., 2019). Technology can help engage students in the mathematics learning process (Cevikbas & Kaiser, 2020). The fundamental notion is that

technology is gradually becoming "infrastructural" as a result of the longer-term changes. While one can examine pertinent collective interactions (Cevikbas & Kaiser, 2020),

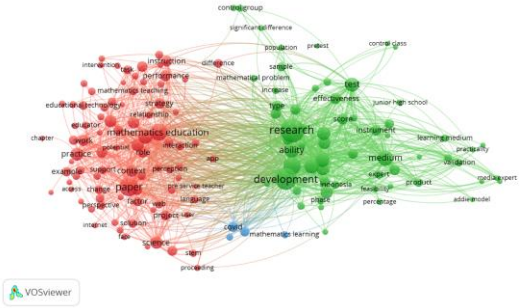

Figure 2. Network visualization

5. Term co-occurrence analysis Terms

In the cluster analysis carried out, 3 clusters consisting of various keywords were found, as shown in Table 5. And Table 6. Further analysis will be carried out for each cluster.

Cluster 1	**Cluster 2**
access	ability
advantage	Addie model
app	alternative
article	augmented reality
author	category
benefit	control class
case	control group
case study	data analysis
challenge	data collection technique
change	development
Chapter	development research
collaboration	effectiveness
communication	elementary school
communication technology	evaluation
computer	experimental class
context	experimental group
country	expert
difference	feasibility
digital technology	form
educational game	high school
educational technology	implementation
educator	increase
engagement	Indonesia
engineering	instrument
environment	junior high school
evidence	junior high school student
example	learning medium
experience	learning process
face	lecturer
factor	material expert
feature	mathematical problem
feedback	media expert
focus	medium
framework	model
hand	multimedium
higher education	observation
idea	percentage
implication	phase
importance	population
insight	practicality
instruction	pretest
interaction	procedure
Internet	product
intervention	questionnaire
issue	r & d
language	realistic mathematics education
learner	research
literature	research method
mathematics classroom	response
mathematics curriculum	sample
mathematics education	score
mathematics instruction	significant difference
mathematics teaching	stage
methodology	step
opportunity	subject
paper	teaching material
perception	technique
performance	test
perspective	type
place	validation
platform	validity

point	value
potential	
practice	
pre-service teacher	
proceeding	
project	
reflection	
regard	
relation	
relationship	
role	
science	
secondary school	
set	
situation	
solution	
stem	
strategy	
student learning	
success	
support	
survey	
task	
user	
View	
way	
web	
work	

Table 5. Cluster 1 and 2

5.1. Cluster 1

Cluster 1 is a broad cluster that covers various topics related to mathematics education, including the use of learning media and technology, instructional strategies, and teacher training. This cluster contains keywords related to the advantages and benefits of digital technology and the role of technology in enhancing student learning. The keywords in this cluster also include research methodology, case studies, and surveys to investigate the effectiveness of different learning media and technology in mathematics education. Furthermore, this cluster highlights the importance of communication and collaboration among educators and learners and the need for effective feedback and support systems.

The keywords in Cluster 1 also focus on the teacher's role in mathematics education, including pre-service teacher training and the impact of different teaching strategies on student learning. This cluster includes keywords related to mathematics classroom instruction and mathematics curriculum development. Additionally, this cluster emphasises the importance of STEM education and the potential for technology to enhance science, technology, engineering, and mathematics (STEM) learning.

Cluster 1 highlights the importance of effective communication, collaboration, and support systems in mathematics education. It emphasises the potential of digital technology and the need for effective teacher training and instructional strategies to enhance student learning. Additionally, this cluster highlights the importance of research methodology, case studies, and surveys to evaluate the effectiveness of different learning media and technology in mathematics education.

The findings of Cluster 1 suggest that effective communication, collaboration, and support systems are crucial elements in mathematics education. The use of digital technology can provide opportunities for students to interact and engage with mathematical concepts in a meaningful way (Alabdulaziz, 2021). However, to maximise the benefits of technology, teachers need to be equipped with the necessary skills and knowledge to use it effectively. This highlights the importance of effective teacher training and instructional strategies to enhance student learning.

Moreover, Cluster 1 emphasises the importance of research methodology, case studies, and surveys to evaluate the effectiveness of different learning media and technology in mathematics education. This is important because it allows educators to make informed decisions about which learning media and technology to use, based on evidence rather than intuition (Cevikbas & Kaiser, 2020). By using data-driven approaches, mathematics educators can improve the quality of education and provide students with the best possible learning experience. Overall, the findings of Cluster 1 demonstrate the importance of effective communication, collaboration, and support systems, as well as the potential of digital technology and research methodology in mathematics education (Skulmowski & Rey, 2020; et al., 2021). By utilising these elements,

educators can enhance student learning and promote the use of effective learning media, particularly in the context of online learning during the COVID-19 pandemic.

5.2. Cluster 2

Cluster 2 on the data analysis "Learning media in mathematics education: a bibliometric analysis" relates to developing and evaluating mathematics learning media. This cluster consists of several keywords, such as student abilities, the ADDIE model, alternatives, augmented reality, evaluation, control class, control group, data collection techniques, development research, effectiveness, elementary school, senior high school, implementation, improvement, Indonesia, instruments, junior high school students, learning process, lecturers, teaching material experts, mathematical problems, media experts, models, multimedia, observation, phases, population, feasibility, pretest, procedures, products, questionnaires, research and development, realistic mathematics education, methods research, response, sample, score, significant difference, stage, subject, teaching materials, technique, test, type, validation, validity, and value.

This cluster provides information about the learning media development process, starting from the learning media's planning, implementation, evaluation, and testing stages. This cluster also discusses the effectiveness of instructional media in improving students' abilities to learn mathematics. In addition, this cluster also highlights data collection techniques and research methods used in evaluating learning media. This cluster also highlights the importance of the validity and reliability of the instruments used in collecting data for evaluating learning media. In addition, this cluster also raises the topic of research and development (R&D) in making quality learning media (Mukhadis et al., 2021; Nissa et al., 2021). This cluster also highlights the reality of mathematics education in Indonesia, focusing on elementary and senior high schools.

In conclusion, Cluster 2 provides detailed information on developing and evaluating mathematics learning media. This cluster provides an understanding of research techniques and data collection that can be used to evaluate instructional media. This cluster also highlights the importance of instrument validity and reliability in collecting data for evaluating instructional media. In addition, this cluster provides views on the reality of mathematics education in Indonesia and raises the topic of development research in making learning media (Setiyani et al., 2020; Ummah et al., 2019).

5.3. Cluster 3

Cluster 3 consists of words related to learning mathematics during the COVID-19 pandemic. The words contained in this cluster are "COVID", "mathematics learning", "online learning", and "pandemic". This indicates that much research has focused on how learning mathematics can be done online or remotely during the COVID-19 pandemic. During the COVID-19 pandemic, many schools experienced closures or restrictions on physical access to schools, so mathematics learning was carried out online. Therefore, "online learning" and "pandemic" appear in this cluster. Many studies have evaluated the effectiveness of online mathematics learning and how technology can be used to enhance learning.

Cluster 3
covid
mathematics learning
online learning
pandemic

Table 6. Cluster 3

The words "COVID" and "pandemic" also show that research on learning mathematics during a pandemic is very relevant and important. Researchers can evaluate the impact of the COVID-19 pandemic on mathematics learning and how this impact can be reduced. This cluster shows that learning mathematics during the COVID-19 pandemic is important and has received considerable research attention. This shows that this cluster can become an interesting research focus to see how learning mathematics can be done effectively in this difficult time.

The finding that learning mathematics during the COVID-19 pandemic has received considerable research attention is significant because it demonstrates the importance of mathematics education even during challenging times. The pandemic has disrupted traditional learning environments and forced educators to adapt to online and remote teaching methods (Pather et al., 2020; Turnbull et al., 2021). This has led to increased interest in exploring how to effectively teach mathematics in a virtual setting. The fact that this cluster highlights the importance of learning mathematics during the pandemic suggests that it could be a fruitful area of research for mathematics educators, as they seek to

identify best practices and effective strategies for teaching mathematics in this difficult time. By focusing on this cluster, educators may be able to identify new and innovative approaches to teaching mathematics that can help students succeed in the face of these unprecedented challenges (Pather et al., 2020; Turnbull et al., 2021).

5.4. Inter-cluster analysis

Based on the cluster analysis, it can be seen that there are three clusters related to the research "Learning Media in Mathematics Education: A Bibliometric Analysis". Cluster 1 covers various topics related to mathematics, mathematics education, educational technology, and other factors influencing mathematics learning, such as the use of instructional media, environment, student engagement, and student achievement. Cluster 2 covers various topics related to research methods and evaluating the use of instructional media, such as data collection techniques, evaluation of effectiveness, and research and development (R&D) of instructional media. Meanwhile, Cluster 3 covers topics related to the context of the COVID-19 pandemic and its impact on mathematics learning, especially online mathematics learning.

It can be concluded that these three clusters are interrelated and can provide valuable information for researchers and practitioners of mathematics education in the development and use of effective and adaptive learning media. Clusters 1 and 2 can help researchers understand the factors influencing using and evaluation of learning media in learning mathematics. In contrast, Cluster 3 helps to understand how the context of the COVID-19 pandemic and online learning can influence the use of learning media and learning mathematics.

In developing learning media, media developers need to consider various factors included in Cluster 1, such as the learning environment, student involvement, and student achievement and pay attention to aspects included in Cluster 2, such as data collection techniques and evaluation of effectiveness. Meanwhile, mathematics educators can utilise the information covered in the three clusters to increase the use of learning media and maximise mathematics learning, especially in the context of the COVID-19 pandemic and online learning, which is increasingly being implemented.

The findings of this research indicate that mathematics educators have access to valuable information that can be used to improve mathematics learning outcomes. By utilizing the three clusters of factors related to learning media development, including considerations for the learning environment (Cevikbas & Kaiser, 2020), student involvement, and data collection and evaluation techniques, educators can effectively design and implement learning materials that are tailored to the needs of students in the context of the COVID-19 pandemic and online learning. As online learning becomes increasingly prevalent, educators must be equipped with the necessary tools and strategies to maximize student engagement and learning in this new environment (Cevikbas & Kaiser, 2020). Using the information provided by this research, mathematics educators can take proactive steps to improve their teaching practices and ensure that students are receiving the best possible education, even amid the challenges presented by the pandemic.

Conclusion

The research results show an increasing trend in the number of publications on the topic under study, indicating a growing interest among researchers. The subject areas with the most frequency are social sciences, computer science, physics and astronomy. The most common document types are conference papers and articles published in scientific journals, followed by conference reviews, book chapters, and reviews. Meanwhile, books, notes, and short surveys have lower frequencies. The fluctuations in the number of publications over the years suggest various factors that may affect research, such as changes in the interest of researchers, external factors, and limitations due to the Covid-19 pandemic. Overall, the results indicate active academic activities in producing and reviewing published scientific work on the topic under study. The development of effective learning media requires consideration of factors related to the learning environment, student involvement, and achievement, as well as data collection and evaluation techniques. Mathematics educators can utilise these factors to maximise mathematics learning, particularly in the context of online learning during the COVID-19 pandemic. Further research is needed, especially in mathematics, to develop knowledge and understanding of mathematical concepts and their application in various other fields.

Based on the results of this research, it can be suggested that researchers continue to explore and contribute to the topic under study, particularly in areas such as mathematics and its applications in other fields. It is also important for future research to consider the potential impact of external factors, such as the Covid-19 pandemic, on academic activities and publication trends. Finally, researchers should utilise various document types to ensure that their work reaches a wider audience and contributes to advancing knowledge in their field.

References

Alabdulaziz, M. S. (2021). COVID-19 and the use of digital technology in mathematics education. *Education and Information Technologies*, *26*(6), 7609–7633.

Arifin, M., Sholeh, M., Hafiz, A., Agustin, R., & Wardana, M. (2021). *Developing Interactive Mobile Mathematics Inquiry to Enhance Students' Problem-solving Skill*.

Attard, C., & Holmes, K. (2022). An exploration of teacher and student perceptions of blended learning in four secondary mathematics classrooms. *Mathematics Education Research Journal*, *34*(4), 719–740. https://doi.org/10.1007/s13394-020-00359-2

Borba, M. C. (2021). The future of mathematics education since COVID-19: humans-with-media or humans-with-non-living-things. *Educational Studies in Mathematics*, *108*(1–2), 385–400. https://doi.org/10.1007/s10649-021-10043-2

Capuno, R., Revalde, H., Etcuban, J. O., Aventuna, M., Medio, G., & Demeterio, R. A. (2019). Facilitating Learning Mathematics Through the Use of Instructional Media. *International Electronic Journal of Mathematics Education*, *15*(1), 677–688. https://doi.org/10.29333/iejme/5785

Cevikbas, M., & Kaiser, G. (2020). Flipped classroom as a reform-oriented approach to teaching mathematics. *ZDM - Mathematics Education*, *52*(7), 1291–1305. https://doi.org/10.1007/s11858-020-01191-5

Djeki, E., Dégila, J., Bondiombouy, C., & Alhassan, M. H. (2022). E-learning bibliometric analysis from 2015 to 2020. *Journal of Computers in Education*, *9*(4), 727–754. https://doi.org/10.1007/s40692-021-00218-4

Fauzi, M. A. (2022). E-learning in higher education institutions during COVID-19 pandemic: current and future trends through bibliometric analysis. *Heliyon*, *8*(5), e09433. https://doi.org/10.1016/j.heliyon.2022.e09433

Hallifax, S., Lavoué, E., & Serna, A. (2020). To tailor or not to tailor gamification? An analysis of the impact of tailored game elements on learners' behaviours and motivation. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *12163 LNAI*, 216–227. https://doi.org/10.1007/978-3-030-52237-7_18

İbili, E., Çat, M., Resnyansky, D., Şahin, S., & Billinghurst, M. (2020). An assessment of geometry teaching supported with augmented reality teaching materials to enhance students' 3D geometry thinking skills. *International Journal of Mathematical Education in Science and Technology*, *51*(2), 224–246. https://doi.org/10.1080/0020739X.2019.1583382

Li, J., Antonenko, P. D., & Wang, J. (2019). Trends and issues in multimedia learning research in 1996–2016: A bibliometric analysis. *Educational Research Review*, *28*(June), 100282. https://doi.org/10.1016/j.edurev.2019.100282

Moradoff, Y., Kramarski, B., & Heaysman, O. (2021). Leveraging student-centred teaching practices by authentic simulations environment and self-regulated learning. *Teachers and Teaching: Theory and Practice*, *27*(1–4), 316–334. https://doi.org/10.1080/13540602.2021.1955673

Mukhadis, A., Putra, A. B. N. R., Kiong, T. T., Sumarli, Sutadji, E., Puspitasari, P., Sembiring, A. I., & Subandi, M. S. (2021). The innovation of learning plan designer based mobile web to improve quality of

learning media in vocational technology for education 4.0. *Journal of Physics: Conference Series*, *1833*(1), 012030. https://doi.org/10.1088/1742-6596/1833/1/012030

Ng, W. L., Teo, B. C., Yeo, J. B. W., Ho, W. K., & Teo, K. M. (2019). *Use of Technology in Mathematics Education*. 313–348. https://doi.org/10.1007/978-981-13-3573-0_14

Nissa, A. D. A., Toyib, M., Sutarni, S., Akip, E., Kadir, S., Ahmad, & Solikin, A. (2021). Development of Learning Media Using Android-Based Articulate Storyline Software for Teaching Algebra in Junior High School. *Journal of Physics: Conference Series*, *1720*(1), 12011. https://doi.org/10.1088/1742-6596/1720/1/012011

Papadakis, S., Kalogiannakis, M., & Zaranis, N. (2021). Teaching mathematics with mobile devices and the Realistic Mathematical Education (RME) approach in kindergarten. *Advances in Mobile Learning Educational Research*, *1*(1), 5–18. https://doi.org/10.25082/amler.2021.01.002

Pather, N., Blyth, P., Chapman, J. A., Dayal, M. R., Flack, N. A. M. S., Fogg, Q. A., Green, R. A., Hulme, A. K., Johnson, I. P., Meyer, A. J., Morley, J. W., Shortland, P. J., Štrkalj, G., Štrkalj, M., Valter, K., Webb, A. L., Woodley, S. J., & Lazarus, M. D. (2020). Forced Disruption of Anatomy Education in Australia and New Zealand: An Acute Response to the Covid-19 Pandemic. *Anatomical Sciences Education*, *13*(3), 284–300. https://doi.org/10.1002/ase.1968

Setiyani, Putri, D. P., Ferdianto, F., & Fauji, S. H. (2020). Designing a digital teaching module based on mathematical communication in relation and function. *Journal on Mathematics Education*, *11*(2), 223–236. https://doi.org/10.22342/jme.11.2.7320.223-236

Skulmowski, A., & Rey, G. D. (2020). COVID-19 as an accelerator for digitalization at a German university: Establishing hybrid campuses in times of crisis. *Human Behavior and Emerging Technologies*, *2*(3), 212–216. https://doi.org/10.1002/hbe2.201

Turnbull, D., Chugh, R., & Luck, J. (2021). Transitioning to E-Learning during the COVID-19 pandemic: How have Higher Education Institutions responded to the challenge? *Education and Information Technologies*, *26*(5), 6401–6419. https://doi.org/10.1007/s10639-021-10633-w

Ummah, S. K., In'am, A., & Azmi, R. D. (2019). Creating Manipulatives: Improving Students' Creativity through Project-Based Learning. *Journal on Mathematics Education*, *10*(1), 93–102.

van Eck, N. J., & Waltman, L. (2014). Visualizing Bibliometric Networks. In Y. Ding, R. Rousseau, & D. Wolfram (Eds.), *Measuring Scholarly Impact* (pp. 285–320). Springer International Publishing. https://doi.org/10.1007/978-3-319-10377-8_13

van Langen, A., & Dekkers, H. (2005). Cross-national differences in participating in tertiary science, technology, engineering and mathematics education. *Comparative Education*, *41*(3), 329–350. https://doi.org/10.1080/03050060500211708

Williams, J., & Choudry, S. (2016). Mathematics capital in the educational field: Bourdieu and beyond. *Research in Mathematics Education*, *18*(1), 3–21. https://doi.org/10.1080/14794802.2016.1141113

Yadav, S. (2019). Role of Mathematics in the Development of Society. *International Journal of Research and Analytical Reviews*, *6*(4), 295–298. www.ijrar.org