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Article

Bibliometric Analysis of Flipped Classroom Trends in Physics Education: Insights from the Scopus Database

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ABSTRACT

This study aims to analyze research trends from flipped classrooms in physics learning from 2019 to 2023 in the Scopus database with bibliometric analysis. Research trends consistently show an increasing interest in flipped classrooms as a relevant and interesting topic in physics learning. Through bibliometric mapping there are several different clusters. The main keywords that often appear include flipped classroom, physics, and physics learning. In this case, there are five top authors and affiliates from various countries with the largest contributions coming from Indonesia. The findings of this study show that the flipped classroom has significant potential to improve students' understanding of physics learning by applying a more participatory methodology and involving students directly in the learning process.

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INTRODUCTION

The flipped classroom model has become prominent in contemporary education as a pedagogical technique that redefines the conventional learning environment. This model highlights a transition from traditional teacher-focused teaching to a more dynamic approach that centers on student participation and learning. In this model, students interact with course materials such as videos, readings, or online activities prior to class, which facilitates more interactive and collaborative in-class sessions (Jurmey et al., 2022; Suhartono E, 2021). The flipped classroom is significant because it facilitates the development of profound comprehension, analytical thinking, and problem-solving abilities in students, which corresponds to the requirements of modern education in the 21st century (Janapati et al., 2022; Бороненко & Yakusheva, 2019). The flipped classroom improves student engagement and motivation by allowing more time for interactive and application-based activities, resulting in better (Hew et al., 2021; Wijayanto et al., 2022).

The flipped classroom paradigm is highly significant in the field of physics education. Physics educators can utilize digital resources and technology to develop captivating pre-class materials, such as videos elucidating intricate concepts, simulations, or interactive exercises. These materials serve to equip students with the necessary knowledge and understanding for in-depth discussions and practical exercises during class sessions (Bhakti et al., 2021; Rapi et al., 2022). Contemporary studies in physics education have indicated an increasing focus on

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investigating the effects of flipped classrooms on students' comprehension of concepts, development of critical thinking abilities, and motivation to learn physics (Warman, 2022; Ying & Ayub, 2022). Research has shown that the flipped classroom method is beneficial in enhancing students' learning outcomes and promoting a more profound comprehension of physics concepts through active engagement and practical application (Carpenter & Redcay, 2019; Muzumdar et al., 2019).

Technology and digital media are essential for facilitating flipped classrooms. Platforms such as Google Classroom, online videos, interactive simulations, and educational applications offer ways to distribute content, facilitate discussions, and evaluate student progress in a flipped learning setting (Pattiserlihun & Setiadi, 2020; Youhasan et al., 2021). Technology facilitates customized learning experiences, prompt feedback, and availability of abundant resources that amplify the efficacy of the flipped classroom approach (Karnawati & Istianingrum, 2021; Nurpratiwi et al., 2021). Performing a bibliometric analysis on flipped classrooms in physics education from the last five years entails methodically examining research publications, citations, and patterns to determine significant topics, emerging areas of research, and the influence of flipped classrooms on physics learning outcomes (Chegenizadeh, 2020; Sumarni et al., 2020). This analysis attempts to provide insights into the development of flipped classroom research, identify areas where the literature is lacking, and provide guidance for future research in physics education by examining the scholarly environment.

The goals of the bibliometric analysis would involve investigating the scientific output and research patterns pertaining to flipped classrooms in physics education during a defined timeframe, such as the previous five years. This analysis seeks to determine the main themes, developing research fields, prominent authors, top journals, and impactful papers in the field of flipped classrooms in physics education (Julia et al., 2020; Limaymanta et al., 2021). In addition, the goal could be to suggest a structure for incorporating flipped classrooms into physics education, taking into account in-person, blended, or online learning methods (Limaymanta et al., 2021).

The methodology for conducting the bibliometric analysis could employ a systematic mapping approach, which entails searching for pertinent articles in databases such as Scopus, categorizing articles for analysis, completing metadata, and utilizing bibliometric tools like VOSviewer for data analysis (Julia et al., 2020). The analysis may encompass multiple facets, including publication patterns, highly referenced publications, author-selected keywords, author cooperation, institutional cooperation, and geographic dispersion of research on flipped classrooms in the field of physics. Moreover, the methodology could utilize inductive content analysis to examine specific subjects, methodological approaches, technological tools, popular search trends, research countries, positive effects, and challenges associated with flipped classrooms in physics education (Zainuddin et al., 2019).

METHODS

This research involves conducting a literature study and analyzing it using bibliometric analysis. The study data is obtained from the Scopus database, which is accessed through the Scopus website (www.scopus.com). Scopus was selected due to its status as the largest worldwide academic database, containing citations that include abstracts from a wide range of scientifically evaluated literature and research. The Scopus database efficiently presents, monitors, and examines patterns in research topics.

The data collection was conducted on May 5, 2024, using the keywords "Flipped Classrooms" and "Physics" for the time period spanning from 2019 to 2023. Figure 1 displays the research procedure. The acquired data consists of annual publication numbers, authors, and publications that encompass works in the realm of physics education pertaining to flipped classrooms. Search results in bibliometric form can be downloaded in the .ris file format.

The data was analyzed using the VOSviewer program, employing three types of mapping techniques: network visualization, overlay visualization, and density visualization. The research data was examined using Microsoft Excel to examine the publication trend of flipped classrooms and the distribution of document formats. The data is graphically represented using Microsoft Excel to enhance the comprehensibility of the research for readers. Following the acquisition of statistical results, data mapping analysis was conducted utilizing VOS.

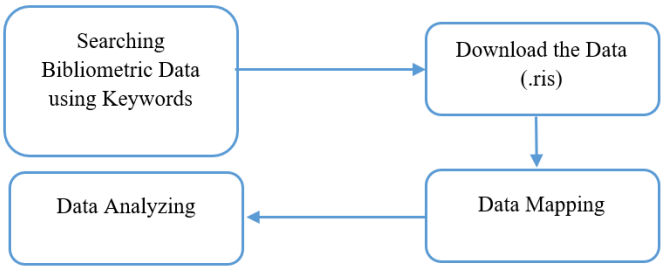

Figure 1. Bibliometric Research Scheme on the Topic of Flipped Classroom

RESULTS AND DISCUSSION

Figure 2 shows the trend of research publications from 2019 to 2023. This publication trend reflects the development of research interests and activities in the field of physics learning with flipped classrooms. In 2019, there were about 20 publications that showed early interest in this method. The figure increased to a peak in 2020 with 23 publications, likely triggered by the increasingly urgent adaptation of distance learning due to the COVID-19 pandemic. In 2021, there was a slight decline with around 19 publications, but the trend increased again in 2022 and 2023 with a stable number of publications of around 22 per year. This pattern shows that the flipped classroom method in physics learning remains a relevant topic and continues to attract researchers, although there are small fluctuations from year to year.

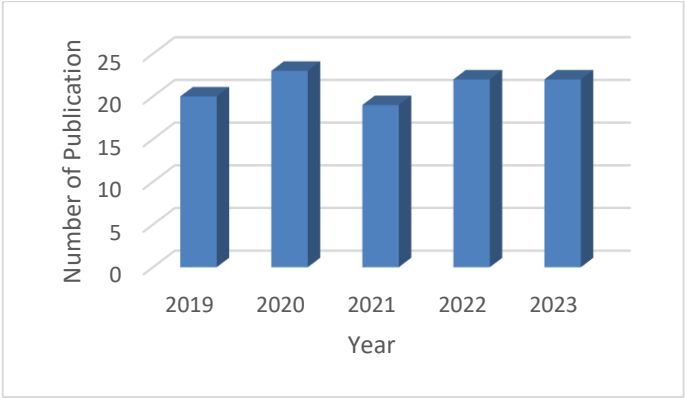

Figure 2. Trend Publication in 2019-2023

Table 1. Top Five Author with Publication in Flipped Classroom

Rank	Top Author	Document Number
1	Sulisworo, D.	4
2	Cascarosa, E.	3
3	Celma, S.	3
4	Sánchez-Azqueta, C.	3
5	Toifur, M.	3

Table 1 displays the five most prominent authors who have published on Physics Learning using the flipped classroom approach in the Scopus Database. The table displays the name "Sulisworo, D." The author who made the greatest contribution to this year's study on

this topic. Specifically, Sulisworo, D. in collaboration with Toifur, M. Astuti, Basriyah, Bhakti and la Aca conducted research on the flipped classroom approach in physics education. Their studies focused on various aspects, including the creation of instructional videos, the implementation of the flipped classroom model to enhance understanding of physics concepts, and the promotion of students' autonomy and motivation in learning physics.(Astuti et al., 2019a, 2019b; Basriyah et al., 2020; Bhakti et al., 2021; la Aca et al., 2020).

Cascarosa, E., E., Celma, S., and Sánchez-Azqueta, C. conducted research on the integration of flipped learning in higher education using a flipped classroom-contest approach. Their studies focused on developing scientific skills, applying the flipped classroom for model-based learning in electronics, and utilizing ICT-based didactic strategies to build a knowledge model in electronics for higher education (Garcia-Bosque et al., 2023; Sánchez-Azqueta, Cascarosa, et al., 2019; Sánchez-Azqueta, Celma, et al., 2019).

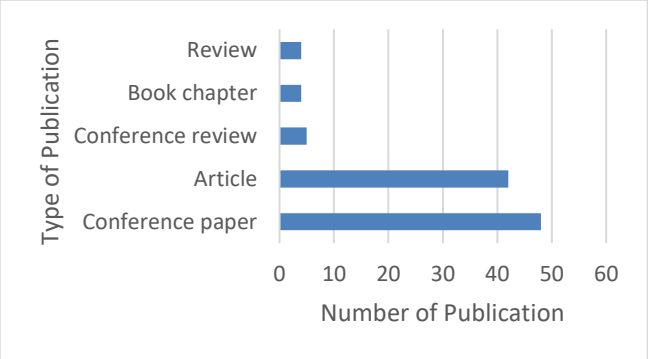

Figure 3. Document Type of Publication about Flipped Classroom

Figure 3 shows that the majority of the research on the topic of Flipped Classroom is presented in the form of conference papers. The conference consisted of 48 papers in its proceedings, however only 42 papers were published in scientific publications. Researchers primarily select conferences due to their expeditious and dependable dissemination of research findings, in contrast to scientific journals. In addition, it is worth noting that 4 out of the top 5 source titles are conference proceedings, as seen in Table 2.

Table 2. Top Five Source Title Publication about Flipped Classroom

Rank	Top Author	Document Number
1	Journal Of Physics Conference Series	16
2	Aip Conference Proceedings	5
3	ACM International Conference Proceeding Series	4
4	ASEE Annual Conference And Exposition Conference Proceedings	3
5	Ceur Workshop Proceedings	2

Table 2 displays the five most prominent source title publications in Scopus regarding the subject of Flipped Classroom. The majority of them are primarily composed of conference proceedings. The optimal number of papers for publication in the Journal of Physics Conference Series is 16. The quantity of publications on JPCS is significantly greater in comparison to the other top 5 publications on Flipped Classroom. Notably, the sole scientific journal among the top 5 source titles is AIP Conference Proceedings, which includes a total of five publications.

Table 3. Top Five Keyword about Flipped Classroom

No	Keyword	Total
1	Flipped Classroom	38
2	Students	38
3	Physics	15
4	Active Learning	14
5	Ceur Workshop Proceedings	2

Table 3 displays the five most prominent keywords related to the Flipped Classroom in the Scopus database. The terms that have the highest occurrence are "Flipped Classroom" and "Students", with each keyword appearing 38 times. The terms Physics, Active Learning, and E-learning appear 15, 14, and 14 times, respectively. Moreover, according to Figure 2, the total number of publications amounts to a mere 177 studies over a span of 10 years. This indicates that the study of the Flipped Classroom approach has continued to expand from 2013 to 2022.

Table 3 has the keyword "E-learning", which is an intriguing discovery. According to this data, there is a strong correlation between e-learning and the Flipped Classroom model. Additional evidence corroborates these findings, indicating that the majority of study on the Flipped Classroom approach is centered around the creation of educational resources and media. This research necessitates a range of technological competencies, particularly in the creation of e-learning materials.

Table 4. Top Five Affiliation with Publication about Flipped Classroom

No	Keyword	Total
1	Universitas Ahmad Dahlan	4
2	Universitas Negeri Jakarta	4
3	Universidad de Zaragoza	3
4	De La Salle University	3
5	Université Catholique de Louvain	2

Table 4 displays the five most prominent affiliates in the field of Flipped Classroom research subjects. The leading contributors in this area of research were Ahmad Dahlan University and Jakarta State University, both with four documents. The Universidad de Zaragoza and De La Salle University are the second-largest contributors, with each institution having three documents. The findings of this study align with the data shown in Table 1, indicating that authors from these institutions are more likely to be ranked at the top.

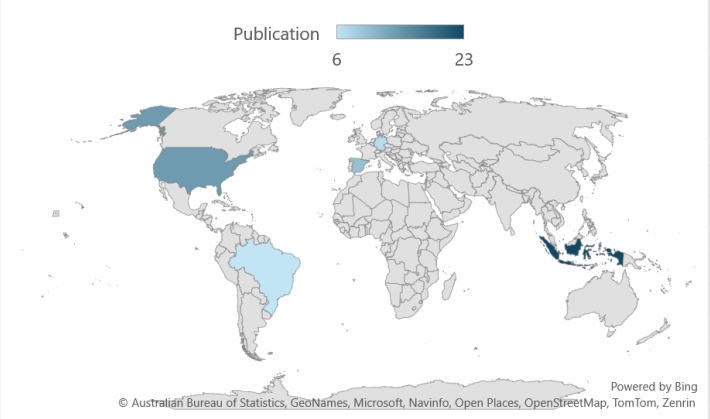

Figure 4. Top Five Countries in Publication About Flipped Classroom

Figure 4 depicts the leading publications in the field of Flipped Classroom, categorized by nation. Indonesia is the leading country in terms of publications in this scientific topic, with a total of 23 documents. The findings align with the data shown in Table 4, which indicates that two out of the top five affiliates are affiliated with colleges in Indonesia. The United States had 14 documents, whereas Spain had 10 documents. Germany and Brazil sent 7 and 6 documents, respectively. Indonesia, renowned for its heterogeneous society, exhibits considerable promise in the field of Flipped Classroom research, aligning with the nation's focus on pioneering educational methodologies.

Subsequently, VOSViewer was employed to scrutinize 106 papers pertaining to the research on the Flipped Classroom in the Scopus database. VOSViewer is a tool that is utilized for the purpose of visually representing keyword maps and the relationships between keywords. Maps can also serve as a means to discover new and original research findings. The study's findings reveal significant characteristics that define the relationship between variables in the

context of Flipped Classroom and other variables. The presence of colored circles in the title and abstract serves to highlight keywords. The magnitude of the circle also indicates the frequency with which research is associated with a certain issue. The frequency of the keyword increases proportionally with the size of the circle.

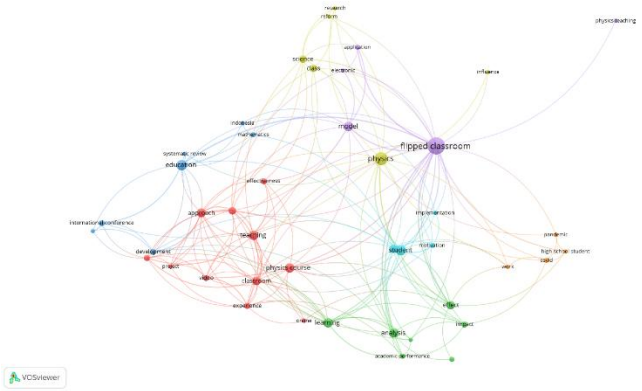

Figure 5. Network Visualization of Flipped Learning

Figure 5 depicts a graphical representation of the Flipped Classroom network. Typically, there exist many clusters comprising various colors. The purple cluster comprises the keywords Flipped Classroom, Physics, Model, and Science. The green cluster comprises the keywords Learning, Effect, Impact, and Analysis. The blue cluster comprises the keywords Education, Approach, Teaching, and Project. The yellow cluster comprises the keywords Student, Motivation, Implementation, and Academic Achievement.

Another noteworthy discovery is the prominent occurrence of the keyword "physics" on the keyword map. This demonstrates a robust emphasis on researching the use of flipped classroom approach in physics education and its influence on student learning and motivation. Various organizations represent distinct areas of emphasis in research on the flipped classroom, illustrating the multifaceted character of this teaching approach.

This map illustrates the correlation between factors in the Flipped Classroom model and other variables. The presence of colored circles in the title and abstract serves to show keywords. The magnitude of the circle corresponds to the frequency with which the research is associated with the topic. The frequency of the keyword increases proportionally with the size of the circle. This graphic facilitates the identification of significant research patterns and areas of emphasis in flipped classroom research, emphasizing the interdependence of several elements in education and technology.

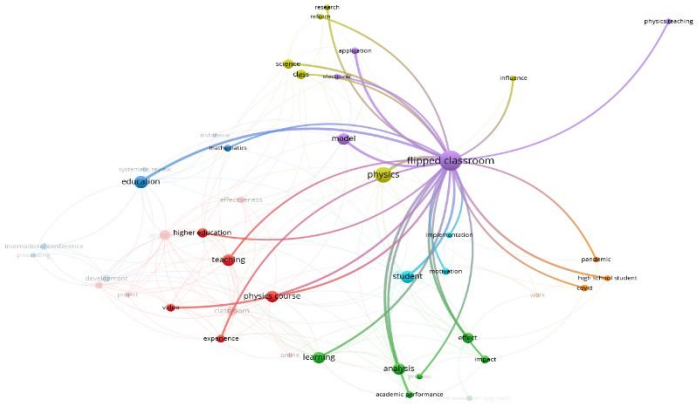

Figure 6. The Visualization Focuses on The Flipped Classroom

Figure 6 emphasizes the connection between the Flipped Classroom term and other keywords. The Flipped Classroom is strongly associated with the purple cluster, which includes Physics, Model, and Science. It is also tightly linked to the blue cluster, which consists of Education, Approach, and Teaching. Additionally, it is connected to the green cluster, which encompasses Learning, Effect, and Analysis, as well as the orange cluster, which involves Student, Motivation, and Implementation. The Flipped Classroom research encompasses several elements, namely the advancement of learning techniques in the purple cluster, the implementation of pedagogical approaches in the blue cluster, the evaluation of learning results in the green cluster, and the assessment of student engagement in the orange cluster. The researchers focused on analyzing several Flipped Classroom models and implementations within the purple cluster, with a particular emphasis on their implementation in physics education and other academic fields. Researchers frequently prioritize evaluating the efficacy of these models and their influence on student learning.

The blue cluster focuses on investigating educational approaches and instructional methods specifically within the context of the Flipped Classroom. The researchers examined many approaches to efficiently applying the Flipped Classroom model, such as project-based learning and the incorporation of technology in education. The green cluster is dedicated to studying the educational outcomes and impacts of the Flipped Classroom model. Scientists assessed the influence of different instructional techniques on student achievement, drive, and total educational encounter. They frequently employ qualitative and quantitative methodologies to evaluate the efficacy of the Flipped Classroom approach.

The orange cluster highlights the importance of student involvement and drive. The research in this field investigates the impact of the Flipped Classroom model on students' attitudes, motivation, and engagement in the learning process. The researchers examined multiple variables that influence student involvement and explored how the implementation of the Flipped Classroom model can enhance the learning environment. This map illustrates the connections between these variables, emphasizing the complex and diverse character of Flipped Classroom research and its capacity to enhance educational practice.

CONCLUSION

This paper investigates the trajectory of physics education research focused on the flipped classroom model. This study employs bibliometric analysis covering the period from 2019 to 2023. Research trends consistently indicate a growing interest in flipped classrooms as a relevant and compelling topic in physics education. Through bibliometric mapping, distinct clusters were identified, including purple, blue, green, and orange clusters. Furthermore, there exist prominent keywords, including Flipped Classroom, Physics, and Student. Regarding this matter, the top 5 authors and affiliates originate from various countries, with the most significant contribution coming from Indonesia. The study's findings indicate that flipped classrooms had significant potential for enhancing students' comprehension of physics education by employing a more participatory methodology and involving students directly in the learning process.

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