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 related to flipped classrooms in physics learning from 2019 to 2023 through bibliometric analysis. The research trends consistently show a growing interest in flipped classrooms as a relevant and compelling topic in physics education. Using bibliometric mapping techniques, several distinct clusters were identified, including purple, blue, green, and orange clusters. Key keywords such as flipped classroom, physics, and student emerged as prominent themes. Furthermore, the top five authors and affiliated institutions contributing to this research were identified, with the largest contributions originating from Indonesia. The research was conducted by systematically collecting data from the Scopus database using the keywords "flipped classroom" and "physics" for the selected time frame. Data were analyzed using VOSviewer, focusing on three types of visualizations: network visualization, overlay visualization, and density visualization. Microsoft Excel was used to graph publication trends and document distribution, providing additional insights into the results. The findings of this study highlight the significant potential of flipped classrooms to improve students' understanding of physics learning by employing participatory methodologies and engaging students directly in the learning process.

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1. 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; N. K. Rapi et al., 2022).

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Contemporary studies in physics education have indicated an increasing focus on 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, 2020a; Youhasan et al., 2021). Previous studies have also emphasized the importance of technology in fostering interactive learning. For example, Misbah et al., 2024 highlighted how interactive media and virtual reality technologies can enhance students' understanding of fluid concepts. These technologies not only make learning more engaging but also help students grasp abstract physics concepts more effectively. Additionally, technology facilitates personalized learning experiences, prompt feedback, and access to abundant resources, amplifying 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. This study highlights the critical role of digital technology and media in facilitating flipped classrooms, such as the use of Google Classroom, online videos, interactive simulations, and educational applications. However, the novelty of this research lies in its bibliometric approach to exploring trends and impacts of flipped classrooms in physics education over the past five years. This analysis provides new insights by identifying key topics, emerging areas of research, and the contribution of technology to physics learning outcomes. Thus, this study is relevant for addressing gaps in the related literature and offering guidance for future research in this field.

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).

2. Method

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.

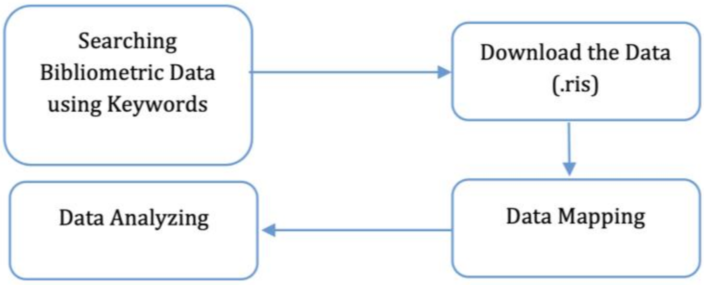

Figure 1. Bibliometric Research Scheme on the Topic of Flipped Classroom

3. 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.

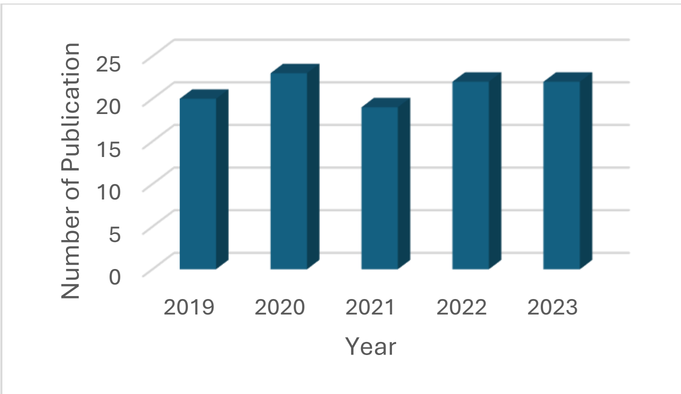

Figure 2. Trend Publication in 2019-2023

The trend for publication shows a notable increase for the year 2020, most probably because of the COVID-19 pandemic that initiated the use of distance learning characteristics. So, flipped classrooms have been an innovation during transitional phases towards remote learning because they are innovative yet permit technology-based rigid teaching formats (Bolyard, 2020; Latorre-Cosculluela et al., 2021). The small decline in the year 2021 could indicate an initial adjustment to this format (Collado-Valero et al., 2021), but constancy through 2022 and even into 2023 shows that flipped classrooms continue to be embedded in physics teaching (Tunggyshbay et al., 2023a), (Bitzenbauer & Hennig, 2023). These numbers suggest that flipped classrooms are more than just a stop-gap measure, but rather an appropriate learning approach in the contemporary timeframe (Chamorro-Atalaya et al., 2023; Rahayu et al., 2022b).

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

Figure 2 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).

Activities at Flipped Classroom in Physics Education: The Contribution of Leading Authors (such as Sulisworo, D.) according to the Development and Implementation of Flip Classroom. This research not only results in video learning that allows students to understand physics concepts more deeply but also strives to provide an avenue for independent motivation and learning among the students. Their paper demonstrates the potential of meeting 21st century education challenges through development of blended technology and participatory approaches to flipped classrooms (Rahayu et al., 2022b; Tunggyshbay et al., 2023a).

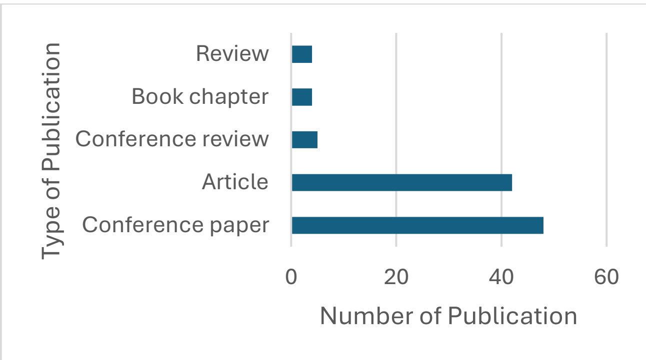

Figure 3. Document Type of Publication about Flipped Classroom

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.

The prevalence of studies published at conferences rather than in journals highlights the need for innovation diffusion in flipped classroom research quickly (Julia et al., 2020). They give researchers the opportunity to present their novel research results, often faster than through scientific journals (Haidov & Bensen, 2021). This is applicable on the fast pace of physics education development, for the implementation of technologies like flipped classrooms needs a rapid feedback and updating to satisfy students and teachers requirements (Tunggyshbay et al., 2023a).

Table 2. Top Five Source Title Publication about Flipped Classroom

Rank	Source Title	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
4	Physics	15
5	Active Learning	14
6	E-learning	14

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

Rank	Affiliation	Document Number
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.

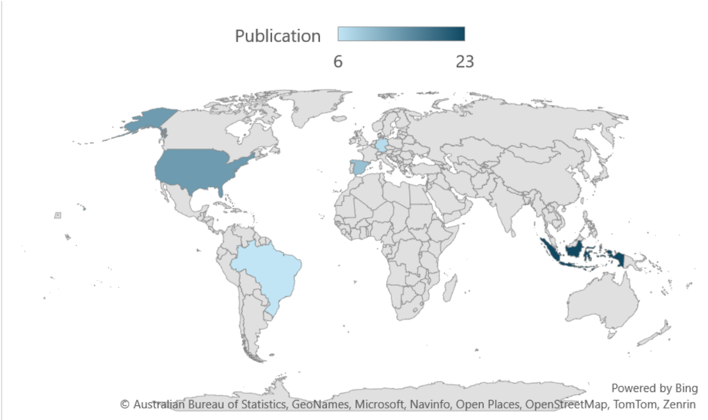

Figure 4. Top Five Countries in Publication About Flipped Classroom

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.

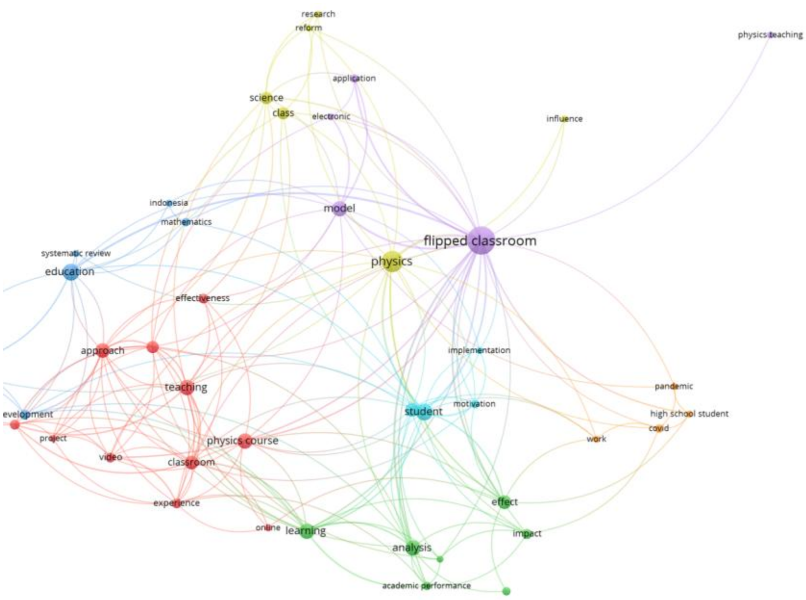

Figure 5. Network Visualization of Flipped Learning

Figure 5 provides a visual representation of the Flipped Classroom research network, showcasing multiple keyword clusters with distinct areas of focus. The purple cluster highlights keywords such as Flipped Classroom, Physics, Model, and Science, reflecting the significant role of flipped classrooms in enhancing STEM education, particularly physics (Tunggyshbay et al., 2023). The green cluster, which includes Learning, Effect, Impact, and Analysis, underscores the outcomes and effectiveness of flipped classroom methodologies in improving student performance and engagement.

The blue cluster, comprising Education, Approach, Teaching, and Project, indicates the emphasis on innovative instructional techniques, with studies suggesting that combining flipped classrooms with project-based learning enhances critical thinking and collaboration skills (Lo & Hew, 2017). Meanwhile, the yellow cluster, which includes Student, Motivation, Implementation, and Academic Achievement, highlights the importance of student-centered learning approaches that foster motivation and active participation in the learning process. The prominence of the keyword "physics" on the map indicates robust research interest in utilizing the flipped classroom model to address conceptual challenges in physics education. As reported by Altemueller and Lindquist (2023), flipped classroom strategies provide effective solutions for teaching complex physics concepts by integrating pre-class preparation with interactive, problem-based in-class activities.

This visualization underscores the interconnectedness between flipped classroom approaches, teaching strategies, and technological advancements. The size and frequency of keywords emphasize key research areas, such as the integration of digital platforms and simulations, which have been shown to enhance learning outcomes in science education (Ariani et al., 2024). Future research should focus on exploring advanced technologies, such as artificial intelligence and augmented reality, to further improve the effectiveness of flipped classrooms in physics and other STEM disciplines.

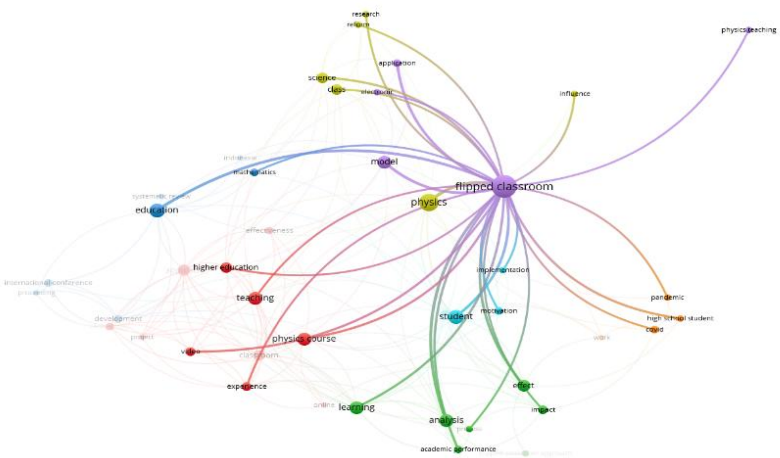

Figure 6. The visualization focuses on the Flipped Classroom

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. If we look at the network visualization, it indicates a close relation between some keywords like 'Physics', 'Students' and 'E-learning'. The integration between technology and content enables physics learning through flipped classrooms. One of the benefits is that e-learning enables students to access materials in advance from home and student-centeredness provides a more active and personalized learning environment (Hung & Young, 2021). It is a network that illustrates the nature of technology use in flipped classrooms and how those classrooms are connecting physics theory to practice (Tuveri et al., 2022).

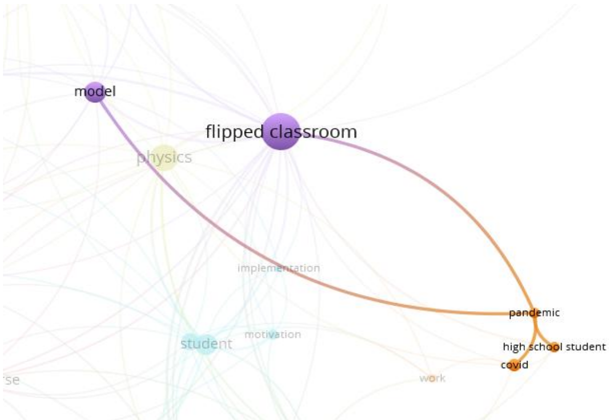

Figure 7. Visualization of the relationship between Flipped Classroom and The Pandemic

Figure 7 highlights the strong relationship between the Flipped Classroom model and the pandemic, with terms such as Pandemic, High School Students, and COVID appearing prominently. The pandemic acted as a catalyst for the adoption of the Flipped Classroom method due to the global demand for remote learning solutions. This phenomenon occurred because schools worldwide were compelled to transition to online and hybrid learning environments to ensure continuity in education (Boettcher & Behr, 2021; Gamez-Montero et al., 2020). The use of pre-recorded videos, interactive digital tools, and online assessments enabled flipped classrooms to provide flexibility, student-centered learning, and effective time utilization during disrupted instructional schedules.

The link to high school students emphasizes that this model became particularly relevant in secondary education, where students benefited from structured learning experiences that combined independent study and teacher-led activities. Recent studies have shown that flipped classrooms effectively improve students' engagement and comprehension by encouraging active learning and deeper interaction with course content (Rahayu et al., 2022a). Future research should further investigate the long-term impact of flipped classrooms on learning outcomes and identify strategies to enhance digital infrastructure for broader implementation across various educational contexts.

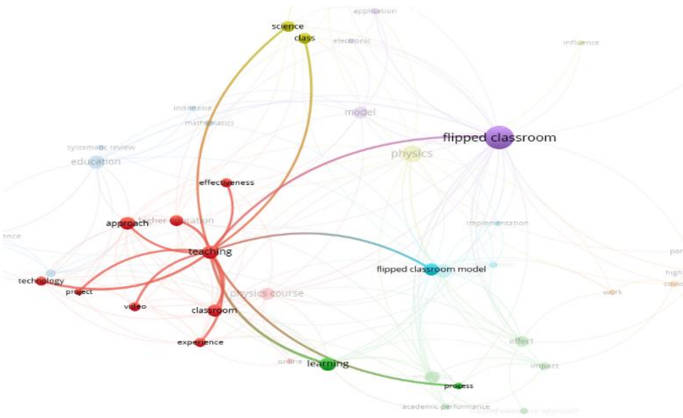

Figure 8. Visualization of the relationship between Flipped Classroom and Teaching

Figure 8 illustrates the significant correlation between the flipped classroom approach and teaching practices, highlighting its role in enhancing instructional effectiveness and student engagement. This phenomenon arises because the flipped classroom model replaces traditional lectures with interactive, student-centered activities that promote deeper understanding and retention of knowledge. Recent studies have demonstrated that flipped classrooms can improve student performance and satisfaction by fostering active learning environments (Akçayır & Akçayır, 2018; Ryan & Reid, 2016). Additionally, the integration of technology in flipped classrooms has been shown to enhance learning outcomes, particularly in higher education settings (Sánchez et al., 2022). Educators are encouraged to adopt flipped classroom strategies to create more engaging and effective teaching experiences. Future research should explore the long-term impacts of flipped classrooms on various educational contexts and identify best practices for implementation to maximize student success.

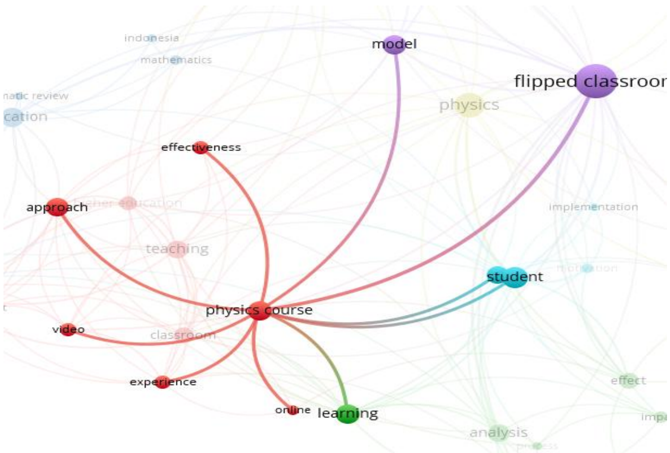

Figure 9. Visualization of the relationship between Flipped Classroom and Physics Course

Figure 9 illustrates the correlation between the terms "Flipped Classroom" and "Physics Course." The Flipped Classroom model exhibits a significant and robust relationship with Physics Courses. The association demonstrates that the flipped classroom methodology is commonly utilized in physics courses to enhance the learning experience and efficacy. The flipped classroom paradigm enhances physics courses by providing students with the opportunity to actively participate in the learning process. This is achieved through pre-class video lectures and in-class problem-solving sessions. This methodology enhances students' comprehension of intricate physics principles by using them in tangible situations.

Furthermore, network visualization demonstrates the interconnectedness of physics courses with other pertinent keywords such as methodology, efficacy, students, and learning. This demonstrates that research in the flipped classroom frequently investigates different pedagogical practices and their influence on student learning outcomes in physics courses. The focus on student participation and the efficacy of teaching approaches underscores the significance of flipped classrooms in enhancing educational practices in physics education. This visualization highlights the capacity of the flipped classroom to transform conventional physics teaching approaches by promoting a more engaging and student-focused learning atmosphere, ultimately resulting in improved educational results.

Flipped classroom and physics learning is suitable to be implemented, because the more students are able to understand complex physics concepts through flipped classroom learning (Rahayu et al., 2022b; N. Rapi et al., 2022; Tunggyshbay et al., 2023a). Students can learn the theory through pre-class videos, and in-class problem-solving activities are used to ensure that class time is spent on deepening understanding with discussions and applications (Robinson, Reeves, Caines, & Grandi, 2020; Tuveri et al., 2022). This approach will not only help the students, but also reduces the need for rote memorization and increases critical thinking, which is very much needed in modern physics (Agustini et al., 2022).

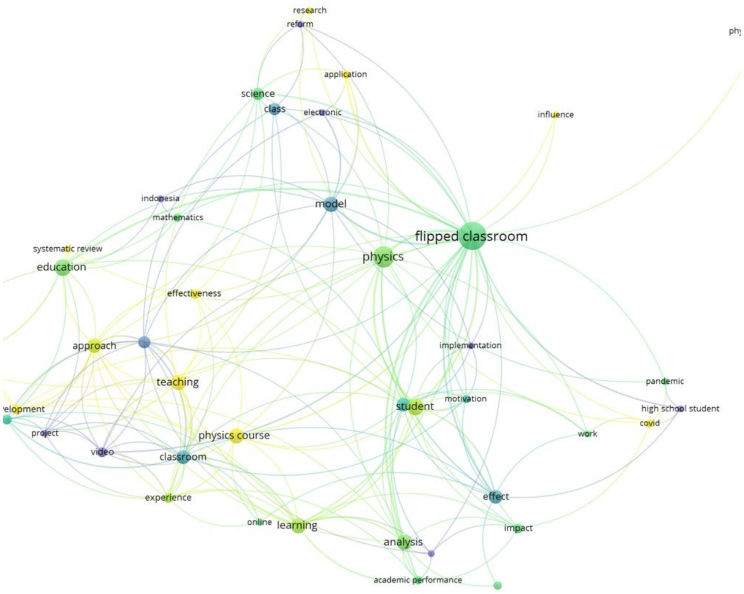

Figure 10. Overlay Visualization of Flipped Learning

Figure 10 illustrates the annual research patterns, showing the evolution and shifts in flipped classroom research over time. The phenomenon of this transition can be attributed to the rapid integration of technology in education and the increasing need for innovative teaching models, particularly during the COVID-19 pandemic. As highlighted by Misbah et al., (2024), interactive media and virtual learning tools have played a significant role in addressing learning challenges, particularly in science education. This aligns with the observed trend in flipped classroom studies, which increasingly focus on applications in physics education, using digital platforms and online resources to enhance learning outcomes.

The rise of digital tools, such as simulations, videos, and virtual learning platforms, has provided opportunities to implement flipped classrooms effectively (Pattiserlihun & Setiadi, 2020b; Rahayu et al., 2022a). These tools enable personalized pre-class learning and allow in-class sessions to emphasize interactive problem-solving activities. Future research should explore the long-term impact of technology-driven flipped classrooms on student performance and engagement. In particular, a deeper investigation into specific digital tools and their adaptability to various educational levels can help refine the flipped classroom approach and ensure its scalability across disciplines. This aligns with the recommendations of previous research, which suggests the integration of virtual reality and collaborative platforms to address specific pedagogical challenges in science education (Misbah et al., 2024; Robinson, Reeves, Caines, & De Grandi, 2020).

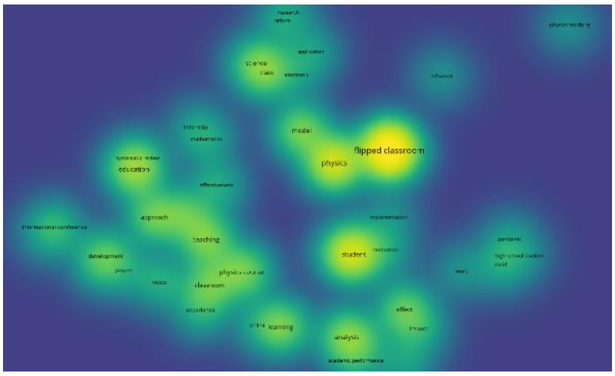

Figure 11. Density Visualization of Flipped Learning

The density visualization in Figure 11 highlights the dominance of the keywords "Flipped Classroom", "Physics", and "Students", reflecting the primary focus of research on flipped classrooms in physics education. This phenomenon occurs because the flipped classroom model has been widely adopted as an effective method for enhancing active student engagement and understanding of complex physics concepts (Hung et al., 2021). The integration of technology, such as instructional videos, interactive simulations, and e-learning platforms, plays a crucial role in providing personalized pre-class materials and supporting problem-solving activities during in-class sessions (Pattiserlihun & Setiadi, 2020b; Robinson, Reeves, Caines, & De Grandi, 2020). Moreover, previous studies indicate that flipped classrooms can foster students' critical thinking skills and learning motivation through a participatory, student-centered approach (Rahayu et al., 2022a; Tunggyshbay et al., 2023b). However, to ensure broader implementation, it is essential to evaluate potential barriers, such as limited technological access, and conduct further research to identify optimal strategies for integrating flipped classrooms with collaborative problem-solving methods (Hung et al., 2021; Robinson, Reeves, Caines, & De Grandi, 2020). Thus, this visualization underscores the significance of flipped classrooms in creating more effective and student-centered physics learning, supported by technological innovation and relevant pedagogical approaches.

4. 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. The implications of this research suggest that integrating flipped classroom models into physics education can foster active learning, improve conceptual understanding, and increase student engagement. Additionally, educators are encouraged to utilize technology-enhanced tools, such as interactive simulations and digital platforms, to further support flipped classroom implementation. Future research can explore the scalability of flipped classroom strategies across diverse educational contexts and investigate their long-term impact on learning outcomes and teaching practices.

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All authors have equal contributions to the paper. All the authors have read and approved the final manuscript.

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