Trends in 10 Years of Implementation of Inquiry Learning – STEM in Science Learning: Bibliometric Analysis Research

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Abstract. Dynamic changes in the 21st century trigger education to produce a better generation as the nation's successor. Inquiry-STEM is a learning model to solve problems based on STEM aspects, namely science, technology, engineering, and mathematics. The aim of this study is to analyze the application of the inquiry learning model that integrates STEM in science learning from the bibliometric distribution. The analysis was carried out by taking data sourced from the Scopus database using the keywords "inquiry, STEM, science education learning n " in 2014–2024. Data mapping is done using the VOS Viewer software. The data obtained was 320 documents sourced from the Scopus database in the form of articles (not conference papers). So, from the data obtained, the most significant relationship by applying the integrated inquiry learning model in the context of science learning is the topics of critical thinking skills, science literacy, motivation, creativity, problem-solving skills, and cooperation. The subject matter that is widely used is related to the topic of alternative energy. In addition to the discovery-based learning model, other learning models integrated with STEM are discovery, problem-based, project-based learning. Science learning activities that apply the inquiry-STEM model are experimental activities both in the laboratory and outside the laboratory.

Keywords: Bibiliometric Analysis, Inquiry-STEM, Science Learning.

1 Introduction

Education is one of the key elements in the progress of a nation. In welcoming the latest technology and communication that is growing, the improvement of the quality of human resources also continues to be pursued in order to form an intelligent, skilled, independent, and characterful person [1]. One way to improve the quality of education in Indonesia, especially in formal education is by using the “Merdeka” curriculum. The merdeka curriculum aims to increase the curiosity of learners and spur students to be more active. In the merdeka curriculum, each educational unit carries out planning, process implementation, and learning assessment to

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improve graduate competence. Therefore, teachers need to understand the models, methods and approaches used to develop learning in the classroom.

One of the prioritized learning models in the implementation of the 2013 curriculum is inquiry learning [2]. Inquiry learning is an innovative learning model that encourages students to investigate, collaborate in research, and create projects by applying their knowledge to discover new things, master technology, and be able to solve problems[3]. Inquiry that are carried out can be individually or in groups that are done within a certain period of time collaboratively, produce products, and the results are then presented or displayed. Inquiry learning is a form of instruction centered on three principles of constructionism, namely 1) learning is a specific context, 2) students are actively involved in the learning process, and 3) students achieve their goals through social interaction and sharing knowledge and understanding [4]. The application of inquiry learning can be combined with a STEM approach because of its characteristics that emphasize more on process design with a systematic approach to solving problems [5].

Science is an empirical science, which means that every aspect studied in science is based on observations of science phenomena [6]. Science can be understood and obtained from the results of research, experiments, measurements, and presented mathematically[7]. The purpose of learning science is for students to be able to master the concepts of science and their interrelationships and be able to use scientific methods based on scientific attitudes to solve the problems they face. Based on data compiled, the solution to the problem of the quality of Human Resources and competitiveness between countries in developed and developing countries is STEM education[8]. STEM which is an acronym for *Science Technology Enginering Mathematic* integrates science, technology, engineering / engineering, and mathematics that are still related to the world of work and experience in everyday life [9]. STEM also provides opportunities for students to apply concepts and knowledge from different disciplines in order to solve real-world problems[10]. In its application to the science learning process, STEM can be supported by various learning models, this is because of the integrative nature of STEM.

Inquiry learning integrated STEM is a learning model that uses projects to solve problems based on STEM aspects. Several studies show that there are several topics of application of Inquiry Learning – STEM in science learning, including to improve critical thinking [11], [12], [13],[14] to improve problem-solving skills[15], [16], [17]. The use of STEM approaches is also integrated with *i*nquiry learning model. Based on this background, the purpose of this study is to analyze the application of the STEM-Inquiry Learning model in science learning in terms of mapping bibliometric distribution using the Scopus database using VOS Viewer software. In addition, the study also aims to find out the 5 best articles and the top five authors from the Scopus database

2 Research Methods

This research is a literature study that is analyzed using bibliometric analysis guidelines. The data used in this study was sourced from the Scopus database (http://scopus.com). Scopus was chosen because it is the largest academic database globally with citations presenting abstracts from various reviewed science and research literature[18]. So, the Scopus database is effective for visualizing, tracking and analyzing research. Data collection was carried out on July, 2024 through the official Scopus website with keywords from the title and abstract "inquiry", "STEM", and "science learning" from 2014 to 2024.

The data obtained is in the form of publications based on numbers each year, authors, and journals containing science articles. Next, the search results are formed sample data downloaded in .ris and .csv format. This study was analyzed using VOS viewer software from three types of mapping generated, namely network visualization, *overlay* visualization and density visualization. Based on the search results using the Scopus database, 321 documents were obtained. It then determined the top five SSI-related articles based on the number of citations. Trends in the development of international research on inquiry learning models integrated in science learning were analyzed using VOS Viewer software with network visualization and density visualization.

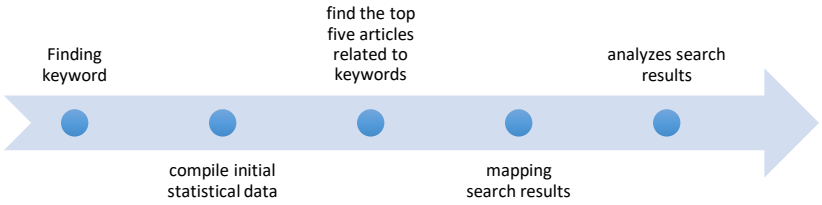

Fig. 1. Stages of research with bibliometric analysis.

3 Result and Discussion

The results obtained were 321 documents for research on inquiry learning models integrated with STEM in science learning in the Scopus database. Articles are selected from issues from the beginning of 2014 and those published in 2024 at the latest. The specific results are in Table 1. Based on the number of article citations, search results are obtained by the top five articles.

Table 1. Top Five Articles from Scopus Data.

Tittle	Writer	Publication	Number of Citation
From STEM to STEAM: Cracking the Code? How Creativity & Motivation Interacts with Inquiry-based Learning	Conradty, C., Bogner, F.X.	Creativity Research Journal	59
Design and validation of inquiry-based STEM learning strategy as a powerful alternative solution to facilitate gifted students facing 21st century challenging	Abdurrahman, Ariyani, F., Maulina, H., Nurulsari, N	Journal for the Education of Gifted Young	48
Using educational data from teaching and learning to inform teachers' reflective educational	Sergis, S., Sampson, D.G., Rodríguez-Triana, M.J., Gillet, Denis, Pelliccione, L.,	Computers in Human Behavior	42

design in inquiry-based STEM education	de Jong, T.		
Effects of 6E-oriented STEM practical activities in cultivating middle school students' attitudes toward technology and technological inquiry ability	Lin, K.-Y., Hsiao, H.-S., Williams, P.J., Chen, Y.-H	Research in Science and Technological Education	33
The effects of STEM education on scientific process skills and STEM awareness in simulation based inquiry learning environment	Sari, U., Duygu, E., Şen, O.F., Kirindi, T.	Journal of Turkish Science Education	32

From the results of Conradty et al. research in 2019, it is believed that STEM (science, technology, engineering, and arts) courses will improve and make science classes more appealing. A cross-disciplinary STEAM curriculum that incorporates inquiry-based learning was introduced to a group of 160 pupils. The results suggest that investigating the promotion of motivation and creativity in educational settings can begin with nurturing creativity, such as in STEAM environments [19]. Almost similarly, research conducted by Abdurrahman et al. (2019) the design and operational aspects that were crucial for the expressive function of the learning strategy in a field research of an inquiry-based STEM learning strategy. According to the study's findings, talented students' skills could be enhanced by using an inquiry-based STEM learning approach in line with 21st century learning frameworks[20]. Meanwhile, research conducted by Sergis, et al (2019) to explore the use of educational data analytics techniques and resources from the design and implementation of inquiry-based instructional designs (IED) based STEM to facilitate this methodical reflection process. The methodology's outcome allows us to positively evaluate our approach's ability to analyze IED and offers preliminary proof that the insights produced give statistically significant indicators that influence students' behavior when these IED are being delivered [21]. Meanwile Lin, Kuen-Yi et al (2020) the result about technology teachers should think about improving the 6E-oriented STEM practical activity process in order to help students perform better in these two areas: attitudes toward technology and technological inquiry skills [22].In fifth place is an article from the research of Ugur Sari, et al (2020) it seems that simulations based inquiry learning are effective for integrating STEM activities and developing students' scientific process skills [23].

Based on the number of top article citations, the search results show that articles that often appear in Inquiry Learning STEM topics. From the results of VOS Viewer it is known that there are 117items. Of the 117 items, there are divided into 6 clusters.

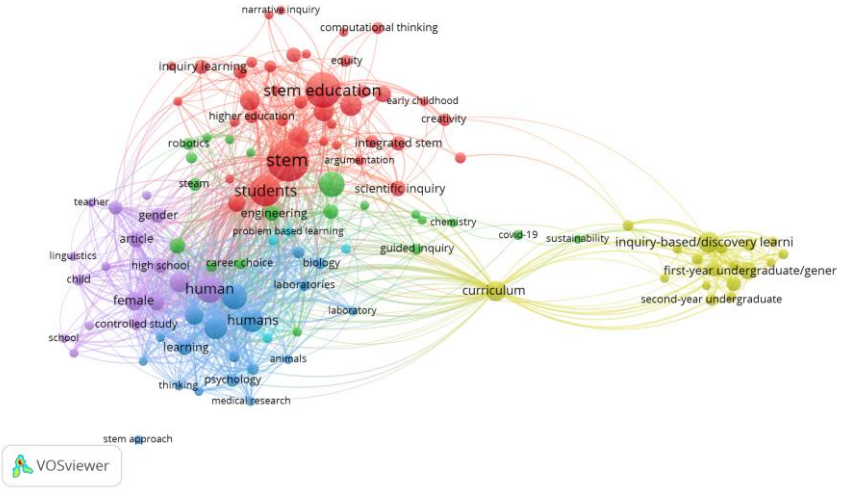

Fig. 2. Results of Inquiry STEM keyword mapping using VOS Viewer

Based on analysis using VOS Viewer through network visualization, there are 6 clusters/clusters (red, green, blue, yellow, purple, and light blue). Figure 2 that show the relationship between one topic and another. Cluster 1 is indicated by the color red which has a very close relationship with, inquiry, inquiry learning and integerated model of STEM. Cluster 2 with green color is closely related to the student skill in inquiry model for example active learnin and science literacy. Cluster 3 in blue is related to the effect of inquiry and STEM learning. Cluster 4 is yellow about application of STEM education. Cluster 5 is purple with the main topic of gender. Cluster 6 in light blue is related to other model learning (problem based learning, project based learnig) and there are still 6 other clusters related to integration and other topics.

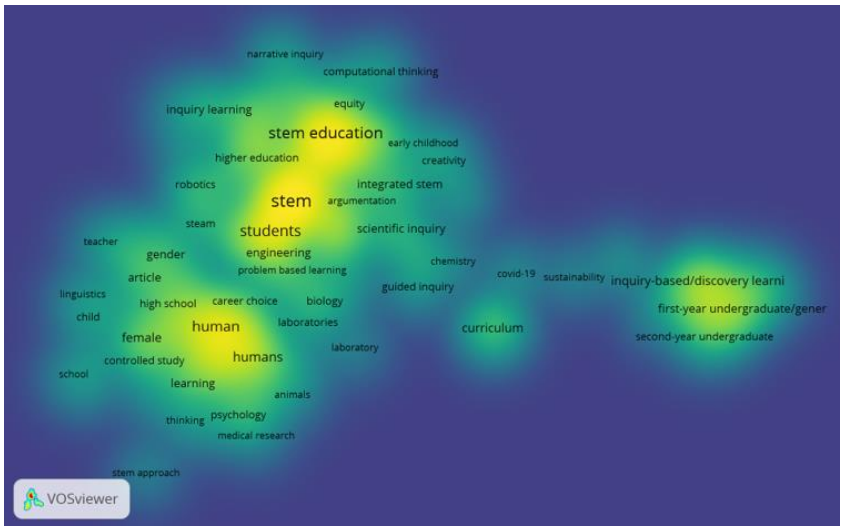

Fig 3. Density visualization using VOS Viewer

Based on the search result words, the keyword STEM and STEM education most often appears in several research articles indicated by the appearance of keywords in the yellow section (Figure 3). In addition, the words "inquiry learning" and "student " are also opaque yellow. This indicates that the topic of Inquiry-STEM learning models and science has appeared quite a lot in titles and abstracts in several scientific articles. On the other hand, one of the keywords that still rarely appears includes the words curriculum, gender, scientific literacy, and many other words shown in green. Research topics based on the time the research article was published are shown in Figure 4.

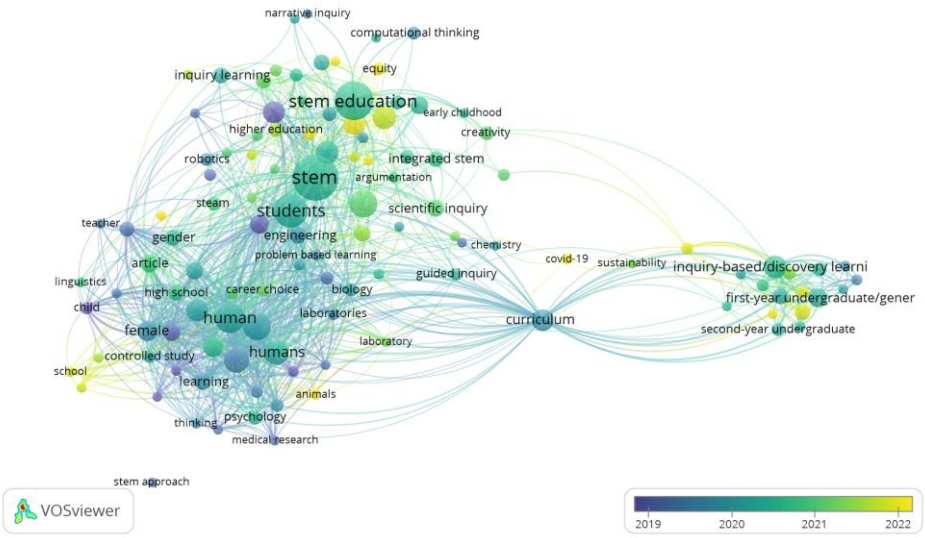

Fig. 4. Inquiry-STEM research topics by year

The latest research topics related to the main keywords (Inquiry – STEM) include web based learning [24], critical thinking [25], inquiry learning, school, and many others.
In the context of education the results of this research are expected to be taken into consideration for teachers to be able to apply the STEM integrated inquiry model in the context of learning and the basis for the development of teaching materials, especially on science topics. The results of studies conducted by several researchers also show that by combining inquiry learning with STEM approaches, students become trained to integrate several disciplines in the problem-solving process in everyday life. This has an impact on improving students' thinking skills and skills that are useful in preparing competencies to face the world of work

4 Conclusion

The implementation of Inquiry Learning– STEM model in science learning, especially science, has a broad correlation. This is evidenced by the results of VOS Viewer which shows that there are many links or networks (in one cluster) including high school students' words, critical thinking, problem solving, creativity, science laboratories, alternative energy, web-based

learning, curriculum, and learning. So from these results, it can be concluded that the relevance of applying the Inquiry – STEM model in the context of science learning is dominated by learning tools and skills. The science material taught is related to alternative energy (for example solar energy).

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