Utilization of the Internet of Things (IoT) in Mathematics Learning in Indonesia: Literature Study Using Bibliometric Methods from 2015 to 2023 Period

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Abstract
Internet of Things (IoT) is a concept where an object has the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. The aim of the research is to provide a general overview of the research literature on the use of IoT for mathematics learning based on bibliometric analysis of a number of journal articles published in the Scopus database and to identify scientific gaps as a reference for further research. The method used is bibliometric analysis assisted by VOSviewer software. The research results show an increasing trend in research on the use of IoT in mathematics learning and several topics/keywords were found that can be used as a basis for further research. Research in Indonesia in the 2018-2023 period, related to IoT on Mathematics Learning in mathematics subjects, was minimally carried out. This is also a gap for further research (gap research) to carry out IoT research on Mathematics Learning. The conclusion is that bibliometric analysis provides information and knowledge about the development of research on the use of IoT in mathematics learning for the possibility of carrying out further new research.

1. Introduction

In the 21st century, personal computers and mobile phones combined, creating the smartphone one of the most successful platforms of all time (Mouha, 2021). Nearly hundreds of billions of connected devices are predicted by 2020, of which around 50 billion will be IoT-related. Many devices are connected to the internet. (Elkhodr et al., 2013). One piece of equipment used can connect to other devices just by using an internet connection. allows easy access and interaction with various devices such as household appliances, CCTV cameras, monitoring sensors, actuators, displays, vehicles, and so on (Farooq et al., 2015). Internet of Things (IoT) is a concept where an object has the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction (Mukhopadhyay & Suryadevara, 2014). Where the aim is to expand the benefits and connectivity of the internet which is continuously discarded, in the physical world, food, electronics, any equipment, including living objects which are all connected to local and global networks through embedded sensors and are always "on" (Byun, 2016).

Teaching aids are defined as aids for educating or teaching so that the concepts taught by teachers are easily understood by students and become aids in the learning process made by teachers or students from simple materials that are easily obtained from the surrounding environment (Nurcahyandi et al., 2022). Mathematical teaching aids can be defined as a set of concrete objects that are designed, made and arranged deliberately and are used to help instill and understand concepts or principles in mathematics (Puspaningtyas & Ulfa, 2020). On the other hand, based on the 2019 Indonesian telecommunications statistics released by the National Statistics Agency, the number of gadget users in Indonesia who were able to access the internet in the last 3 months of 2019, of the total 100% of users, was found to be 18.5% of whom were in

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elementary school. , while the majority are in high school with a percentage of 39.65 percent (Novita et al., 2022). This proves that children and teenagers are already familiar with gadgets and the world of the internet. In this case, to make it easier for students to understand learning about weight conversion of an object, with the conclusion that children and teenagers are already familiar with technology.

Research on IoT in education has been carried out by (Miraz et al., 2015). This research discusses how the learning system is wrong and can make it difficult for students to grasp lessons and result in a slow decline in the quality of education. The proposed system is a system that uses IoT where students can directly save the results of their work in the system, work history and so on. (Gubbi et al., 2013). Then explain the uses of IoT that have been made in the education sector. Based on students' experience in using ELearning in learning, they get full benefits by interacting directly with this technology and their learning skills increase greatly based on analysis of their learning results(Lee & Lee, 2015). Hopkins research on the application of augmented reality-based smart learning using the Android platform. This paper discusses the application of technology to help teachers describe the knowledge they want to convey accurately and precisely (Hopkins, 2018).

In this research, a study will be carried out on research that has been carried out and published regarding the use of IoT in mathematics learning, namely using the bibliometric analysis method of publication and bibliographic data taken from Scopus data. So it is hoped that from this research study it will be possible to know or identify the trends in research and publication from the period 2015 to 2023, the distribution of countries contributing to research and the dominant research topics taken up in that time period. So that at the end of the research study novelty will be known, which can later be developed as a research gap that can be carried out in further research.

2. Method

The research method used to solve the problems in this research is by retrieving research documents indexed by Scopus based on certain keywords and adjusted to the research topic being carried out, namely learning styles, and then bibliometric analysis is carried out using VOSViewer software version 1.6.18(Botta et al., 2016). Dalam penelitian ini, akan dipergunakan integrasi 2 (dua) metode pendekatan analisis yakni berupa PRISMA (The Preferred Reporting Items For Systematic Reviews and Meta – Analysis) dan Bibiometrik (Hopkins, 2018).

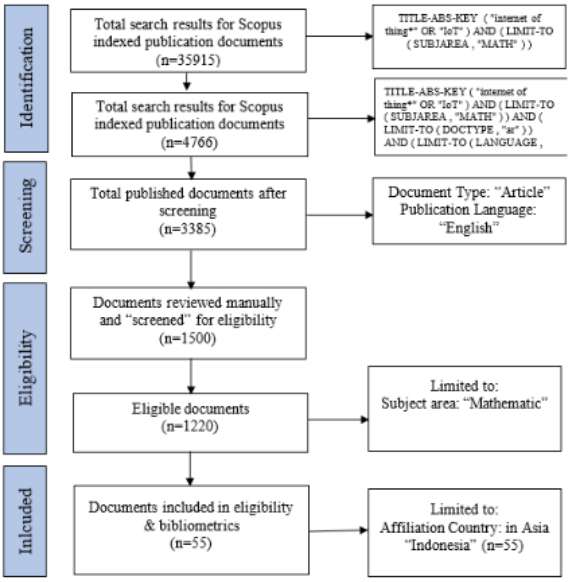
Identify Data Sources

Through the literature study carried out, data collection was completely limited to research documents that have been published and indexed by Scopus, related to the Internet of Things (IoT) since they were first published and included in journals or other publications indexed by Scopus. Research on research documents and bibiometrics, which is only limited to published documents indexed by Scopus, was mostly carried out by previous researchers even though the research topics were different from those carried out by current researchers.

Data Retrieval

Data collection is carried out directly on the official Scopus website (www.scopus.com) by using a user login that already has a legal license (formal authorization access) via certain keywords and continues with the screening process using the PRISMA method.(Andrade-arenas et al., 2023). For the initial stage of data collection, it is not limited to the research publication time period, so that research results documents are obtained for the first time. In collecting data in the form of research publication documents and bibiometric data, by creating a script or search language as follows*: TITLE-ABS-KEY ("internet of thing*" OR "IoT") AND PUBYEAR > 2014 AND PUBYEAR < 2025 AND (LIMIT-TO (SUBJAREA , "MATH")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (OA , "all")) AND (LIMIT-TO (EXACTKEYWORD , "Internet Of Things") OR LIMIT-TO (EXACTKEYWORD , "IoT") OR LIMIT-TO (EXACTKEYWORD , "Internet Of Things (IoT)") OR LIMIT-TO (EXACTKEYWORD , "Internet Of Things (IOT)") OR LIMIT-TO (EXACTKEYWORD , "Internet Of Thing (IOT)") OR LIMIT-TO (*

EXACTKEYWORD , "Internet Of Things Technologies")) AND (LIMIT-TO (AFFILCOUNTRY , "Indonesia"))



Picture 1. PRISMA flow diagram for data collection using IoT for mathematics learning

The first search obtained 35915 published documents for all document types. Next, the search was refined by limiting the year of publication, namely from 2015 to 2023 and only selected articles that were open access and in English, obtained 4766 published documents. By limiting the research area to the "Mathematics" category and publications published in "English" and "Indonesian", 3385 publication documents were obtained. For the purpose of discussing research, namely identifying research conducted by countries in Indonesia, a total of 55 documents.

Data Analysis

Bibliographic data was collected last after all the search processes using the PRISMA method stages as illustrated in the flow in Figure 1. The bibliographic data obtained is a detailed explanation of information from research publication documents obtained for the first time, namely containing author information, name of affiliation, number of citations, references, keywords (based on the author and publisher), publication journal name, research country, publication publication language, research area, document access category, and publication number. Statistical analysis and further bibliometric analysis were carried out using the help of bibliometric analysis software, namely VOSViewer (van Eck & Waltman, 2017) (Oyewola & Dada, 2022) (Arruda et al., 2022)

3. Result and Discussion

Volume Distribution and Research Growth

The first problem in this research is identifying the growth of research regarding the use of IoT in mathematics learning in the world, and overall there are 35915 research documents for all types of publications indexed by Scopus, a total of 13 (thirteen) types or types of publications for all periods, where information is obtained The first research published and indexed by Scopus began in 2015 (14 publications) followed by 2016 (23 publications) jumping to 2018 (131 publications). If you look at publication trends from 2015 to 2017, throughout the 3 years there have been publications indexed by Scopus, although there are no more than 100 Scopus documents. Figure 1 shows the trend of IoT research publications on Mathematics Learning in the world, while details of the types of research publications related to IoT on Mathematics Learning can be seen in Table 1 Types of IoT Publications on Mathematics Learning.

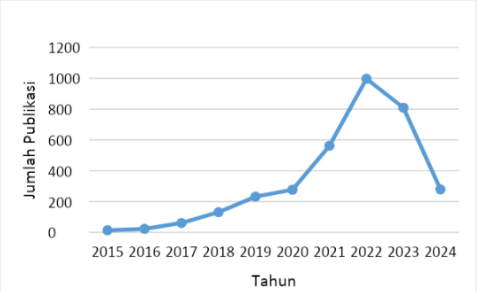


Table 1. Types of IoT Publications on Mathematics Learning in the world

Document Type	Jumlah Publikasi	%-tase
Article	8777	58.1%
Conference Paper	4137	27.4%
Book Chapter	706	4.7%
Review	656	4.3%
Book	163	1.1%
Note	162	1.1%
Conference Review	142	0.9%
Letter	141	0.9%
Editorial	119	0.8%
Short Survey	69	0.5%
Retracted	14	0.1%
Erratum	12	0.1%
Data Paper	2	0.0%

Research publications in the form of journal articles are predominantly carried out by researchers, of which there are 8777 out of 15100 publications or 58.1% of the total research documents that have been published and indexed by Scopus.

In Figure 2. By limiting the publication period from 2015 to 2023, it can be seen that there is an increasing trend in the number of research, especially for the period starting in 2018 and reaching its peak in 2022 with the production of 997 research documents.

In terms of fields or research subject areas, there are a total of 28 fields, so IoT research on Mathematics Learning for the field of mathematics ranks 1st with 3385 publications (33.5%), far above the field of computer science in second place with 2689 publications (26.6%), while for those grouped into others (18 fields), including the fields of energy, environment, agriculture, chemical engineering, chemistry. In detail, the research subject areas related to IoT on Mathematics Learning can be presented in Table 2.

Subjek area	Publikasi	%-tase
Mathematics	3385	33.5%
Computer Science	2689	26.6%
Engineering	2103	20.8%
Materials Science	471	4.7%
Energy	369	3.7%
Physics and Astronomy	327	3.3%
Neuroscience	236	2.3%
Chemistry	124	1.2%
Decision Sciences	109	1.1%

Table 2. Top 10 IoT Research Fields on Mathematics Learning in the World

Geographical Distribution of Research (Asia)

Mapping research on IoT on Mathematics Learning by researchers in Asian countries (there are 10 countries), China is still dominant with 884 publications (49.2%) or the most in Asia and in the world, followed by India with 518 publications (28.8%). Indonesia's position can be categorized as lagging behind, where it ranks 5th in Asia or 19th globally, and is still inferior to

Malaysia (2nd) and Taiwan (4th) for countries in Southeast Asia. Especially for research countries in Asia, with Indonesia ranked 19th in the world, this is a great opportunity to conduct research. Distribution of publications per country and global ranking is shown in Table 3.

Negara	Jumlah Publikasi	%-tase	Rank di Asia	Rank Global
China	884	49.2%	1	1
India	517	28.8%	2	2
Malaysia	206	11.5%	3	8
Taiwan	65	3.6%	4	16
Indonesia	55	3.1%	5	19
Japan	44	2.4%	6	25
Singapore	21	1.2%	7	48
Brunei Darussalam	5	0.3%	8	75

Table 3. Country of IoT Research on Mathematics Learning in Asia

Table 3 shows another way to interpret research relationships between countries, by observing the color of each dot per country which indicates the year the research was published, where in general, the lighter the color of the country dot, the younger or more recent the research results published. Based on bibliographic analysis of research countries with the VOSViewer application, this shows that minimal research in Indonesia in the 2018-2023 period related to IoT on Mathematics Learning in mathematics subjects was carried out. This is also a gap for further research (gap research) to carry out IoT research on Mathematics Learning.

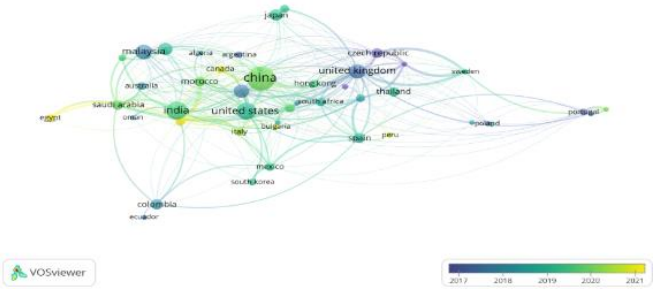


Figure 3. Geographical Distribution of IoT Research on Mathematics Learning Research Distribution Based on Author and Keyword

The research keyword aspect, which also shows the focus of research carried out to date related to IoT on Mathematics Learning and the relationship between these keywords, can be shown in figure 4.

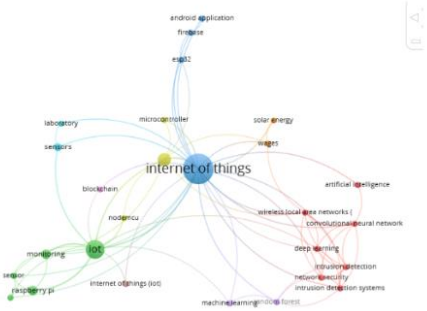


Figure 4.The relationship between IoT research keywords on Mathematics Learning

Table 4 shows the comparison of keywords between authors and all keywords (including keywords entered by publishers and based on research content). IoT on Mathematics Learning which is connected to e-learning is predominantly research conducted with a research link strength level of 879 in first place, while learning style itself is in second place with a research link strength level of 685. The smaller the value of research link strength (total link strength), the more There is increasingly less research on learning styles associated with these keywords, which also means there is a gap for further research (gap research).

keyword	Author Keyword		All Keyword	
	occurrences	total link strength	occurrences	total link strength
Convolutional neural network	6	3	8	22
Deep learning	7	6	7	41
Monitoring	9	9	14	101
Raspberry pi	10	13	14	86
Random forest	9	9	28	16
sensor	6	4	6	26
sensors	5	5	8	29
wages	9	6	13	73
Esp 32	6	6	7	31
Firebase	6	6	6	30
Smart home	7	2	9	42
Android application	45	45	146	879
Artificial Intellegence	16	14	72	441
Blockchain	6	8	9	71
Laboratory	6	1	6	17
Microcontroller	12	10	12	46

Table 4. IoT Keywords on Mathematics Learning (Author vs All) and level of research strength

author	documents	citations
Hilal, A.M.	21	83
Hamza, M.A.	18	56
Al Duhayyim, M.	15	56
Motwakel, A.	15	54
Ahanger, T.A.	14	51
Hsiao, S.J.	12	4
Sung, W.T.	12	38
Jhanjhi, N.Z.	11	37

Table 5. Top 10 Author of IoT Research on Mathematics Learning with the most citations

Researchers from non-Asian countries are dominant with the largest citations, namely Hilal, although 21 documents were published, there were 83 citations. This can mean that the research results are very interesting and of high quality so that many subsequent studies refer to or cite research that has been carried out.

4. Conclusion

Research conducted regarding student learning styles in mathematics subjects shows quite a variety of research topics or keywords, namely Convolutional neural network is the top research keyword, while research that is less focused and can be carried out further research (gap research), among others, is related to . In terms of the number of international publications indexed by Scopus, Indonesian researchers are not included in the top 5 researchers in Asia and publications for the 2017-2023 period, so it is very open for further research on aspects of student learning styles in Indonesia. To obtain a more comprehensive research gap, after a literacy study has been carried out using bibliometric methods, further studies can be carried out on the content of research conducted using other literacy study methods, one of which is Systematic Literature Review (SLR).

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