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THE TRENDS OF STUDIES IN TECHNOLOGY-ASSISTED INQUIRY-BASED LEARNING: THE PERSPECTIVE OF BIBLIOMETRIC ANALYSIS

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Abstract

This study presents a bibliometric and bibliographic review of the studies of technology-assisted inquiry-based learning (IBL). A bibliometric approach using VOSviewer was used to conduct this study. 191 eligible and included documents published between 1999 - 2022 from the Scopus database were analysed using some main analyses such as performance, citation, co-authorship, and co-word supported by visualization and clustering analysis. The results revealed that the development of publications regarding technology-assisted IBL studies relatively soared from 1999 to 2020 while the development of citations related to the studies of technology-assisted IBL relatively fluctuated between 1999 and 2022. Furthermore, the United States relatively had the dominant influence in which most influential documents, authors, sources, and institutions affiliated with the United States. Moreover, most of the authors coming from the United States became the leaders in conducting the studies of technology-assisted IBL in the social interactions among authors and also countries. This study implies that the use of technologies such as websites, computers, robots, and video conferencing extremely supports educational practitioners such as teachers and lecturers in implementing IBL. Additionally, this study suggests exploring the trending research topic related to critical digital literacy, an essential cognitive skill.

Keywords: Bibliometric, Inquiry-based learning, Scopus, Technology, VOSviewer.

1. Introduction

Mastery of digital technology has become a necessity for the world of education in the 21st century. OECD report the development of internet technology and the rapid increase in users in the world accessing information requires people to be skilled in using digital devices to support their activities. The 21st-century skills are often referred to as life skills, including soft skills, transversal skills, critical skills, and digital skills [1]. The 21st-century skills can be consolidated into 5 main areas, namely communication skills, individual learning approaches, individual autonomy, and ICT and digital literacy [2].

The use of technology has become a demand that inevitably must be followed, not least in learning activities, several learning activities involve the use of technology or ICT such as hybrid learning models or those combined with certain learning models or approaches such as Inquiry-Based Learning (IBL). IBL is a learning way that emphasizes why an event occurred, the teacher teaches students about procedures and the use of knowledge and general principles through collecting and analysing data until the answers to the questions raised are found [3]. IBL has a focus on inquiry, which has been widely used in science pedagogy but tends to lag in mathematics pedagogy. Inquiry is a process of defining and investigating problems, formulating hypotheses, designing experiments, collecting data, and drawing conclusions about these problems. Furthermore, IBL as a pedagogical approach involves active students in knowledge construction through students creating answerable questions. In addition, IBL can be said to be a student-centred approach that focuses on questioning, critical thinking, & problem-solving with students active in formulating questions. In this research, the topic that will be studied is IBL which in its implementation uses technology assistance.

Currently, many studies implement IBL in learning, but there are still few studies reporting the development of research on the implementation of technology-assisted IBL. Therefore, in this study, the development of research on technology-assisted IBL will be studied using bibliometric analysis. Bibliometrics is a method of applying mathematics to books and other communication media which quantitatively analysed both mathematical and statistical methods [4]. This method is used for exploring and analysing large volumes of scientific data to present emerging trends in a topic or field [5]. There has been some bibliometric research that discusses inquiry as was conducted by Dewi et al. [6] focusing on web-based inquiry learning while this study focuses on technology-assisted IBL. As a consequence, this current study aims to present a bibliometric and bibliographic review of the studies related to technology-assisted IBL.

2. Method

To conduct this study, bibliometric analysis was employed. Fuad et al. [7] stated that there were five steps in carrying out a bibliometric analysis study. Firstly, define search keywords. Scopus database was used to search the keywords because the database had many well-qualified documents. Some combinational keywords such as “technology” and “inquiry-based learning” were employed to search the documents in which the keywords eased the document search that was suitable to the problems of this study. Secondly, conducting the initial search. The document search using the combinational keywords found 1.154 documents published between 1994 - 2023. The documents were sourced from journals, books,

conference proceedings, and book series which these documents consisted of articles, book chapters, conference papers, conference reviews, book, reviews, erratum, and short surveys. The publication stage of documents was final and the article was in press. The documents were written in English, Chinese, Portuguese, Spanish, French, Czech, Turkish, Dutch, Russian, Slovenian, and Lithuanian.

Thirdly, refining the search results. Some inclusion criteria were established to get the documents that were suitable for this study. Systematically, to select the documents which were suitable to the inclusion criteria, four steps were: (1) identification, (2) screening, (3) eligibility, and (4) inclusion. In the identification step, 1.154 documents were found in the Scopus database. In the screening step, there were only 804 documents that contained the keywords such as "technology" and "inquiry-based learning" in the document title. In the eligibility step, there were only 191 eligible documents. These documents were only written in English, sourced from journals, and only consisted of articles published between 1999 and 2022, and in the final publication stage. In the inclusion step, 191 eligible documents were included in this bibliometric analysis study.

Fourthly, the eligible and included documents were downloaded from the Scopus database in two formats such as Comma Separated Values (CSV) and Research Information System (RIS). Hudha et al. [8] argued that CSV and RIS contained bibliometric and bibliographical information. In addition, the RIS format opened in the Publish or Perish (PoP) software provided some information such as citation, document title, author, document type, source, publication year, and publisher [9]. Fifthly, there were several analyses used in this study such as performance analysis, citation analysis, co-authorship analysis, and co-word analysis [5]. PoP software was used to support the performance analysis. In addition, Networking and overlay visualization, and hierarchical clustering analysis were performed to enrich citation, co-authorship, and co-word analysis. The VOSviewer software was utilized to support those analyses [10].

3. Results and Discussion

3.1. Performance analysis

This analysis was used to present the development of publications and citations regarding technology-assisted inquiry-based learning studies in the period of 1999 - 2022 (See Fig. 1). Figure 1 shows that the development of publications related to technology-assisted inquiry-based learning studies relatively soared from 1999 to 2020 even though it underwent a decrease of the publication from 2020 to 2022. It was relevant to research that states that scientific publications in the field of social sciences and humanities tend to increase in the 90s to 2020s [11]. Meanwhile, from 2020 to 2022, during the Covid-19 pandemic era, the number of scientific publications decreased due to changes in the life and research subject focuses [12]. Furthermore, the documents had been cited as many as 4.592 times from 1999 to 2022. The development of citations to the studies regarding technology-assisted inquiry-based learning relatively fluctuated from 1999 to 2022. This result is supported by research conducted by Colavizza et al. [13].

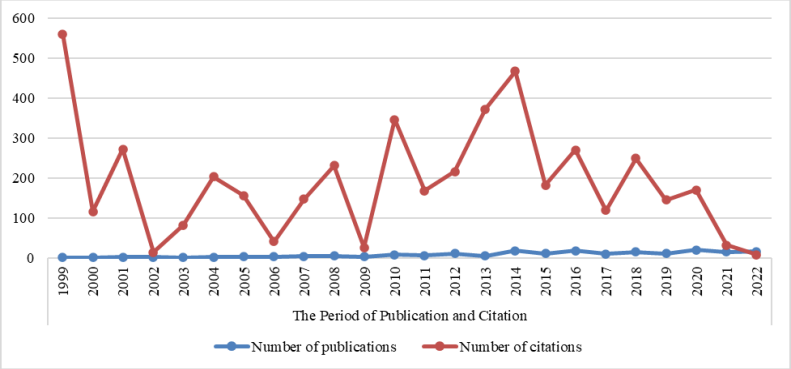

Fig. 1. The development of publication and citation of the studies about technology-assisted inquiry-based learning.

3.2. Citation analysis

This analysis was employed to show the most influential document, author, country, source, and institution related to the studies of technology-assisted inquiry-based learning between 1999-2022. The highest citation was used to present the most influential document, author, country, source, and institution [7]. Firstly, the document titled "addressing the challenges of inquiry-based learning through technology and curriculum design" was the most influential document related to technology-assisted inquiry-based learning in which the document written by Edelson et al. and published in the Journal of the Learning Sciences in 1999 had been cited as many as 560 times. Secondly, Edelson, D. C. was the most influential author affiliated with Northwestern University, United States in which the documents published by him had been cited as many as 813 times. Thirdly, the United States was the most influential country related to the studies of technology-assisted inquiry-based learning and the documents published by the country had been cited as many as 2.432 times.

Fourthly, the Journal of Research in Science Teaching was the most influential source in which the documents published by Emerald Group Holding Ltd had been cited as many as 721 times. Fifthly, the Centre for Technology in Learning was the most influential institution affiliated in the United States by which the documents published by the institution had been cited as many as 565 times. The highest citation document is obtained by the document entitled "Addressing the challenges of inquiry-based learning through technology and curriculum design" from the United States of America (USA). Furthermore, the USA become the highest citation country that published technology-assisted inquiry-based learning studies. In addition, the highest citation author, source, and institution is also affiliated with the USA. As we know the USA is well known for the constructivism introduced by John Dewey (an American philosopher) as a root of inquiry-based learning theory [14].

3.3. Co-authorship analysis

This analysis was used to present the social interactions among authors and their countries related to the studies of technology-assisted inquiry-based learning. Firstly, co-authorship analysis in the unit of the author was conducted by selecting

the minimum number of documents of an author as many as 2 authors which appeared as 40 inter-connected authors (See Fig. 2).

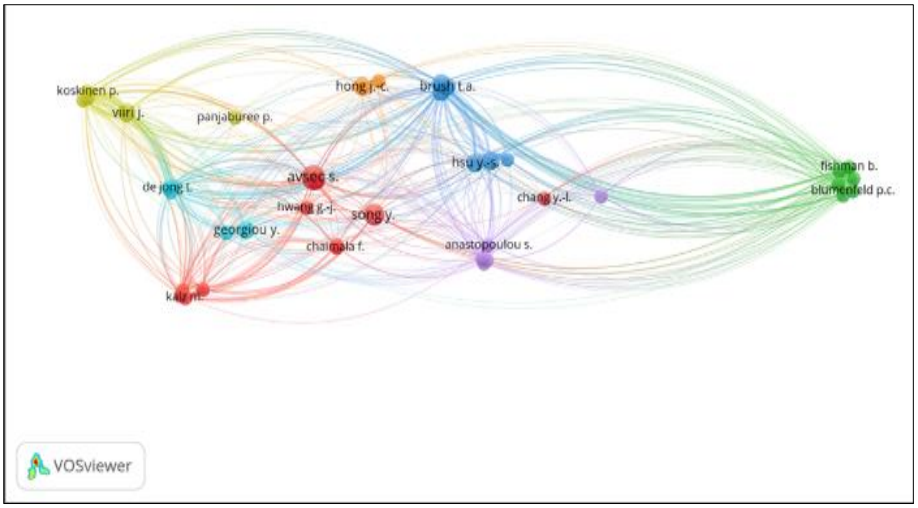

Fig. 2. Network visualization of co-authorship analysis in the unit of the author.

Figure 2 shows that there were eleven authors distributed in the red cluster such as Avsec, S., Chaimala, F., Chang, Y. I., Firssova, O., Hwang, G. J., Kalz, M., Kocijancic, S., Prisen, F., Song, Y., Specht, M., and Ternier, S., followed by six authors in the green cluster such as Blumenfeld, P. C., Fishman, B., Geier, R., Krajcik, J. S., Marx, R. W., and Soloway, E., six authors in the blue cluster such as Brush, T. A., Glazewski, K. D., Hong, J. C., Hwang, M. Y., Shin, S., and Wentworth, N., five authors in the yellow cluster such as de Jong, T., Georgiou, Y., Gillet, D., Kyza, E. A., and Rodriguez-Triana, M. J., five authors in the purple cluster such as Hamalainen, R., Koskinen, P., Lamsa, J., Panjaburee, P., and Viiri, J., five authors in blue sky cluster such as Anastopoulou, S., Edelson, D. C., Kerawalla, I., Mulholland, P., and Scanlon, E., and two authors in the orange cluster such as Hsu, Y. S., Wang, C. Y., and Zhang, W. X.

Secondly, co-authorship analysis in the unit of country was conducted by selecting the minimum number of documents of a country as many as 1 country in which it appeared 42 inter-connected countries (See Fig. 3). Figure 3 presents that there were nine countries distributed in red cluster such as Belgium, Brazil, Cyprus, Czech Republic, Israel, Oman, Sweden, Turkey, and United States, followed by eight countries in green cluster such as Australia, Austria, Bulgaria, Estonia, Germany, Greece, Netherlands, and Switzerland, eight countries in blue cluster such as Finland, Indonesia, Italy, Poland, Russian Federation, Slovakia, Taiwan, and Thailand, six countries in yellow cluster such as China, Hong Kong, Ireland, Singapore, Slovenia, and South Korea, four countries in purple cluster such as Malaysia, Nigeria, Philippines, and South Africa, three countries in blue sky cluster such as France, Tunisia, and United Kingdom, two countries in orange cluster such as Canada and Spain, one country in brown cluster such as Romania, and one country in pink cluster such as New Zealand.

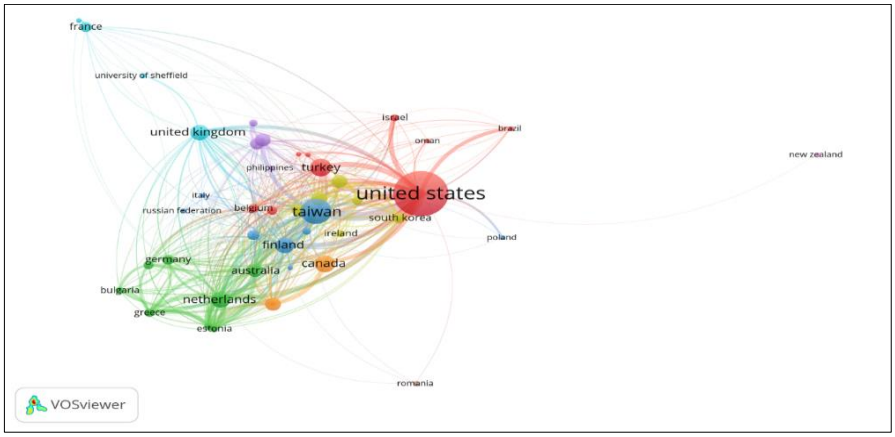

Fig. 3. Network visualization of co-authorship analysis in the unit of the country.

3.4. Co-Word Analysis

This analysis was used to present the frequently appearing keywords related to the studies of technology-assisted inquiry-based learning and show the distribution of the emerging keywords from 1999 to 2022. Firstly, this analysis was carried out by selecting the minimum number of occurrences of a keyword as many as 2 keywords. As a result, it emerged 65 inter-connected keywords (See Fig. 4).

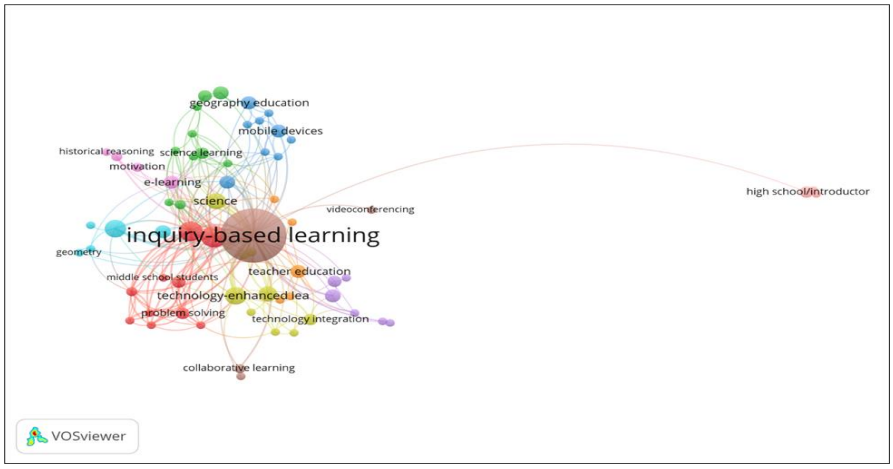

Fig. 4. Network visualization of the most emerging keywords regarding technology-assisted inquiry-based learning.

Figure 4 shows that there were some themes or topics that could be grounded such as learning types, technology types, cognitive skills, affective skills, research participants, educational field, and scientific field. Some technology types such as computers, robots, websites, and video conferencing support the IBL implementation in which technology-assisted IBL is implemented to enhance some cognitive and affective skills such as problem-solving, critical thinking, historical

reasoning, technological literacy, artificial intelligence, metacognition, collaboration, reflection, and motivation. Additionally, the intervention of technology-assisted IBL mostly implements in science education, mathematics education, engineering education, and technology education for urban students in primary school, secondary school, and higher education. A bibliometric analysis study conducted by Dewi et al. [6] also revealed that the implementation of inquiry learning in science learning utilizes the website as a technological support. It indicates that the utilization of the website in supporting science learning by implementing IBL is the trending research related to technology-assisted IBL. Secondly, overlay visualization analysis was carried out by selecting the minimum number of occurrences of a keyword as many as one keywords. As a result, it emerged 887 inter-connected keywords (See Fig. 5). Figure 5 presents that some keywords were appearing in the recent period such as "mobile application", "learning technology", "technology concept", "teaching systems", "5E model", "critical digital literacy", "curriculum confidence", and "cryptocurrency technology". Moreover, the keyword "critical digital literacy" emerged in the most current period specifically in June 2022. This shows that critical digital literacy is a trending cognitive skill that becomes the development focus in the studies of technology-assisted IBL. It indicates that critical digital literacy becomes the focus of many educational researchers by implementing IBL or discovery learning.

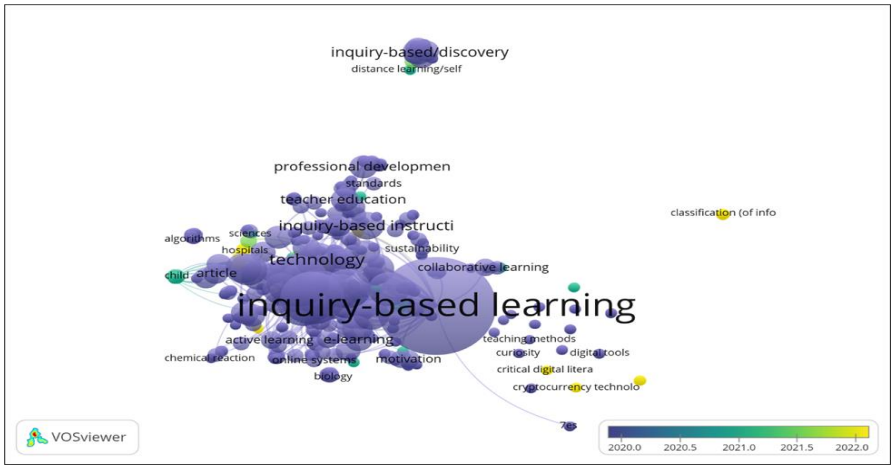

Fig. 5. Overlay visualization of the most emerging keywords regarding technology-assisted inquiry-based learning.

This result also confirms the effectiveness of bibliometric analysis to explore and visualize the current literature that can be used for deciding whether further research be done, as this study has been reported by other papers [15-51].

4. Conclusion

191 documents related to the studies of technology-assisted IBL analysed using the bibliometric analysis reveal that the development of publications regarding technology-assisted IBL studies relatively soared from 1999 to 2020 while the development of citations related to the studies of technology-assisted IBL relatively fluctuated between 1999 and 2022. Furthermore, the United States relatively had

the dominant influence on the studies of technology-assisted IBL which is the most influential document, author, source, and institution-affiliated in the United States. Moreover, most of the authors coming from the United States became the leaders in conducting the studies of technology-assisted IBL in the social interactions among authors and also countries. Hereinafter, the utilization of some technologies such as robots, computers, websites, and video conferencing support the implementation of technology-assisted IBL in which the use of the website in supporting the intervention of technology-assisted IBL is mostly employed. In addition, critical digital literacy became the main focus in the studies of technology-assisted IBL. This study implies that the use of technologies such as websites, computers, robots, and video conferencing extremely support educational practitioners such as teachers and lecturers in implementing IBL. Additionally, this study suggests exploring the research topic related to critical digital literacy because it is an essential cognitive skill that has to be enhanced in the learning process specifically in the implementation of IBL.

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