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RESEARCH TRENDS ABOUT STEM OF INTERNET OF THINGS FOR SCIENCE TEACHERS: A BIBLIOMETRIC ANALYSIS

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Abstract

This paper aims to provide a detailed overview of how to use the bibliometrics approach to study trends in the STEM using Internet of Things (IoT) for science teachers. This study comes from 25 collected papers that Scopus indexed concerning STEM with IoT for science teachers from 2016 to 2023 using co-word and text analysis. We use VOSviewer for bibliometric analysis purposes. Research on STEM with IoT as a support for technology development in learning for science teachers can be done in various ways including holding training for teachers, giving teachers confidence in applying technology in the learning process, and the need for collaboration in carrying out STEM with IoT learning, implementing both for students and teachers. In further research to support the successful implementation of STEM learning with IoT, it is necessary to have a module designed as a guide.

Keywords: Bibliometric analysis, Internet of Things (IoT), Science teachers, STEM.

1. Introduction

The rapid development of technology provides challenges in the world of education. The teacher as the spearhead of planners and implementers in learning must be able to design and carry out the learning process properly [1], choosing the right strategy is one of the priorities that must be considered properly by the teacher, especially in achieving learning goals that can keep up with technological advances [2]. Science Technology Engineering and Mathematics (STEM) is an interesting topic to be explored collaboratively by researchers and educators around the world [3]. Teachers play an important role in developing the nation's STEM workforce and increasing students' interest in STEM fields. However, there are limited opportunities available for in-service teachers to leverage their engineering and technology content knowledge and apply that knowledge effectively in designing integrated STEM learning environments [4]. Teachers have limitations in their knowledge of technology development. Thus, it is necessary to have a strategy given to teachers to increase creativity in practicing technology for the advancement of Education. This paper provides a comprehensive overview using bibliometrics of the present current state and trends in STEM of the Internet of Things (IoT) for science teachers. In particular, the bibliometric analysis focused on the following research questions: a) What are the thematic patterns in IoT on science education research, as regards the use of keywords in the publications?; b) What are the trends and directions of development in STEM learning with IoT?; and c) how is the research conducted to develop STEM with IoT learning for science teachers? To explore this matter, bibliometric analysis was done. This analysis is effective in explaining the current research trend (see Table 1).

2. Method

We employed bibliometric analysis to assess search results in Scopus on 5 August 2023 using the keywords of STEM AND internet AND of AND things AND for AND science AND teacher in the period of publication of 2016-2023. Keyword analysis and the title of the article are used to analyse groups and topics for research utilizing Scopus sources. Figure 1 shows the presentation of publications based on the type of document issued. Sample articles retrieved in *CSV format are processed using VOSviewer software to aid visualization and identify trends [26, 27].

Table 1. Previous studies of bibliometric analysis.

No.	Title	Topic Discussion	Ref
1	Introducing ASEAN Journal of Science and Engineering: A Bibliometric Analysis Study. Journal of Advanced Research in Applied Sciences and Engineering Technology.	This research discusses the impact and verifies the success of the ASEAN Journal of Science and Engineering in internationalization.	[5]
2	Dental suction aerosol: Bibliometric analysis.	This study explains the development of dental aerosol suction through the distribution of bibliometrics maps and research trends using VOSviewer.	[6]
3	A bibliometric analysis of covid-19 research using VOSviewer.	This study discusses the development of research during the Covid-19 era using bibliometric analysis.	[7]
4	The latest report on the advantages and disadvantages of pure biodiesel	This research discusses the literature review of the advantages and	[8]

No.	Title	Topic Discussion	Ref
	(B100) on engine performance: Literature review and bibliometric analysis	disadvantages of pure biodiesel on engine performance.	
5	A bibliometric analysis of management bioenergy research using VOSviewer application	This study discusses the trends and developments of research in the field of bioenergy management.	[9]
6	Oil palm empty fruit bunch waste pretreatment with benzotriazolium-based ionic liquids for cellulose conversion to glucose: Experiments with computational bibliometric analysis	This research was conducted to analyse the utilization of benzotriazole ionic salt liquid as a solvent for empty palm oil fruit bunches using bibliometric analysis and VOSviewer.	[10]
7	Biomass-based supercapacitors electrodes for electrical energy storage systems activated using chemical activation method: A literature review and bibliometric analysis.	This research discusses the potential of biomass-based carbon as the electrode of a highly efficient supercapacitor that can facilitate highly efficient current transport in energy storage systems.	[11]
8	Management information systems: bibliometric analysis and its effect on decision making.	This study discusses the information regarding decision-making	[12]
9	Bibliometric analysis of nano metal-organic frameworks synthesis research in medical science using VOSviewer	This study discusses the bibliometric analysis of nFs for medical science by combining mapping analysis using VOSviewer software.	[13]
10	Past, current and future trends of salicylic acid and its derivatives: A bibliometric review of papers from the Scopus database published from 2000 to 2021.	This research discusses scientometric studies in the organizational progress and prospects of SA and its derivatives.	[14]
11	Correlation between process engineering and special needs from bibliometric analysis perspectives.	This study discusses the integration of mapping analysis using the VOSviewer program.	[15]
12	Bibliometric analysis for understanding the correlation between chemistry and special needs education using VOSviewer indexed by Google.	This study explains combining mapping analysis with the use of VOSviewer.	[16]
13	Computing bibliometric analysis with mapping visualization using VOSviewer on “pharmacy” and “special needs” research data in 2017-2021.	This research discusses mapping visualization in research that has pharmaceutical topics and special needs in five years (2017-2021).	[17]
14	Nutritional research mapping for endurance sports: A bibliometric analysis.	This study discusses research mapping in the field of nutrition for endurance sports.	[18]
15	Bibliometric and visualized analysis of scientific publications on geotechnics fields.	This study analysed the development of research related to Geotechnical Engineering through bibliometric distribution maps using VOSviewer	[19]
16	A bibliometric analysis of computational mapping on publishing teaching science	This study discusses the description of research developments in the fields of science education and engineering.	[20]

No.	Title	Topic Discussion	Ref
	engineering using VOSviewer application and correlation.		
17	What is the correlation between chemical engineering and special needs education from the perspective of bibliometric analysis using VOSviewer indexed by Google Scholar?	This study analyses "Special Needs of Chemical Engineering" by combining mapping analysis and the VOSviewer application.	[21]
18	Counselling guidance in science education: Definition, literature review, and bibliometric analysis.	This research discusses the topic of guidance and counselling in science education using a literature review and bibliometric analysis.	[22]
19	Phytochemical profile and biological activities of ethylacetate extract of peanut (Arachis hypogaea L.) stems: In-vitro and in-silico studies with bibliometric analysis.	This study analysed the chemical content and pharmacological activity of A.hypogaea stems in-vitro and in-silico.	[23]
20.	A bibliometric analysis of materials research in Indonesian journal using VOSviewer	The research trends in the realm of materials are discussed in this paper.	[24]
21.	Research trend on the use of mercury in gold mining: Literature review and bibliometric analysis	In this study, the use of mercury in gold mining is discussed.	[25]

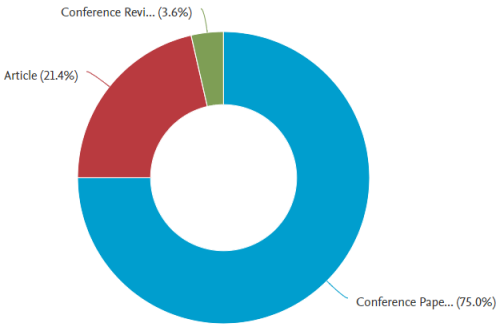

Fig. 1. Presentation of publications based on the type of document issued.

3. Results and Discussion

The minimum number of occurrences of terms used in the analysed research results from Scopus. After being analysed, we discuss five categories, they are by year, country, keyword, and results. The results by year about STEM IoT for science teachers first appeared in 2016. Two articles were published in 2016. Both are published in an International conference with the IEEE Publisher (see Fig. 2). Research about STEM with IoT for science teachers is likely that the number of research will continue to increase because STEM is a trend approach in science learning [28]. Some of the results of the research have been carried out as an effort to implement and understand the STEM IoT in the world of education for both teachers and students. Table 2 shows 25 titles of articles that are discussed regarding the methods used and the results of research on STEM Internet for science teachers.

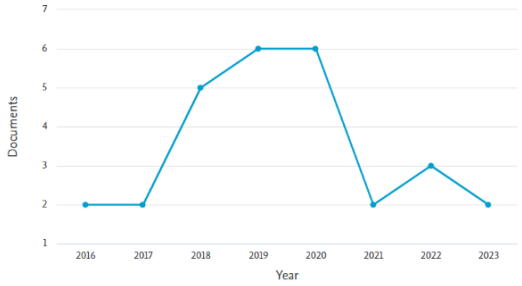

Fig. 2. Papers regarding STEM IoT for science teachers.

We conclude: a) IoT projects for learning using the STEM approach (article no. 6, 19, 20, 24)[29-30]; b) a need for an Education program for teachers in designing and practicing IoT in STEM learning that can be applied in classes (article no. 1, 3, 5, 7, 9, 10, 17, 18, 23) [2, 31]; c) collaboration that can be improved through IoT-based STEM learning (article no. 4, 22) [1, 32]; d) integration of STEM learning with student expertise competencies by utilizing IoT technology, Arduino devices, and runlinc can be used to STEM practice to develop IoT and Artificial Intelligence (article no. 11, 14, 15, 21)[4, 33-35]; e) STEM learning as a provision in solving problems in everyday life (article no. 8, 13, 16) [3, 36]; f) Integrated IoT programming in STEM learning that is applied to course activities provides opportunities to work with robots in completing any work in the future (article no. 2, 12, 25) [37].

Table 2. Article about STEM with IoT for science teachers from 2016-2023.

No.	Title	Year
1	Exploiting ubiquitous computing, mobile computing and the internet of things to promote science education	2016
2	A Wireless robotic educational platform approach	2016
3	Leveraging STEM education via UMI technologies	2017
4	Collaborative multidisciplinary engineering design experiences in IoT (Internet of Things) for teachers through summer research site program	2018
5	Design of interactive toy as support tool in STEM education for children with special needs	2018
6	Smart schoolhouse—Designing IoT study kits for project-based learning in STEM subjects.	2018
7	A Design Framework for Interdisciplinary Communities of Practice Towards STEM Learning in 2nd Level Education	2018
8	Assessing the effects of authentic experiential learning activities on teacher confidence with engineering concepts	2018
9	Enabling primary school teachers to deliver STEM programmes with the internet of things: Challenges and recipes for success.	2019
10	Contribution to the setting up of a remote practical work platform for STEM: The case of agriculture	2019
11	Co-Designing the Kits of IoT Devices for Inquiry-Based Learning in STEM	2019
12	Experience with Using Robots for Teaching Programming	2019
13	Developing a Mini Smart House model	2019
14	IoT as an Introduction to Computer Science and Engineering: A Case for NodeMCU in STEM-C Education	2020
15	The MetroSea student contest: An amazing educational experience at 2019 IMEKO TC-19 international workshop on metrology for the sea	2020
16	Problem Solving and Digital Transformation: Acquiring Skills through Pretend Play in Kindergarten	2020

17	Contribution to the Setting of an Online Platform on Practical Application for the Science, Technology, Engineering and Mathematics (STEM): The Case of Medical Field	2020
18	Professional development activities for secondary stem teachers and students' engineering content knowledge and attitudes	2020
19	Fostering Secondary Students' STEM Career Awareness through IoT Hands-On Educational Activities: Experiences and Lessons Learned	2020
20	Covid-19 as an agent of change in teaching and learning stem subjects	2020
21	Performance Comparison of Arduino IDE and Runlinc IDE for Promotion of IoT STEM AI in Education Process	2021
22	A Proposed Implementation of Internet of Things as a Teaching Aid for Learning Science Collaboratively	2022
23	Integrating Data Science and the Internet of Things Into Science, Technology, Engineering, Arts, and Mathematics Education Through the Use of New and Emerging Technologies	2022
24	A study on the effects of using gamification with the 6E model on high school student's computer programming self-efficacy, IoT knowledge, hands-on skills, and behavioural patterns	2023
25	Bhutanese students' low performance in Mathematics dealt with IoT	2023

Counting papers by countries for keyword STEM IoT for science teachers, Fig. 3 shows15 countries which have a publication about STEM IoT for science teachers: the US, Greece, Ireland, Estonia, Senegal, Belgium, Bhutan, Colombia, India, Indonesia, Italy, Malaysia, Slovenia, South Africa, Spain, etc. The US is the country that publishes the most papers discussing the STEM IoT for science teachers, and then the second country from Greece, and then Ireland. But from Indonesia, one paper has been published. Research about STEM IoT for science teachers still a little research, and this opportunity to make links to research about STEM IoT for science teachers.

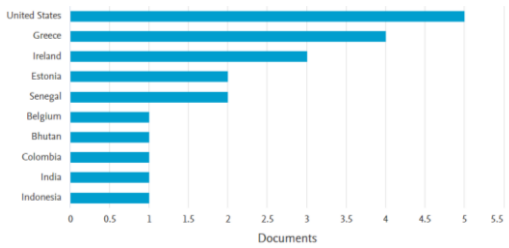

Fig. 3. Top ten countries/regions about STEM IoT for science teachers' research

This section presents the analysis results of keywords in the publication, which help to elucidate the major research themes and research trends in STEM IoT for science teachers. Keywords are considered "content descriptors at macroscopic levels" [38], and the topics in a field can be delineated by the keywords of relevant publications [39]. Figures 4 and 5 show 279 items connected with IoT.

The VOS viewer can show bibliometric mapping in different visualizations. The results of the data analysis are then tabulated and put into tables, diagrams, and curves. The results are based on the keywords in the field of the IoT in science education in making STEM education (see Fig. 4). 279 terms are obtained overall. But, when you want to show the most themes with IoT in the STEM education area, it is shown in Fig. 5. The most closely related research topics are six terms, which are IoT for STEM, collaborative learning, project-based learning for developing IoT in STEM, STEM

concepts in IoT, and e-learning for STEM with IoT. As shown in Fig. 6, the subject area is mostly computer science (30.6%), engineering (30.6%), social science (14.3%), and other (14.5%). STEM with IoT for science teachers is the most interesting topic [40], which has relevant characteristics to be developed in the world of education, especially introduced and provided to science teachers. Thus, they can design and implement learning.

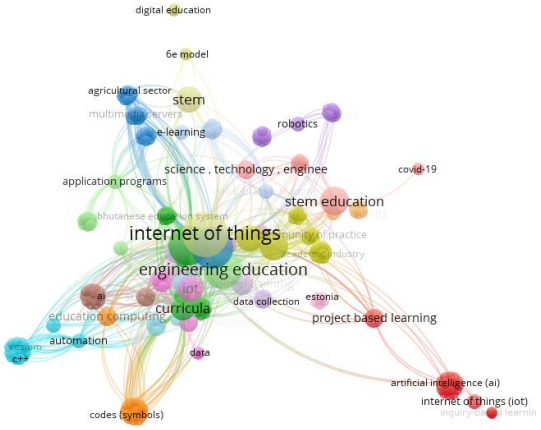

Fig. 4. Visualization topic area using VOS Viewer using network visualization.

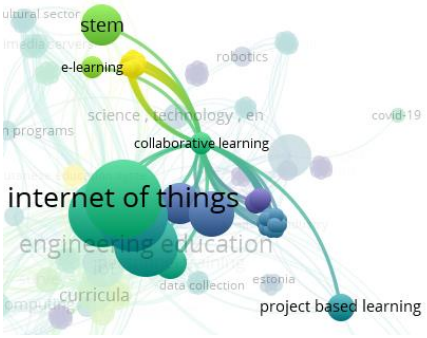

Fig. 5. Visualization topic area using VOS viewer using overlay visualization.

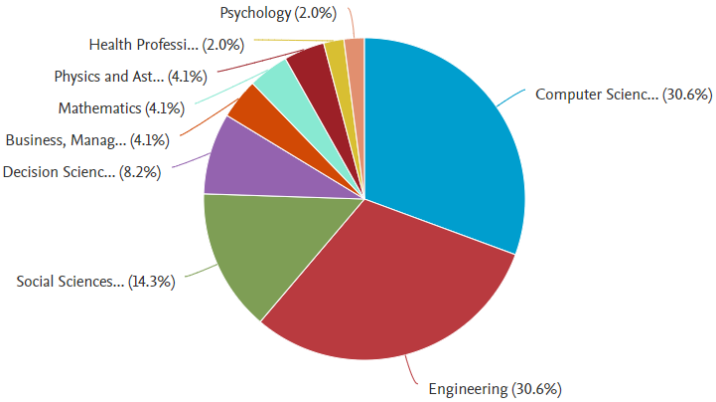

Fig. 6. Subject area from Scopus analysis.

4. Conclusion

The development of research on the trends in STEM IoT for science teacher areas from 2016 to 2023 fluctuates. Most publications on this theme are in 2019 and 2020. Based on the results obtained from the results of previous research, it was found that training for teachers in studying IoT technology integrated into STEM learning is needed to be able to design learning that can prepare students to solve problems in everyday life and prepare to face technological developments in the future.

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