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Trend and Pattern in Research on 6E Learning by Design in Science: Bibliometric Approach

Syaiful Rochman[1,2], Nuryani Rustaman[1]*, Taufik Ramlan Ramalis[1], Khairul Amri[3], Alif Yanuar Zukmadini[2], and Supriyadi Supriyadi[4]

[1]Departement of Science Education, Universitas Pendidikan Indonesia, Bandung, Indonesia
[2]Departement of Science Education, Universitas Bengkulu, Bengkulu, Indonesia
[3]Departement of Civil Enginering, Universitas Bengkulu, Bengkulu, Indonesia
[4]Department of Physic Education, Universitas Musamus, Merauke, Indonesia

ORCID
Nuryani Rustaman: https://orcid.org/0000-0003-1956-9494
Taufik Ramlan Ramalis: https://orcid.org/0000-0002-7188-5673
Supriyadi Supriyadi: https://orcid.org/0000-0002-5944-3055

Abstract.
This study proposes an approach using bibliometric methods to analyze the scientific literature related to 6E Learning by design in the context of science. Through the collection and analysis of bibliographic data, we aim to identify publication trends, patterns of authorship and collaboration, as well as the research topics of most interest in this domain. The number of articles collected in this study used the publish or perish data download tool with a total of 100 relevant data. The year range used in the last 10 years, namely 2013-2023. The selection of 100 criteria is because the most relevant selection is 100 data. Furthermore, linkage mapping is carried out using VoSViewer. The results of our analysis will provide valuable insights into the contribution of research related to 6E Learning by design in science learning, as well as highlight areas that require further attention. We hope that the results of this study will provide direction for further research in developing this approach to improve science learning in the future.

Keywords: 6E learning by design, science, bibliometric analysis

Corresponding Author: Nuryani Rustaman; email: nuryanirustaman@upi.edu

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1. INTRODUCTION

Education Science education has an important role in preparing future generations to understand natural phenomena and modern technology. One instructional approach that is receiving increasing attention is the “6E Learning by Design” approach which emphasizes six key elements: Engage, Explore, Explain, Engineer, Enrich, and Evaluate. [1], [2], [3], [4]. This approach has been applied in various educational contexts, including science learning. However, despite the growing interest in the application of this approach, there are not many studies that specifically look at trends and patterns in research related to the “6E Learning by Design” approach in the context of science

education. Therefore, a bibliometric study is relevant to identify and analyze the scientific literature that has been published on this topic. [5], [6].

Bibliometric studies can provide valuable insights into publication trends, influential authors, most published journals, as well as the most in-demand research topics in this domain. By understanding trends and patterns in research related to "6E Learning by Design" in science education, we can identify knowledge gaps, highlight themes that need further attention, and provide directions for future research in strengthening this approach to improving science learning. [7], [8], [9].

Science education is an important foundation for building the understanding and skills needed to understand natural phenomena, technology and modern scientific developments. In this context, effective instructional approaches are vital to ensure that students not only acquire knowledge, but are also able to apply scientific concepts in real-world situations. One approach that is receiving increasing attention is 6E Learning by Design [2], [10]. This approach emphasizes students' active involvement in learning, allowing them to investigate scientific concepts, expand their understanding, and connect knowledge to real-world applications. Despite the growing interest in the application of the 6E Learning by Design approach in science learning, there are not many studies that specifically explore and analyze trends and patterns in research related to this approach [8], [9]. Therefore, bibliometric studies are relevant and useful in this context.

A bibliometric study is an analytical method that allows to identify, collect, and analyze bibliographic data from scientific literature related to a specific topic. In the context of this title, bibliometric studies can be used to identify the number of publications related to 6E Learning by Design in science learning, explore publication trends over time, identify influential authors in this field, determine the journals that publish the most related articles, and analyze the most popular research topics. The research that has been published with bibliometrics from various fields, namely: Science and technology there are Nandiyanto and Buule in 2023 and 2021 [11], [12], bidang teknik ada Iacob 2023 dan Rong 2021 [13], [14], in the field of Social Affairs there is Petrovan in 2022 and Zareechian in 2023 [5], [15], In the field of education, we have Felice 2023, Sobb 2023, and Moustafa 2023 [6], [8], [16]. In addition, there are many more authors who write articles on bibliometrics for initial mapping in research.

By understanding the trends and patterns in research on 6E Learning by Design in science education through a bibliometric approach, we can identify knowledge gaps, highlight themes that need further attention, and provide directions for future research in strengthening this approach in improving science learning. Therefore, a bibliometric

study on Trends and Patterns in Research on 6E Learning by Design in Science" is important. The purpose of this study was to identify publication trends, explore patterns of authorship and collaboration between researchers, determine the most popular research topics, and identify knowledge gaps that need further investigation.

2. METHOD

Several steps were taken in conducting literature research using bibliometric analysis, including article data collection. At this time, research documents on "6E Learning by Design in Science" were collected. The article data used is article data indexed by Google Scholar from 2013 to 2023. The data was collected using the Publish or Perish application, which resulted in 100 articles that could be analyzed. The collected research article data was saved in (*.csv) format for Microsoft Excel analysis, and then saved in (*.ris) format for VOSviewer visualization and analysis [11], [12]. Once the data was collected, the article data was filtered to ensure completeness of elements, such as year and author. Next, the article data was analyzed with Microsoft Excel and visualized with VOSviewer [17].

3. RESULTS AND DISCUSSIONS

3.1. Topics Development of 6E Learning by Design in Science Publications 2013-2023

Based on the number of research documents each year, it is known that research publications on "6E Learning by Design in Science" have decreased from 2013 to 2023. Figure 1 shows the graph of the decreasing number of publications on "6E Learning by Design in Science" more clearly. Over the past 10 years, the highest number of research on this topic occurred in 2013 with 3 documents, in 2014 with 6 documents, in 2015 with 5 documents, in 2016 with 5 documents, in 2017 with 5 documents, in 2018 with 11 documents, in 2019 with 8 documents, in 2020 with 26 documents, in 2021 with 18 documents, in 2022 with 11 documents and in 2023 with 2 documents.

In fact, 6E Learning by Design in Science is very important in science learning and also supports the development of higher order thinking skills such as evaluation, analysis, and synthesis [18], [19], [20]. This method allows students to experience scientific concepts thoroughly, strengthen their understanding, and develop the ability to solve complex scientific challenges by utilizing real-life experiences, practical experiments,

and problem-based discussions. In addition, the 6E approach encourages students' interest in science by providing them with context and real-world applications of theories [21], [22], [23]. This motivates them to learn more and learn more about the topic. Therefore, the 6E Learning by Design in Science approach is essential to prepare students to become competent and knowledgeable learners in science for life. [24], [25], [26].

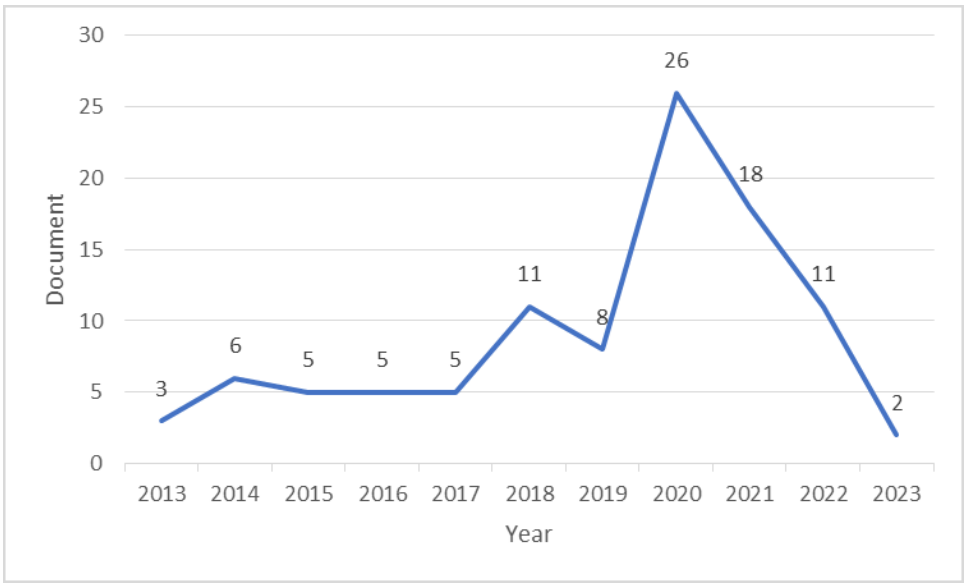

Figure 1: Research Developments regarding "Statistical significance.

3.2. Trend of 6E Learning by Design in Science Research Citations 2013-2023

In this study we show 10 different articles on "6E Learning by Design in Science" that have the highest number of citations. The metadata of the article with the highest number of citations with the title "Advantages and disadvantages of using e-learning in university education: Analyzing students' perspectives" written by Rawashdeh (2021) has been cited 387 times, the title 'Physics-informed neural networks with hard constraints for inverse design' written by Pestourie et al. (2021) has been cited as many as 377, the title "Revisiting five decades of educational technology research: A content and authorship analysis of the British Journal of Educational Technology" written by Bond (2019), the title 'Evidence of STEM enactment effectiveness in Asian student learning outcomes' written by Wahono (2020) has been cited 233 times, the title 'Robotics as an educational tool: Impact of lego mindstorms' Afari (2017 has been cited 207 times, the title "Experimental evaluations of elementary science programs: A best-evidence synthesis" written by Slavin et al. (2014) has been cited 191 times, the title

"The development of internet-based economic learning media using moodle approach" by author Sari (2018) has been cited 167 times, the title "An empirical examination of individual and system characteristics on enhancing e-learning acceptance" by author Lee (2014) has been cited 152 times, the title "Effects of infusing the engineering design process into STEM project-based learning to develop preservice technology teachers' engineering design thinking" written by Lin et al. (2021) has been cited 149 times, and the title "The process of transforming an advanced lab course: Goals, curriculum, and assessments" written by Zwickl (2013) has been cited 148 times.

3.3. Visualization of Research Data Mapping of 6E Learning by Design in Science

The data mapped using VOSviewer produced 3 forms of visualization, namely network visualization (Figure 2), overlay visualization (Figure 3), and density visualization (Figure 4). The network visualization shows that the terms generated from abstracts and keywords that are considered to match the keywords used during data collection are divided into 4 clusters with a total of 44 items. Each item has different links, total link strength, and occurrence. The following is a more detailed explanation of each cluster:

1. Cluster 1 marked in red consists of 14 items, namely activity, development, e-learning, education, implementation, learning, physics, problem, process, student, study, tearher, teaching, and use.
2. Cluster 2 marked in green consists of 12 items, namely articles, effects, effectiveness, experiments, frameworks, performance results, education reform, research, revew, parts, and systems.
3. i) Cluster 3 marked in blue consists of 12 items, namely analysis, approach, case, deep learning, evaluation, learning machine, model, optimization, paramater, prediction, present study, and technique.
4. Cluster 4, marked in yellow, consists of 6 items, namely ability, application, challenge, rational design, statue, and strategy.

If in the network visualization we can see the division of clusters, the relationship between items and items that match and are considered relevant to the keywords used to search for articles, then in the overlay visualization (Figure 3) we can see the time span (year) for each term studied. Unlike the network and overlay visualizations, the density visualization (Figure 4) shows the most frequently used terms using color, which means that the brighter the color of a term, the more frequently it is used.

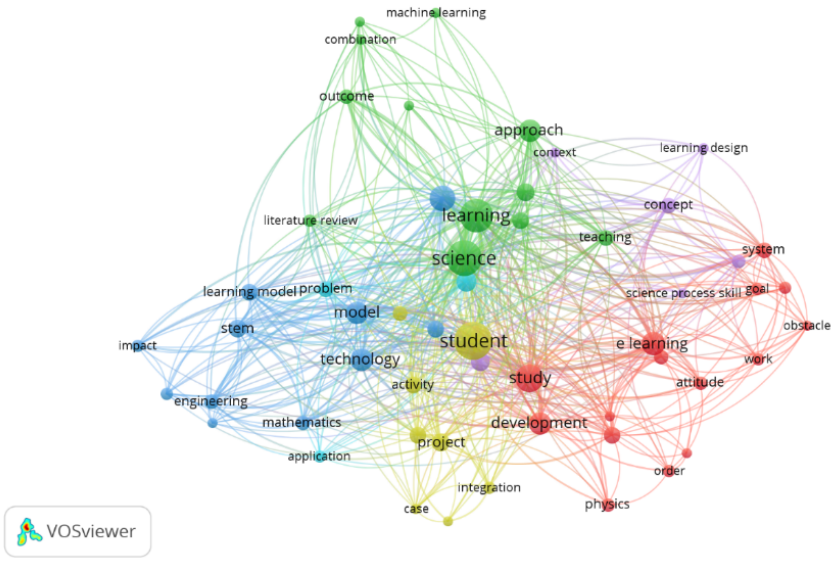

Figure 2: Network visualization based on co-occurrence of terms.

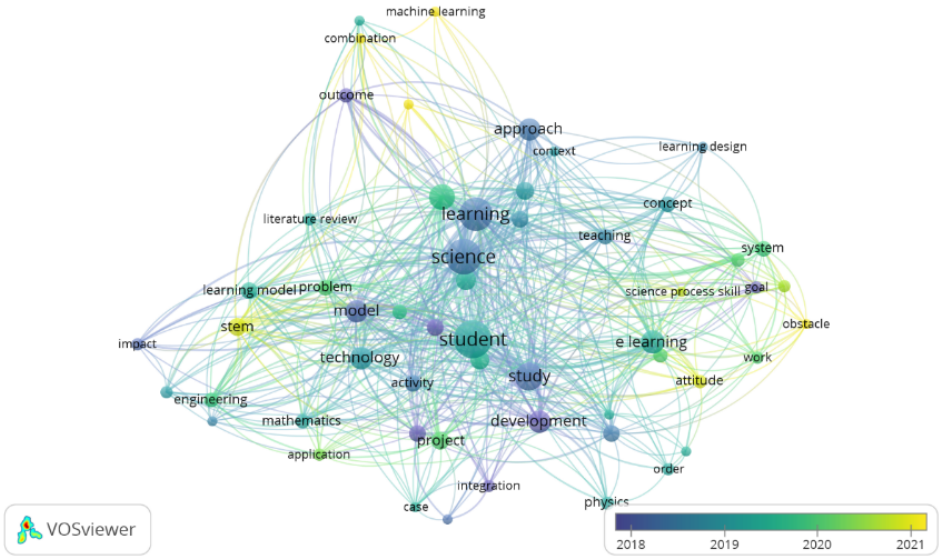

Figure 3: Overlay visualization based on co-occurrence of terms.

4. CONCLUSION

The number of publications regarding “6E Learning by Design in Science” during the last 10 years (2013-2023) was 100 documents. The development of research regarding “6E Learning by Design in Science” has fluctuated. It is known that the total number of documents found during the last 10 years is 100 documents. The details of the number of research documents regarding “6E Learning by Design in Science” are in 2013 as many as 3 documents, in 2014 as many as 6 documents, in 2015 as many as 5 documents,

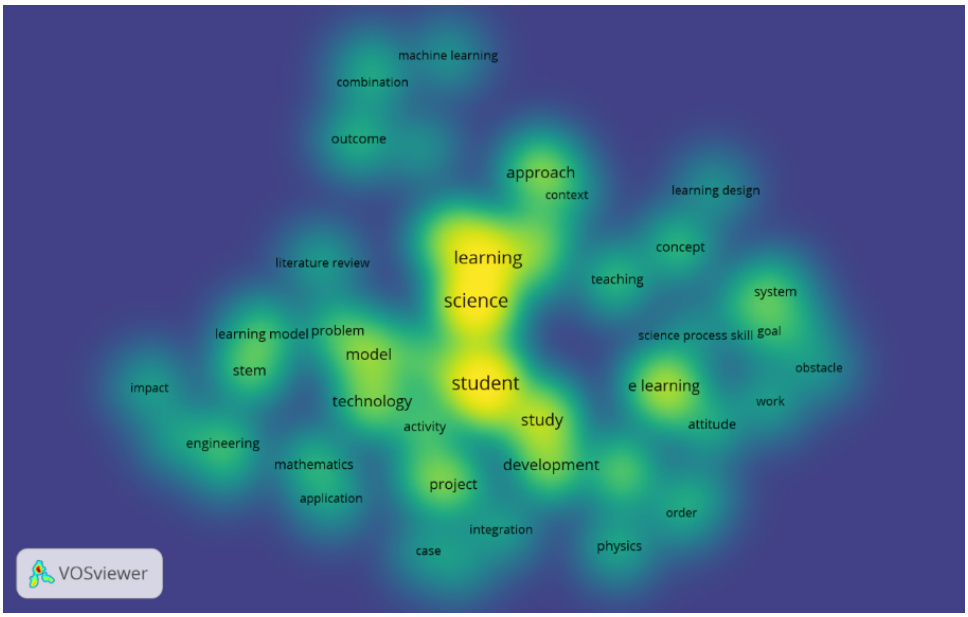

Figure 4: Density visualization based on co-occurrence of terms.

in 2016 as many as 5 documents, in 2017 as many as 5 documents, in 2018 as many as 11 documents, in 2019 as many as 8 documents, in 2020 as many as 26 documents, in 2021 as many as 18 documents, in 2022 as many as 11 documents and in 2023 as many as 2 documents. Research results for "6E Learning by Design in Science have not been found in the development of science education".

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