

RESEARCH TRENDS ABOUT INTERNET OF THINGS ON SCIENCE EDUCATION: 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 of the Internet of Things (IoT) in science education. This study comes from 54 collected papers that Scopus indexed concerning IoT in science education from 2012 to 2022 using co-word and text analysis. We used VOSviewer for bibliometric analysis purposes. Research on IoT in science education is still very low, and only a few countries have just researched IoT in science education. In addition, the relationship between IoT and the subject area discussed in the research is still very shallow. Therefore, based on the results of this bibliometric analysis, provides an overview and opportunities for carrying out future research.

Keywords: Bibliometric analysis, Internet of things (IoT), Science education.

1. Introduction

Internet of Things (IoT) has unknowingly permeated every field of people's daily lives. The majority of individuals in society take pleasure in the intelligent and automated lives that IoT technology has enabled. The Automatic Identification Center, created by the Massachusetts Institute of Technology (MIT) in 1999, first introduced the idea of the IoT, which was derived from Radio Frequency Identification (RFID) technology [1]. IoT is widely used in various fields, such as education, industry, agriculture, transportation and others [2,3]. The usefulness of the IoT technology must also be explored from its potential to contribute to the development of environment and natural knowledge [4]. Especially in the field of education, IoT is mainly used in the field of computerization as a medium for learning and intelligent education [5]. Therefore, we need to be able to obtain clear information about IoT, especially the research developed of the education on natural sciences [6].

This paper provided a comprehensive overview of the present current state and trends of IoT in science education and research. We reported a bibliometric analysis of IoT publications in science education published between 2012 and 2020. We selected pattern on collaboration, major publications, major themes, and research trends. Cover the trend, the following research issues were the main focus of the bibliometric analysis; (i) In terms of the main research fields, significant publications, and collaboration patterns, how is the current situation of IoT in scientific education research? In terms of the usage of keywords in publication; (ii) what are the theme patterns in IoT on science education research?; (iii) What are the trends and directions of development for IoT in science research?.

2. Literature Review

IoT is a fast-expanding network of various "connected things," devices, or things that have given rise to a new era of the internet, anywhere anything like a concept of being connected with the internet and becoming 'smart' [7]. IoT is the most advanced technology that vanishes. They become so ingrained in daily life that it is impossible to tell them apart. [8]. IoT is a network of physically connected items. The phrase "Internet of Everything" is also used by some researchers to refer to both digital and physical objects [9].

IoT is a technology in schooling that has played an extensive role in connecting and instructing students. IoT technological know-how has a vital influence on the schooling field. IoT has no longer only changed the typical teaching practices but has also brought modifications to educational institution infrastructure [10]. The term IoT in education is considered two-faceted due to the fact of its use as a technological tool to decorate tutorial infrastructure and as a problem or path to instruct critical standards of computer science [11].

3. Method

This research is based on systematic quantitative research. To evaluate the literature on the IoT in the Education field, we employ bibliometric analysis to assess search results in Scopus on 23 May 2022, we ran an online search using the keywords {Internet of Things} and {Science Education} and in the topic area. The period of publication was 2012-2022. Keyword analysis and the title of the article were used

to analyze groups and themes for research utilizing Scopus sources in 7 categories. The database contains 54 articles relevant to the IoT in science education, including 35 conference papers, 13 articles, 4 conference reviews, and 2 reviews. In this study, sample articles retrieved in *CSV format from Scopus are processed using VOS viewer software to aid visualization and identify trends [11-13].

The center for science and technology studies created the VOS viewer, a piece of software for creating and viewing bibliometric networks. We can examine the distribution of publications by year and kind, trends in publishing time and type, productive nations and universities, and research fields that are being pursued at Leiden University [14]. The VOS viewer can also be used to evaluate any form of bibliometric network data, including the relationship between publications or journals in terms of citations, the collaboration between scholars, and the relationship in terms of joint emergence between scientific papers [15].

4.Results and Discussion

The smallest number of terms used in the studied research according to Scopus. After being analyzed there are 7 categories, they are by year, countries, affiliation, author, type, subject area, and funding sponsor (see Fig. 1).

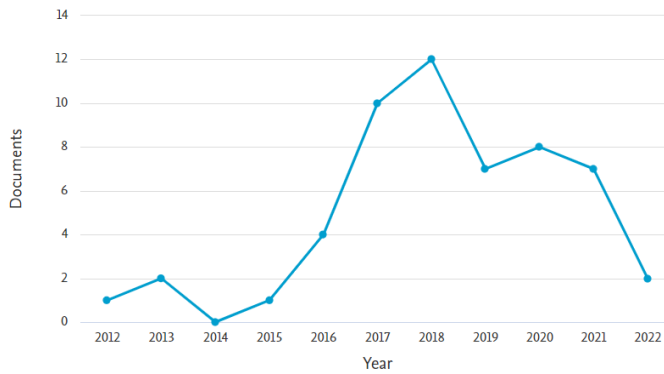


Fig. 1. Papers regarding IoT on science education published in one decade.

Counting papers by countries for keywords of “internet of things” in education, there are 18 countries having publications about IoT in science education. The countries are the US, Peru, China Greece Germany, Italy, Norway, Romania, United Kingdom, Finland, Ireland, Australia, Brazil, Canada, Colombia, Czech Republic, Egypt, India, Israel, Japan, Mauritius, Mexico, Namibia, Netherlands, New Zealand, South Korea, and Spain. The US is the country that publishes the most paper discussing the IoT in education (19 papers). The second country has 6 papers from Peru, and then China has 5 papers. But Indonesia has no paper publication. This opportunity is linked to research about IoT in science education. This statement came with results from the VOS viewer 1.6.18 application, about file CSV. Each cluster is divided as follows: the first cluster there are 5 items, the second cluster are 3 items and the third cluster are 3 items, there are red, green, and blue. The US has the most papers discussed IoT in science education, and they have networked with other countries. Table 1 presents the top ten countries for IoT in

science education research, but from the top ten. Figure 2 presents the US with China or Peru as the most active in collaborative research.

Table 1. Top ten countries/regions for IoT in science education research.

Country/Region	Freq.
United States	19
Peru	6
China	5
Greece	4
Germany	3
Italy	3
Norway	3
Romania	3
United Kingdom	3
Finland	2



Fig. 2. Visualization country using VOS viewer using network visualization.

Keywords are regarded as "content descriptors at macroscopic levels" [16] and can help to clarify the main research themes and research trends in IoT in science education. Topics in a field can be delineated by the keywords of pertinent publications [17]. According to the type of document issued, Fig. 3 shows a presentation of publications. Table 2 indicates the number of publications based on the kind of document. Conference papers are the most. There is a tremendous chance for this study to be explored and published, as well as how exciting it is to publish in credible conference papers. Following analysis with the VOS viewer, visualization and mapping are visible concerning Figs. 4, 5, and 6, respectively. The results produced using the keywords in the brief and abstract display groups of various studies in IoT in science education that form stem education. Overall, 76 terms are collected, however when you wish to highlight the IoT's most prevalent themes in STEM education. The help of bibliometric analysis can enhance research by combining many parameters. We can support future research to leverage the IoT in STEM with data.

Analysis data from Scopus (see Fig. 7) closely related to IoT in science learning is mostly about computer science (29.6%) [18], social science (24.1%) [19], engineering (17.6%) [20], and other subject areas (28.7%). But, IoT in science education is still limited to design, and literature for implementation in the classroom is still lacking. This provides a great opportunity to research science education that applies IoT-based STEM learning to the engineering process [21]. This result also confirms the effectiveness of bibliometric analysis [22-31] on the successful exploring and visualizing the current literature that can be used for deciding whether further research be done.

Table 2. The number of publications about IoT in science education.

By type	Frequency
Conference paper	35
Article	13
Conference review	4
Review	2

Documents by type

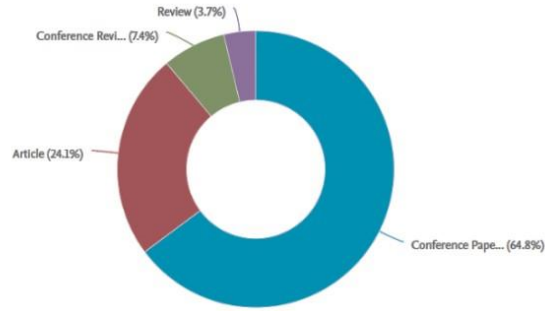


Fig. 3. Publications based on documents by type issued.

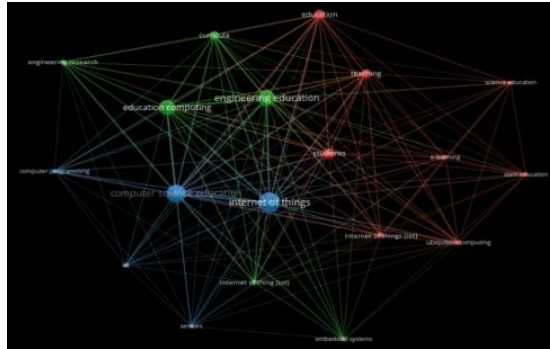


Fig. 4. Visualization topic area using VOS Viewer using network visualization about IoT in science education.

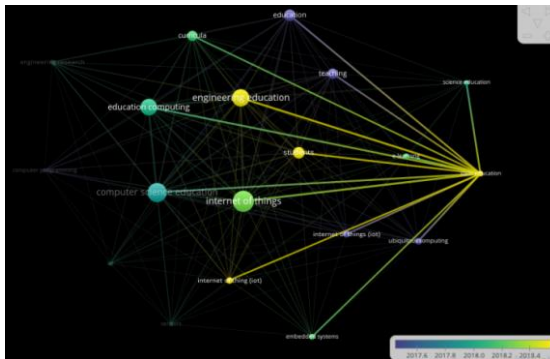


Fig. 5. Visualization topic area using VOS viewer using overlay visualization about IoT in science education.

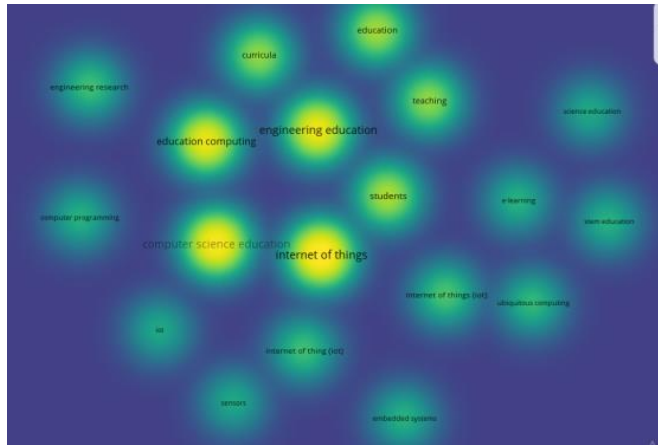


Fig. 6. Visualization topic area using VOS viewer using density visualization about IoT in science education.

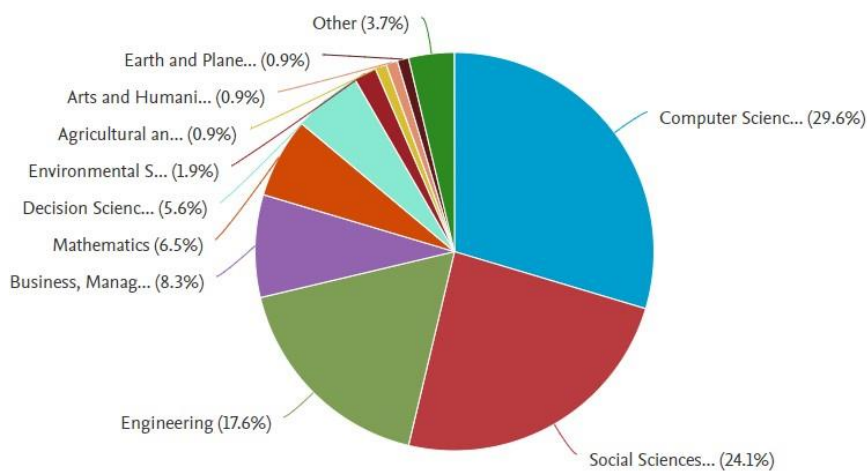


Fig. 7. Visualization of subject area from Scopus analysis.

5. Conclusion

We can conclude that from 2012 to 2022, there is a fluctuation in the research on IoT in science education. Only 12 articles have been published on this topic as of 2018. 52 article documents, in terms of document types, have been released. Articles, conference papers, and reviews are the types of documents that are most frequently researched as shown from the types or types of documents. The findings of this study's VOS viewer indicated three clusters that characterize the current three important research issues in the field. Based on data from Scopus and VOSviewer for IoT in science education, that means many opportunities that can be discussed IoT technology in social science.

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