

Research and Trend on STEM Education in Indonesia: A Systematic Review Based on Bibliometric Mapping (2000-2020)

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ABSTRACT

In recent years, education on Science, Technology, Engineering and Mathematics (STEM) has become a major concern in the world, including in Indonesia. This study will analyze the productivity and development of scientific research on STEM education in Indonesia which has been published in the Scopus database for the period 2000-2020. There were 219 scientific publications taken from the Scopus database for analysis using the bibliometric method and graphic visualization using the VOSviewer (VOS) application. The findings show that the trend of STEM education research in Indonesia began in 2016 and has experienced significant growth in the last three years (2018-2020) with the number of publications reaching 93.1% of all scientific articles. Researchers in Indonesia tend to publish their work to conference papers or proceeding articles (87.2% or n = 191) and very few are published in journal articles (12.8% or n = 28). Metadata analysis using VOSviewer shows various research topics related to STEM education and there are three main focuses of STEM research in Indonesia, namely on students, engineering education and computing education.

Keywords

Indonesia, bibliometric, scopus, STEM Education, VOSviewer

Introduction

The idea of STEM education (Science, Technology, Engineering and Mathematics education) began in the 1990s, originated from the National Science Foundation in the United States, as well as in the European Union. This field is used to understand the interaction of science, technology, engineering and mathematics disciplines from the education viewpoint and responding to demands arising from society (Ardianti et al., 2020). This has resulted in several countries that have the potential to become industrialized begin to intensify their efforts in terms of science and technology development at the educational and industrial levels (Ferrada, 2019). The main objective of STEM education is to construct multidisciplinary knowledge, a set of skills and viewpoints that are aligned with the needs of young people. This type of education has the function of forming a productive and ethical personality in a future work that is dynamic, complex, challenging, and adaptive to the social and political environment. (Bower & Stevenson, 2020).

STEM education could be very critical to be implemented to develop current technology

(Hudha et al., 2019) and has extensive implications in arranging appropriate curricula, providing teachers with the vital expert improvement, and developing countrywide education policies and requirements (Holmlund, 2018; Hsu, 2019; Khuyen, 2020).

The advancement of STEM education will resulting beneficial effect on academic achievements and improvement of students' competencies (Batdi et al., 2019). Education of science, technology, engineering, and mathematics (STEM) has received increasing attention over the past decades and is becoming important in many countries around the world (Barakabitze, 2019; Ha et al, 2020; Lee, 2019; NRC, 2014;). STEM education has undergone substantial shifts and developments (Dare et al., 2019; Huet, 2018). This can be seen through the fast elevation in the number of publications about STEM education in recent years (Li et al., 2020; Margot & Kettler, 2019; Gil-dom & Berbegal-mirabent, 2020).

As a large country, Indonesia which has abundant natural and human resources is considered a nation playing a key role in the improvement of science and technology (Chai et al., 2020). so that STEM education can be applied by utilizing STEM principles as the basis for learning and developing the potential of students

(Ardianti et al., 2020). Investigations of the STEM education movement in Indonesia are quite rare. Specifically, more analysis of particular journal can encourage other researchers to share their knowledge regarding STEM education in Indonesia (Nugroho et al., 2019). Although many studies provide an overview of various aspects of STEM education in Indonesia (Khotimah et al., 2021; Wahono & Chang, 2019), there has been no attention to look at research trends and developments of STEM education in Indonesia that analyze the state of the art from a bibliometric viewpoint.

Bibliometrics techniques have been used mainly by scientists as information to study the growth and distribution of scientific articles (Hernández-torrano & Ibrayeva, 2020). Bibliometric studies are used to identify trends and identify patterns that can help define progress and determine the level of scientific development of a particular topic (Cardona et al., 2017; Melchiorson, 2019). Evolution and development analysis of the scientific domain of these results is very important because the bibliometric approach can provide useful information about the latest evolution of data-based literature (Bran, Grossek, & Gabriel, 2019). This study provides a bibliometric overview of academic research developed in STEM education over the last few years (Gil-Doménech, 2020). Despite the prior aims of VOSviewer to analyze bibliometric networks, VOSviewer can actually be used to produce, depict, and explore maps depending on particular type of network data ((Deshpande & On, 2020; Eck & Waltman, 2017).

Recognizing the current focus on STEM education is very attractive

and requires special attention in analyzing its growth in Indonesia. This study aims to fill this gap by providing an overall picture of the current state and development of research on STEM education in Indonesia using the bibliometric method. The research was carried out on the latest publication of STEM education in Indonesia. Because that researchers try to answer these problems by exploring the following questions: What is the research development overview of STEM education in Indonesia? and What are the major research directions and developmental trends in this period (2000-2020)?.

Methodology

The method used in this study is focused on content and bibliometric mapping analysis (Agbo et al. 2021) to map the published works on STEM education utilizing metadata downloaded from scopus (www.scopus.com) as the universal link of Scopus database. Scientific studies are most commonly used in bibliometric and scientometric studies (Mongeon & Paul-Hus, 2016). Scopus includes more than 8.5 million Open-Access articles and 9 million Conference papers in the sciences, social sciences, humanities, and arts, and holds more than 74 million notes and 1.5 billion cited references published from the 1900s through currently (www.elsevier.com/scopus).

In this study we used a general bibliometric workflow of analysis consisting of 5 (five) stages: (Zupic & Čater, 2015; CT Ha, 2020).

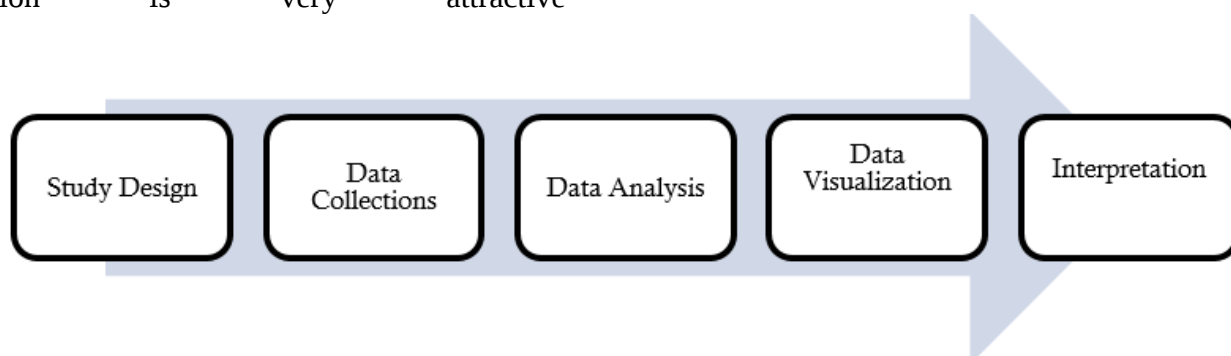


Figure 1. Bibliometric analysis workflow

In the first stage (study design), our primer research query was: Bibliometric publications in STEM education written by Indonesian researchers which are Scopus-indexed from 2000 to 2020. Systematic literature

review and content analysis provide relevant insights into themes, methods and theoretical foundations. STEM education research. However, the scope of research that can be examined using this method is limited, and the

process is very time consuming. Another method of mapping research fields is the bibliometric review, which uses "a set of quantitative methods to measure, track, and analyze the academic literature." (Roemer & Borchardt, 2015).

The data collection stage is carried out by collecting data from the Scopus database then the data obtained is filtered to get data that is ready to be analyzed . The data retrieval uses the Scopus-derived Algorithm-derived String Search Combination database, that is applying the search keywords in the citation to the title, abstract and keyword, also limiting the timeframe to 2000-2020. this method useful for getting publication results related to what you want to search. (CT Ha, 2020).

Query string data via Scopus as follows:

TITLE-ABS KEY (stem AND education OR learning) (TITLE-ABS-KEY(STEM AND education OR learning) AND PUBYEAR > 2000 AND PUBYEAR <2021 AND (LIMIT-TO (AFFILCOUNTRY,"Indonesia")) AND (LIMIT-TO (SUBJAREA,"PHYS") OR LIMIT-TO (SUBJAREA,"SOCI") OR LIMIT-TO (SUBJAREA,"ENGI") OR LIMIT-TO (SUBJAREA,"MATH")) AND (LIMIT-TO (PUBSTAGE"final")) AND (LIMIT-TO (DOCTYPE, "cp") OR LIMIT TO (DOCTYPE, "cp"))

The number of frequencies used to identify the dynamics of trends in publication and citation on STEM education in Indonesia. The frequency of publication sequences and data citations is used to identify leading authors, institutions, and countries, as well as core journals and the most influential publications in the field (Bran et al., 2019). For advanced analysis, we select and take information data from the results into CSV format (.csv file) to conduct analysis on the bibliometric tool. Microsoft Excel is used to summarize data in various stages and the VOSViewer software (Singh, 2021; Yu et al., 2020). VOSViewer (www.vosviewer.com) is an available and free of charge software for producing and visualizing bibliometric maps depending on network data (Eck & Waltman, 2017).

Results and Discussion

The results show that from 2000 to 2015 nothing a single article regarding STEM education in Indonesia published. Articles publication about STEM education in Indonesia was began in 2016, and the publications number increased annually until 2020. The number of papers published was 219 (27 articles and 192 conference papers).

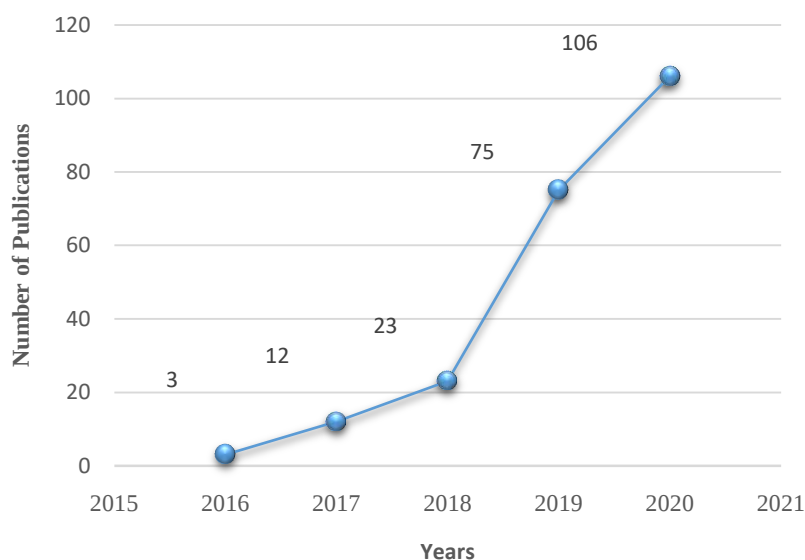


Figure 2. Distribution of STEM education publications in Indonesia since 2015-2021

The results show that study of STEM education in Indonesia has developed significantly since 2018, and the many recent STEM education publications also show that STEM education research has received recognition from various journals and

proceedings for publication as a groundbreaking and worthwhile topic. Figure 2 depicts the first publications of STEM education in Indonesia began in 2016 and the number has elevated gradually until 2017 (12 articles); from 2018 to

2020 there was a striking elevation up to 106 articles, this also indicates that STEM education research in Indonesia has received great attention by researchers in Indonesia.

Most Productive and Influential Institutions

Table 1. Shows on developments and provides interesting insights into the status of research on STEM education in Indonesia. Table 1 presents the institutions that have led the development of research on STEM education in Indonesia. Only institutions with 9 or more publications are listed.

Universitas Pendidikan Indonesia is the institution with the topmost number of

publications in the STEM field. This institution has a significant difference articles number with Universitas Lampung (rank 2). Meanwhile, between the University of Lampung (rank 2) to Universitas Negeri Padang (rank 10), the number of articles produced has a slight difference. In addition, Syiah Kuala University only produced articles in 2020. Universitas Pendidikan Indonesia experienced a fluctuation in the number of publications, but the number of publications in 2019 and 2020 are significantly higher than prior years.

Table 1 . Top Ten Universities with Highest Publications on STEM Education in Indonesia

Rank	Institution	Articles	2016	2017	2018	2019	2020
1	Universitas Pendidikan Indonesia	57	3	9	6	23	16
2	Universitas Lampung	18				1	17
3	Universitas Negeri Semarang	17				6	11
4	Universitas Negeri Malang	14			4	2	8
5	Universitas Syiah Kuala	13					13
6	Universitas Sebelas Maret	13		1	5	2	5
7	Universitas Jember	10				1	9
8	Universitas Negeri Surabaya	10			3	3	4
9	Universitas Negeri Yogyakarta	9				1	8
10	Universitas Negeri Padang	9				4	5

Most Influential STEM Education Conference Journals and Papers in Indonesia

To investigate the most influential journals regarding STEM Education, below shown Table 2 enlisting Top 5 active journals which have been

publishing articles about STEM education. The table consists several information regarding those journals. Journals are ranked depending on the number of published papers.

Table 2. Top Five Most Active Journal Publishing and Conferences of STEM Education in Indonesia

Rank	Journal	Country	Articles	2016	2017	2018	2019	2020
1	Journal Of Physics Conference Series	United Kingdom	176		9	19	59	89
2	AIP Conference Proceedings	United States	15		3		7	5
3	Jurnal Pendidikan IPA Indonesia	Indonesia	9	3		1	2	3
4	Journal for The Education of Gifted Young Scientists	Turkey	6				3	3
5	Universal Journal Of Educational Research	United States	2					2

Table 2. shows distribution of publications on STEM education in Indonesia. Most of the research results are published in scientific conferences with the results of proceedings, namely the Journal of Physics Conference Series (176) and followed by publication in the AIP Conference Proceedings (15), while publications with luran in the form of Scopus indexed journals have not received deep attention for STEM education research in Indonesia. although there are, it can be said that very few publications are published in the international journal Scopus. This can be seen in the publication of articles in the Indonesian Journal of Education, with only 9 articles. In the Journal for The Education of Gifted Young Scientists, Indonesian researchers

published 6 articles and the Universal Journal of Educational Research contained 2 articles.

Most Productive and Influential Authors

Another significant concern in bibliometric analysis is determining the most influential authors in particular field. Table 3 shows 10 most productive Indonesian authors in the scope of STEM education. Top author is Abdurrahman, from the Universitas Lampung (Unila) with 13 articles. Furthermore, there are 6 authors with a total citation index of >100. Universitas Pendidikan Indonesia has the most numerous authors with 4 authors.

Table 3 . Top Ten Most Productive Indonesian Authors in the Scope of STEM Education

Rank	Author	Institution	Number of Articles	H-Index	Total Citations
1	Abdurrahman	Universitas Lampung	13	10	261
2	Suwarma, IR	Universitas Pendidikan Indonesia	10	3	30
3	Permanasari, A.	Universitas Pendidikan Indonesia	8	10	249
4	Irwandi, I.	Universitas Syiah Kuala	6	7	223
5	Kaniawati, I.	Universitas Pendidikan Indonesia	6	10	320
6	Rustaman, NY	Universitas Pendidikan Indonesia	6	6	103
7	Sumarni, W.	Universitas Negeri Semarang	6	5	70
8	Parno	Universitas Negeri Malang	5	3	20
9	Ramli, R.	Universitas Negeri Padang	5	6	129
10	Wiyanto	Universitas Negeri Semarang	5	4	54
10	Yuliati, L.	Universitas Negeri Malang	5	6	68

Map Visualization of STEM Education Journals with VOS Viewer Software

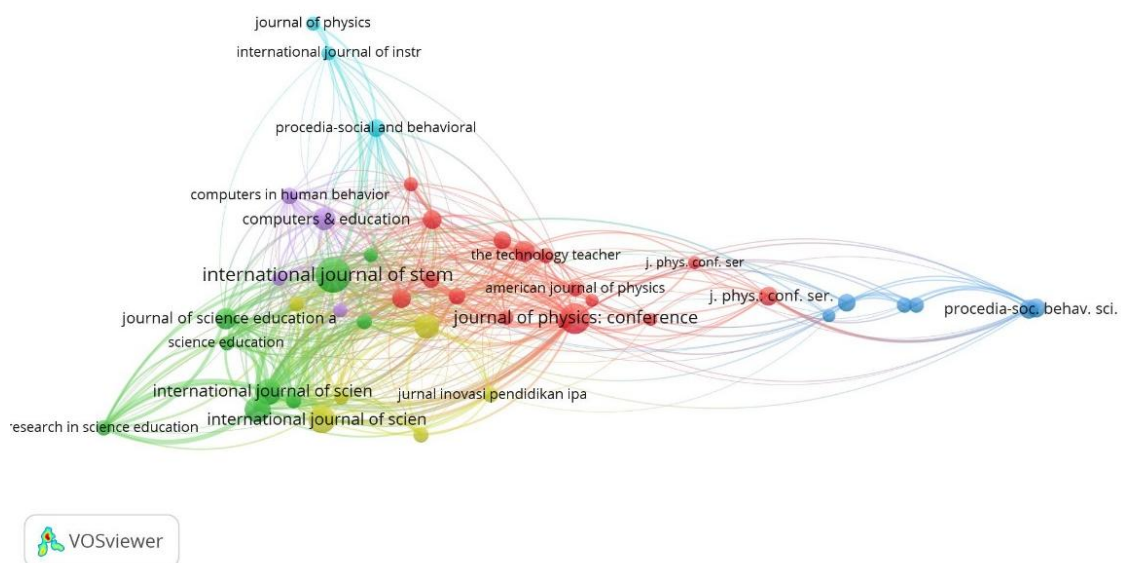


Figure 3. Citation of STEM education journals in Indonesia

Analysis of co-citation was conducted to examine the disciplines underlying the STEM education studies. Two journals are quoted together if a publication in a third journal cites two publications in those two journals. The higher publications number that cite a pair of journals, the higher the co-citation relationship of the journal pairs (Hernández-torrano & Ibrayeva, 2020). The visualization of the journal citation network is presented in Figure 3, where each circle represents a journal. The dimension of the

circle is proportional to the number of papers citing related journals. If the journals are closer together, it means that the journals tend to be more closely related, based on co-citation (Bran et al., 2019). Journal co-citations among STEM publications with a minimum of 10 citations. The most cited journal which has the strongest network connections is The International Journal of STEM Education with 68 citations. Then the second most cited journal is the Journal of Physics Conference.

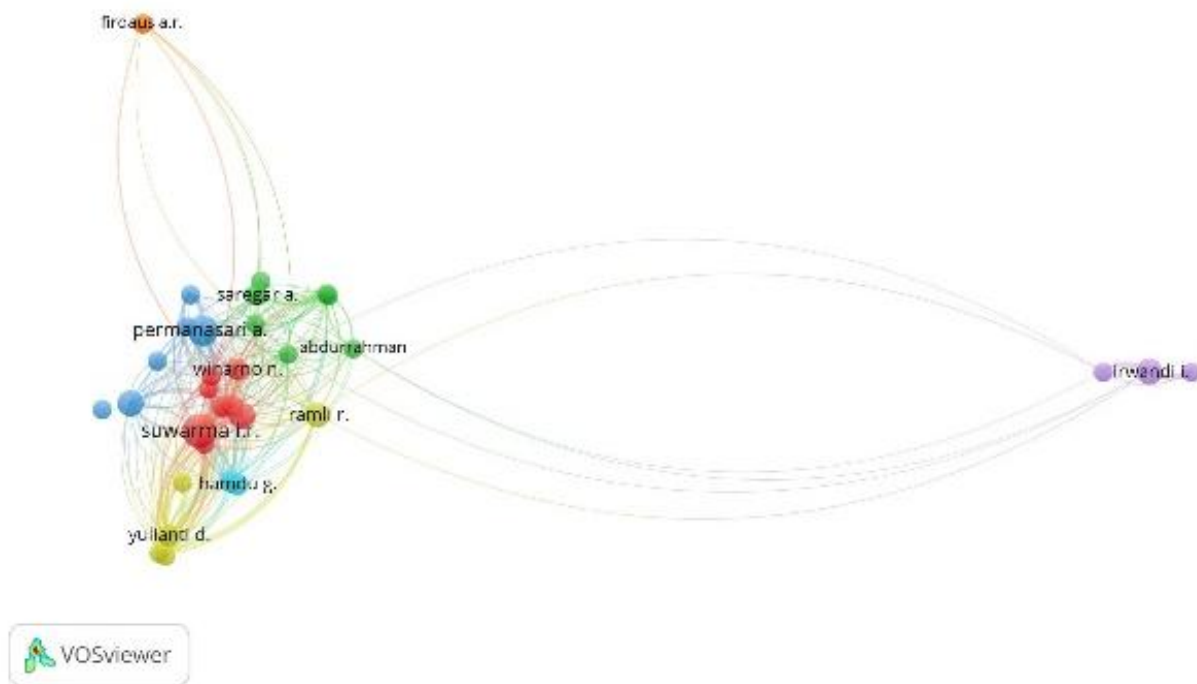


Figure 4 . Bibliographic Coupling between authors on STEM education in Indonesia

To construct a map depending upon Bibliographic Coupling data between the authors, firstly the network is constructed depending on the data available in VOSviewer, and then the map is constructed depending on the network that was built. The combined bibliographic map of files and sources is depicted in Figure 3. The conducted analysis resulting in 7 clusters. In 1st cluster (red color) Suwarna i.r has 10 publication documents, while the most citations are articles owned by permanently a. cited 83 times. The farthest cluster is in the 7th cluster (orange color) with 3 articles and 3 citation times.

Figure 5 shows the correlation between keywords in STEM education in Indonesia. Keyword co-occurrence focuses on understanding

the knowledge components and structure of a scientific field by determining the links between keywords in articles published of the same area (Oyelere et al., 2019). This confirms that research on STEM education has an interdisciplinary perspective, as it relates to various fields including the industrial revolution, physics, and psychology. "STEM" and "Student" are the most frequently used keywords. Some of the other popular keywords in terms of co-emergence are "computing education", "learning systems", "curriculum", and "technical education". Apart from that, from this visualization the small spheres and far from the big ones indicate opportunities for deeper research in the field of STEM education in Indonesia.

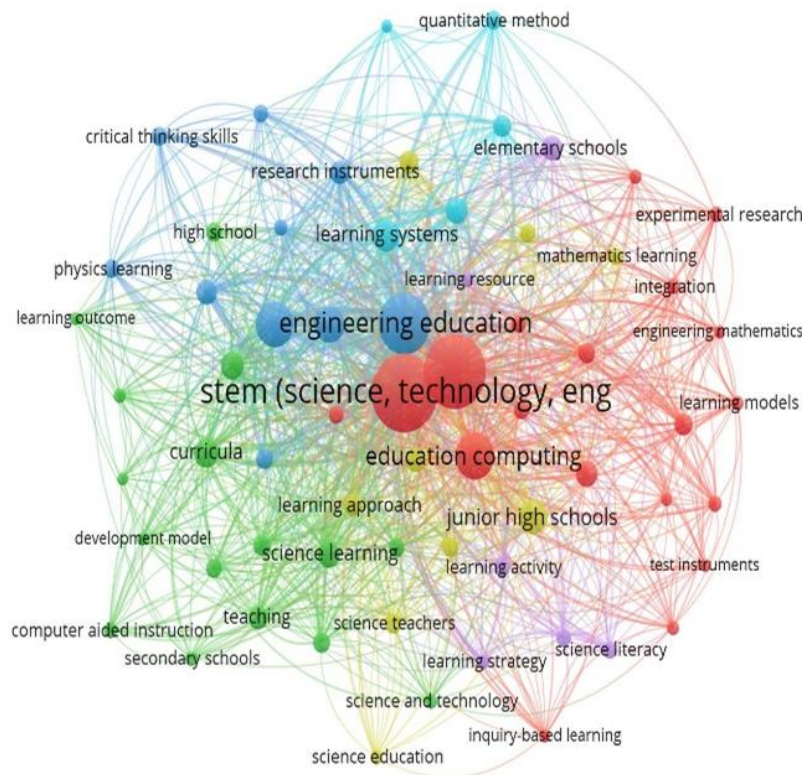


Figure 5. Co-occurrence network with index keywords visualization regarding STEM education in Indonesia

Conclusion(Times New Roman, bold, 12)

This article discusses academic trends in STEM education in Indonesia based on literature studies by analyzing the Scopus database and using bibliometric and citation methods to describe some of the characteristics of the STEM education literature. This article describes the following findings: (1) Although the first research on STEM education in Indonesia began

in 2016, the scientific achievements of STEM education in Indonesia have grown rapidly in the last three years (2018-2020). Indonesian STEM research results tend to be published in conference papers, while few are published in scientific journals. (2) Research on STEM education in Indonesia is primarily aimed at students, and the other main research fields are engineering and computers.

Limitations and Future Studies

The limitation in this study is that it only uses metadata from the Scopus database which may not include all STEM education articles in Indonesia. Using additional bibliographies such as Web of Science and others will result in better visualization.

The results of this study are very useful in providing information for research institutions in Indonesia and it is hoped that the researchers will prepare future plans in supporting the development of research related to international-class STEM education in Indonesia.

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