Steam-Based Learning Bibliometric Analysis: Opportunities in Indonesian Language Teaching Research

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Keyword	Abstract
Bibliometric analysis, STEAM-based learning, language research opportunities	STEAM is a holistic learning approach and is one of the learning models that emphasizes the learning system in Indonesia in the 2013 Curriculum and the Merdeka Curriculum. This study aims to explore various research issues related to the implementation of STEAM in learning. Data collection was carried out using the Publish or Perish application which was sourced from Google Scholar and Scopus metadata with the keywords STEAM Based Learning and STEAM-based Learning from 2020 to 2023. Data analysis was carried out using the VOSviewer bibliometric. The results showed that the highest number of publications with Google Scholar metadata sources occurred in 2021 and 2022, namely 20 article titles. The highest number of publications from Scopus metadata sources is in 2021. Research opportunities related to the use of STEAM in learning Indonesian are still very high because there are no research topics related to the use of STEAM in learning Indonesian.

Introduction

Education and training to increase the professional competence of teachers is a very strategic step to improve the quality of education. Through professional teachers will be able to support the creation of a learning atmosphere that is able to develop students' motivation and

creativity. Professional teachers will always think critically, reflectively, regarding the learning that has taken place, namely in the form of critical questions whether the learning that has taken place has been effective or not. Then, the teacher thinks creatively to find various alternatives that can be done to realize the learning objectives that have been set.

In order to support teacher professional competence, the Ministry of Culture organizes Teacher Professional Education activities, namely in the form of education and training to improve teacher competence. While participating in education and training activities, teachers are equipped with a variety of theoretical and practical abilities so that they can have comprehensive knowledge and practical skills in carrying out education and learning. One of the theoretical and practical abilities given to teachers participating in education and training is in the form of creative-innovative models in learning. Through discussing these learning models, teachers are expected to be able to understand and be able to apply them in learning. Thus, the learning carried out later can take place effectively, interestingly, and fun.

The STEAM approach is a learning approach that is highly emphasized to be understood and practiced by teachers participating in education and training. The STEAM learning model combines science, technology, engineering, art, and mathematics holistically (Heuling, 2021). STEAM (Science, Technology, Engineering, Art, Mathematics education) can be defined as learning to increase students' interest in and understanding of scientific technology and to foster scientific technology-based literacy and the ability to solve real-world problems (Thuneberg et al., 2018). STEAM is a broad concept that aims to unify education in science, technology, engineering, arts and mathematics (Milara et al., 2020). Most innovations emerge from the disciplines of science, technology, engineering, agriculture, and mathematics (Anito & Morales, 2019).

The use of project-based STEAM in groups is able to create learning experiences to solve complex problems and to develop students' creative and critical thinking (Arce et al., 2022). Project-based learning that combines STEAM activities has a significant positive effect on the development of students' creative recognition (Lu et al., 2022). STEAM as a popular pedagogical approach to improve students' creativity, problem solving skills (Perignat & Katz-Buonincontro, 2019). STEAM is an approach to learning in accordance with the industrial revolution 4.0 (Sopapradit & Wannapiroon, 2022). STEAM has emerged as a cross-disciplinary learning model that explicitly aims to develop students' creative thinking skills (Wu, 2022). The group of students with the highest academic achievements increased their test scores after participating in the STEAM learning module (Piila et al., 2021).

Digging in-depth information with bibliometric analysis on various studies related to STEAM implementation from various metadata sources is very interesting and necessary to do. This will obtain an overview of the effectiveness, constraints and how the process of implementing STEAM in learning. Furthermore, it can be used as one of the foundations for conducting various further researches to improve the quality of education.

So far no bibliometric research regarding the implementation of STEAM has been conducted. Therefore, this research is to be carried out. Some research questions that can be asked in this research are: 1) How is the development of research on the implementation of STEAM in learning that has been published in scientific journals? 2) What are the research trends or issues related to research on the implementation of STEAM in learning that have been published in scientific journals? 3) What are the research opportunities regarding the use of STEAM in language learning?

Method

This research was conducted using a bibliometric technique. Bibliometric analysis is a popular and rigorous method for exploring and analyzing large amounts of scientific data (Donthu et al., 2021). Bibliometric analysis offers additional data statistics including authors, affiliations, and keywords (Xu et al., 2018). This bibliometric research uses data sourced from the Google Scholar and Scopus databases. The search keywords used are STEAM Based Learning and STEAM-based Learning.

Data collection was carried out using the Publish or Perish application. Search range for the last three years, i.e. 2020-2023. The data that has been collected is then analyzed based on productivity per year and the highest number of citations. After ranking based on the number of citations using the Publish or Perish application, the analysis is continued qualitatively to find out research trends related to the use of the STEAM approach in learning. The results of the analysis are then used as a basis for drawing conclusions regarding the productivity of publications related to SEAM and opportunities to conduct research on the use of the STEAM approach in language learning.

Results and Discussion

Results

Bibliometric Analysis of STEAM Utilization Metadata Sources Google Scholar

Based on a search using the Publish or Perish application through the Google Scholar metadata source, data is obtained, that the level of publication regarding the use of the STEAM approach in learning is not optimal. The average number of publications from 2020 to early 2023 is still fluctuating. Data from the search results for the number of publications regarding the use of STEAM in learning can be presented in Table 1 below.

Table 1. The development of the number of STEAM-based learning publications originates from the Google Scholar database

No	Year of Publication	Number of Publications
1	2020	10
2	2021	20
3	2022	20
4	2023	6
	Amount	56

The number of articles that were collected using the Publish or Perish application through the Google Schooler database was 56 articles. The highest levels of research or publication productivity will occur in 2021 and 2022, namely 20 article titles. In general, the publication of articles regarding STEAM from 2020 to 2023 can be divided into three categories, namely research articles on the effectiveness of using STEAM in learning, the process of using STEAM in learning, and the perceptions of teachers about using STEAM in learning.

Some research results regarding STEAM that have been published in 2020, namely Harjanty & Hardianti (2020) conduct research that aims to describe the process of implementing STEAM-based learning. Usman et al. (2020) carry out research that aims to see how the application of STEAM-based learning in the learning process as strengthening 21st century education in Integrated Islamic Kindergartens, and Siregar & Rahmawati (2020) about the perspective of elementary school teachers on the development of mathematical literacy through a STEAM-based learning approach.

The publication of research articles regarding STEAM in 2021 is Rahmawati et al. (2021), conducting research on the integration of project-based STEAM learning with the aim of training students' critical thinking skills. Degeng (2021) conducting research on the effect of STEAM on cognitive and affective learning outcomes in science learning. Then Kim (2021). conducted research on design principles for learning environments based on STEAM education.

Publication of research articles on STEAM in 2022, namely Syarfina et al. (2022) about the process of introducing ways to prevent disease transmission in children through STEAM-based learning methods Sigit et al. (2022) on the integration of project-based e-learning with STEAM. Furthermore. Sigit et al. (2022) about the application of STEAM project-based learning in developing early childhood collaboration.

Furthermore, several research articles about STEAM in 2023, namely Detphiphatworakul et al. (2023), The effect of STEAM project-based learning with the engineering design process on the problem solving abilities of grade VIII students. Albar et al. (2021) about the Effect of STEAM-Based Flipped Classroom Approach on Concept Mastery and Interpersonal Intelligence in Online Learning, and (Ozer & Demirbatir, 2023) about STEAM-based digital learning application exams in music education.

Various research articles on STEAM were also analyzed based on the number of citations. Data regarding article ranking based on the number of STEAM-based learning citations sourced from the Google Scholar database can be seen in Table 2 below.

Table 2. Ranking of articles based on the number of STEAM-based learning citations sourced from the Google Scholar database

Number	Writer's name	Article Title	Publication Year	Journal Name	Number of citations
1	ADM Hawari, AIM Noor	Project based learning pedagogical design in STEAM art education	2020	Asian Journal of University Education	55
2	AP Utomo, L Hasanah, S Hariyadi, E Narulita, ...	The Effectiveness of STEAM-Based Biotechnology Module Equipped with Flash Animation for Biology Learning in High School	2020	International Journal of ...	42
3	Qomariyah, N., & Qalbi, Z	PAUD Teachers' Understanding of STEAM-Based Learning with the Use of Loose Parts Media in Bukit Harapan Village	. 2021	JECED: Journal of Early Childhood Education and Development	22
4	J Bayles, AD Peterson, SJ Pitts, H Bian, ...	Food-based Science, Technology, Engineering, Arts, and Mathematics (STEAM) learning activities may reduce decline in preschoolers' skin carotenoid status	2021	... of Nutrition Education ...	21
5	GY Nazikhovna	Programming and robotics based in STEAM Learning	2022	... Journal of Interdisciplinary Research and ...	17
6	KE Ramey, R Stevens, DH Uttal	In-FUSE-ing STEAM learning with spatial reasoning: Distributed spatial sensemaking in school-based making activities.	2020	Journal of Educational ...	14
7	SY Lu, CC Lo, JY Syu	Project-based learning oriented STEAM: The case of micro–bit paper-cutting lamp	2022	...Journal of Technology and Design Education	14

Article 1 has 55 citations. The article contains a description of the results of exploring the potential for using the Project-Based Learning (PjBL) approach in multidisciplinary art classes using STEAM (Hawari, Ahmad & Noor, Azlin, 2020). Article Article 2 of 42 citations. The article aims to determine the effectiveness of STEAM equipped with flash animation for biology learning in high school (Utomo et al., 2020).

Article 3 of 22 citations. This study aims to describe the results of research regarding the level of understanding of PAUD teachers about loose parts games. In addition, it also contains recommendations for PAUD teachers to try to find information about STEAM-based learning in order to be able to keep up with the times and creativity and improve student learning outcomes (Qomariyah & Qalbi, 2021).

The number of citations of article 4 is 21. The article aims to assess the effectiveness of the preschoolers' favorite food-based STEAM approach to 9 vegetables (Bayles et al., 2021). The number of citations of article 5 is 21. Article 5 aims to describe the STEAM approach used to train students' competencies in programming and robotics (Gulshod Yunusova Nazikhovna, 2022).

Articles 6 and 7 have the same number of citations, namely 14 citations. Article 6aims to describe the level of spatial reasoning of grade 5 and 6 students in learning with a series of STEAM activities (Ramey et al., 2020). Article 7 aims to describe the results of research regarding efforts to foster student interest (Lu et al., 2022).

Based on an analysis of the use of STEAM in learning sourced from Google Scholar metadata, it can be seen that there has been no research related to the use of STEAM in language learning. Research on the use of STEAM is generally related to science and technology learning. STEAM principles can be implemented in all subjects because in the STEAM approach the emphasis is on the way of thinking, not the material content. Utilization of STEM can improve student thinking and achievement. In addition, STEM education correlates the subjects taught with real-life problems (Khamhaengpol et al., 2021). The use of STEAM is cross-disciplinary in nature so that it can improve students' lateral thinking skills and creative thinking (Malele & Ramaboka, 2020).

Bibliometric Analysis of STEAM Utilization Source Metadata Scopus

Bibliometric analysis of STEAM utilization of Scopus metadata sources is carried out by publishing or perish using the keyword STEAM based learning with a search maximum of 100. The research data can be seen in Table 3 below.

Table 3. The development of the number of STEAM-based learning publications originates from the Scopus database

No	Year of Publication	Number of Publications
1	2020	8
2	2021	9
3	2022	5
4	2023	2
	Amount	24

Based on the data in the table above, it can be seen that the number of publications about STEAM implementation sourced from Scopus metadata is less when compared to research articles sourced from Google Scholar metadata. The number of publications sourced from Scopus metadata is 24 articles. The highest productivity occurred in 2021, namely 9 article titles.

Several publications of research articles through Scopus in 2020-2023, namely the application of STEAM-based learning in Surakarta State Elementary School (Saddhono et al., 2020). The perspective of elementary school teachers on the development of mathematical literacy through a STEAM-based learning approach (Siregar & Rahmawati, 2020). NgaBatik: An interactive game application to learn to design Ngawi batik based on Android through the application of the STEAM learning model (Febriansari et al., 2021). STEAM-based project learning (Nurramadhani et al., 2021). Create STEAM-based professional learning (Hughes et al., 2021). Project-based e-learning integration with STEAM (Sigit et al., 2022), and the effectiveness of STEAM-based blended learning on students' critical and creative thinking skills (Putri et al., 2023). Data on research articles with the highest number of citations can be presented in Table 4 below.

Table 4. Ranking of articles based on the number of STEAM-based learning citations sourced from the Scopus database

Number	Writer's name	Article Title	Publication Year	Journal Name	Number of Citations
1	ADM Hawaii	Project Based Learning Pedagogical Design in STEAM Art Education	2020	Asian Journal of University Education	16
2	Adriyawati	Steam-project-based learning integration to improve elementary school students' scientific literacy on alternative energy learning	2020	Universal Journal of Educational Research	9

Number	Writer's name	Article Title	Publication Year	Journal Name	Number of Citations
3	J. Bayles	Food-Based Science, Technology, Engineering, Arts, and Mathematics (STEAM) Learning Activities May Reduce Decline in Preschoolers' Skin Carotenoid Status	2021	Journal of Nutrition Education and Behavior	7
4	TO Ramey	In-FUSE-ing STEAM learning with spatial reasoning: Distributed spatial sensemaking in school-based making activities	2020	Journal of Educational Psychology	7

Article 1 with the highest number of citations is entitled Project Based Learning Pedagogical Design in STEAM Art Education (Hawari, Ahmad & Noor, Azlin, 2020). The number of citations is 16. The article also appears in searches via Google Scholar's metadata. The purpose of this article is to describe the potential of the Project-Based Learning (PjBL) approach in multidisciplinary art classes using the STEAM approach. The findings from this study indicate that the use of PBL pedagogical designs with the STEAM approach can improve learning.

Article 2 entitled Steam-project-based learning integration to improve elementary school students' scientific literacy on alternative energy learning with a total of 9 citations. The content of the article is almost the same as the first article, which describes the effectiveness of utilizing the integrated project-based learning model. with the STEAM approach. Based on the research that has been done, information is obtained that the integration of STEAM-Project-Based Learning can improve students' scientific literacy competence (Adriyawati, 2020).

Articles 3 and 4 have the same number of citations, namely 7 citations. Article 3 aims to assess the effectiveness of preschoolers' favorite food-based STEAM learning activities on nine types of vegetables and fruit intake (Bayles et al., 2021). Article 4 examines the role of spatial reasoning in the learning of Grade 5 and 6 students participating in a series of STEAM activities (Ramey et al., 2020).

Furthermore, what are the opportunities regarding the use of STEAM in language learning? Based on the search and analysis using With the Publis or Perish search system, it can be seen that there has not been a single study that specifically relates it to language learning. Language, as a vehicle for all knowledge, has a great opportunity to integrate science, technology, engineering, art, and mathematics in learning. This form of integration can be done by using reading text learning media that contains science, technology, engineering, art, and mathematics. In addition, it can also be substantially applied from the five scientific disciplines

in terms of reasoning or way of thinking. STEAM integration in language learning can be done by using the principle of activeness, the principle of direct involvement, the principle of challenge, the principle of feedback and reinforcement, the principle of individual differences (Dewi et al., 2022).

Research opportunities regarding STEAM in the field of language can also be carried out based on the results of published or persistent bibliometric analysis and VOSviewer which can be visualized in Figure 1 below.
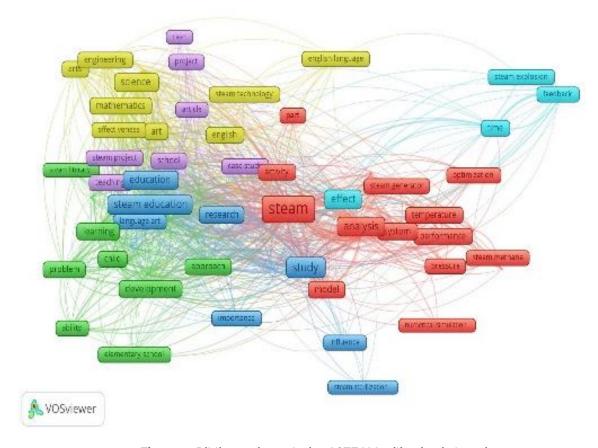

Figure 1. Bibliometric analysis of STEAM utilization in learning

The above analysis was performed based on the Google Scholar metadata source. The search was carried out with publication limits from 2018 to 2022. The search was carried out using STEAM titles and the STEAM keyword, language. The number of titles obtained was 464 article titles. The results of this analysis show a huge opportunity to conduct research on the use of STEAM in language learning by choosing various variables in the picture above. For example, regarding the effectiveness of STEAM in learning English, Optimizing language learning outcomes using the STEAM approach, case studies regarding children's language learning using the STEAM approach, and so on.

Based on the results of previous studies regarding STEAM implementation, information was obtained that the STEAM approach was very effective in improving student learning

outcomes. For example, (Reswari, 2021) STEAM based learning STEAM influences critical thinking skills in children aged 5-6 years (Salsabila & Muhid, 2021). STEAM based on parental support is effective in increasing the creativity of children learning from home during the Covid-19 pandemic (Nasrah, 2021) the science learning process using the STEAM model for fourth grade students at Marendeng Marampa SD Pertiwi Makassar is effective. Ulfayani & Jeranah (2022), The STEAM approach is effective for student learning outcomes in class VII mathematics learning at MTs Nurul Azis DDI Barobbo.

Conclusion

Research on the use of STEAM in learning has been carried out a lot. Based on metadata sources from Google Scholar from 2020 to 2023, 56 articles were obtained, then 24 articles were sourced from Scopus metadata. Most of the articles describe that the use of STEAM in learning can improve student learning outcomes. Research results regarding the use of STEAM in language learning have not yet been found. Therefore, opportunities for further research related to the implementation of STEAM in language learning are very interesting to do. Thus, more comprehensive information will be obtained regarding the level of effectiveness of STEAM utilization.

Authorship Contribution Statement

Fill in contributions from all authors by following the steps below. **Safi'i**: Generating ideas and conceptualization, developing the research design, translating, and managing the entire research process. **Hikmat**: Field research including data collection. **Wahdini**: Writing the literature review, organizing the discussion and conclusion, and supervising the research. **Jaenali**: Data analysis, data presentation, results composition, and final editing.

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