

Bibliometric Analysis of Research Trends on Flipped Classroom and Project-based Learning in Physics Education (2020–2024)

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Article Info	Abstract
Article history: Received: February 14, 2025 Accepted: May 12, 2025 Published: June 27, 2025 Keywords: Bibliometric analysis Flipped classroom Project-based learning Publish or perish VOSviewer This article is licensed under a Creative Commons Attribution-NonCommercial- NoDerivatives 4.0 International License © 2025 Berkala ilmiah Pendidikan Fisika	This study analyzes the development of research related to the Flipped Classroom and Project-based Learning (PjBL) models in Physics Education through bibliometric analysis. Data were collected from Google Scholar using the Publish or Perish software with the keywords “flipped classroom,” “Project-based Learning,” and “physics education” for the period 2020–2024. The metadata of the collected articles was analyzed using VOSviewer to visualize collaboration patterns, research trends, and topic clusters. Results show that both models attract significant attention but are often studied separately. Flipped Classroom is linked to motivation, classroom models, and academic performance, while PjBL is associated with blended learning and science learning. Overlay and density maps confirm distinct developmental paths and minimal thematic overlap. These findings suggest the need for further research integrating both models to create more comprehensive, student-centered instructional frameworks aligned with the goals of physics education.
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INTRODUCTION

The rapid advancement of information technology in the 21st century has driven educational systems to adopt more innovative learning approaches. Traditional teacher-centered methods are increasingly considered inadequate for developing essential 21st-century skills such as collaboration, critical thinking, communication, and problem-solving ([Asif & Fazel, 2024](#); [Liang, 2021](#)). As education evolves, students are expected to receive information and engage in learning processes that involve analyzing, synthesizing, and applying knowledge in real-life contexts ([Sridharan et al., 2023](#); [Presty et al., 2024](#)). These demands have strengthened the role of interactive and technology-based learning environments to support more meaningful and student-centered learning experiences ([Muammar et al., 2022](#); [Butar et al., 2024](#)).

Several active learning strategies have been developed in response to these challenges, among which Flipped Classroom and Project-based Learning (PjBL) have received considerable attention. Flipped classrooms enable students to explore fundamental content independently before class, allowing deeper engagement and discussion during face-to-

face sessions ([Sudirjo, 2023](#); [Mirarchi et al., 2018](#)). PjBL, on the other hand, involves students in collaborative problem-solving and inquiry-based projects that foster authentic learning. Although both approaches are effective, most studies examine them separately, limiting understanding their combined potential ([Marchesani et al., 2023](#); [Du et al., 2024](#)). Moreover, few studies investigate the impact of integrating these models within specific educational contexts ([Vedpathak & Mithari, 2024](#); [Kimmons & Rosenberg, 2022](#)), leaving a gap in the literature that needs to be addressed ([García-Delgado et al., 2023](#); [Akinlolu et al., 2020](#)).

One such educational context where the integration of Flipped classroom and PjBL can be highly relevant is renewable energy learning. As a global priority, renewable energy offers rich interdisciplinary content that connects science, environment, and technology. Organizations like the International Energy Agency (IEA) and the United Nations emphasize equipping students with knowledge and innovation skills s energy-related challenges ([Afkar, 2023](#); [Torres-Hernández & Arrufat, 2022](#)). While this study does not focus specifically on renewable energy education, it recognizes that integrating active learning models into meaningful themes such as sustainability may enhance the applicability and impact of instruction ([Faruolo et al., 2024](#); [Wang et al., 2024](#)). Therefore, understanding research trends in integrating the flipped classroom and PjBL provides foundational insights for future implementation in diverse subject areas.

Addressing this necessity, the present study conducts a bibliometric analysis to explore the trends, patterns, and contributions of research on integrating the flipped classroom and PjBL. Using Publish or Perish software to extract data from Google Scholar and VOSviewer to visualize relationships among terms and concepts, this study aims to identify dominant themes, research clusters, and opportunities for further exploration ([Allman et al., 2023](#); [Almufarreh & Arshad, 2023](#)). The results are expected to provide valuable insights for educators in designing more integrative and effective teaching models, for researchers mapping current developments, and for policymakers supporting educational transformation in the digital age ([Fernando et al., 2021](#); [Lim & Go, 2024](#)). Ultimately, this study builds more innovative, cohesive, and future-oriented educational practices ([Marchesani et al., 2023](#); [Du et al., 2024](#)).

METHODS

This study applied a bibliometric analysis based on metadata generated using the Publish or Perish (PoP) software ([Susanti et al., 2022](#); [Firmansyah & Faisal, 2020](#)). Bibliometric analysis involves summarizing and analyzing scientific articles on selected topics to uncover literature trends, patterns, and relationships. Research articles were retrieved through Harzing's Publish or Perish application ([Habibi & Ana Fitriana, 2022](#); [Horata, 2024](#)) using the keywords "flipped classroom," "project-based learning," and "physics learning."

The data search was conducted through Google Scholar and was limited to articles published between 2020 and 2024 to ensure the novelty of the findings. The resulting data were stored in Research Information System (RIS) format, the standard output format of the PoP software.

The study was carried out in June 2024. All data were collected online using the Publish or Perish tool, which identified and downloaded relevant articles from Google Scholar. Data analysis was performed using VOSviewer software to generate comprehensive visualizations of bibliometric relationships.

This study analyzed metadata from scientific articles related to the flipped classroom, PjBL, and physics learning. The metadata were analyzed to identify research trends, patterns of collaboration, and each article's contribution to the field's development. Table 1 summarizes the software used.

Table 1 General software information

Software	Version	Year	Developer
Publish or Perish	v8.12.4612.8838	2024	Tarma Research Software
VOSviewer	v1.6.20	2023	Leiden University

The RIS data were processed using VOSviewer by applying binary counting methods. Keywords from article titles and abstracts were selected based on a minimum occurrence threshold of three times, which was considered sufficient to represent the frequency and relevance of terms ([Dicle & Dicle, 2018](#); [Derbyshire et al., 2023](#)). VOSviewer then generated three visualizations: network, overlay, and density maps ([Mustapha et al., 2024](#); [Fardi et al., 2024](#)).

- Network visualization highlights the relationships among clusters, keywords, and articles ([Jalal & Ali, 2021](#); [Zhang et al., 2022](#)).
- Overlay visualization reflects the evolution of research topics over time.
- Density visualization shows the concentration of research activity in specific thematic areas ([Pirnău et al., 2024](#); [Lailiyah et al., 2023](#)).

The research process steps are as follows: First, relevant articles were retrieved using specific keywords through the Publish or Perish application. Second, the RIS-format metadata was analyzed to determine the number of publications and overall research trends. Third, topic mapping was conducted using VOSviewer to explore conceptual linkages and keyword co-occurrence. Fourth, a network analysis was performed to understand collaborative patterns between authors and topics. Finally, the analysis results were interpreted to identify dominant themes and research gaps.

RESULTS AND DISCUSSION

Bibliometric analysis in this research uses the Publish or Perish application as a metadata collection tool from Google Scholar related to the targeted discussion topic. Next, the search results for their relationship will be read using the VosViewer application. The data collection process in this study was conducted systematically through several stages, which are described in detail as follows:

Searching for Research Data

Google Scholar is widely used to search for references from various academic sources. The choice to use Google Scholar is primarily due to its free access model, which allows researchers from diverse backgrounds and institutions to utilize it without financial barriers. Additionally, Google Scholar indexes many scientific publications, including journal articles, conference papers, theses, books, and technical reports ([Anker et al., 2019](#); [Jensenijs et al., 2018](#)). This extensive coverage is particularly beneficial for researchers conducting comprehensive literature reviews and research reporting ([Gottlieb et al., 2021](#); [Zientek et al., 2018](#)). In this research, the reference search focused on several things. First, the type of reference is taken from keywords. Second, the keywords used are "flipped classroom, project-based learning, and physics learning." Third, the search was limited to articles in English, so the keywords used were in English. Fourth, the number of articles is limited to only 200 articles. The five years of article publication range from 2020 to 2024. An overview of the data search process can be seen in Figure 2.

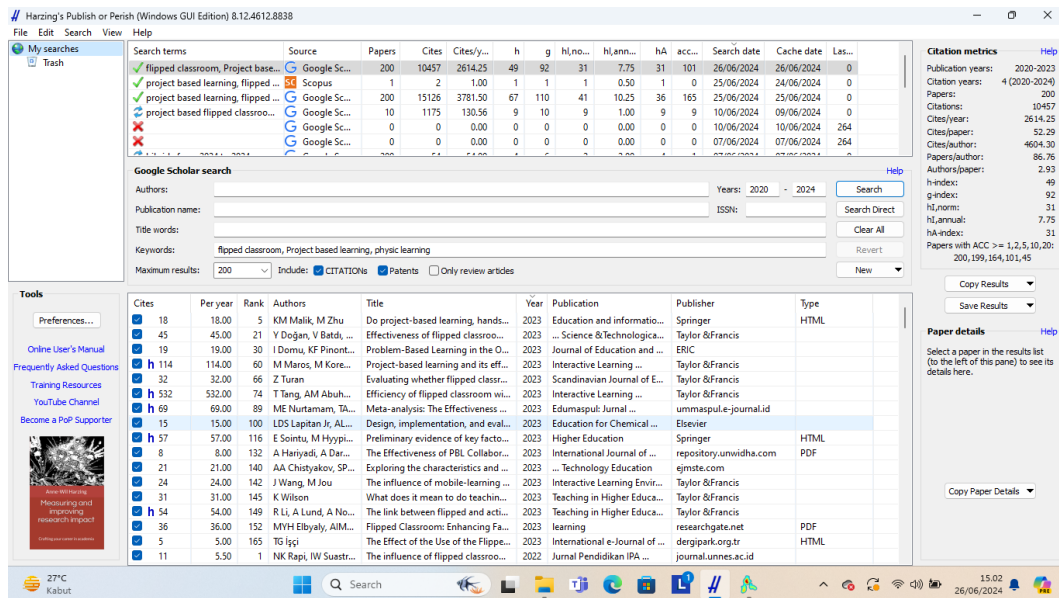


Figure 2 Data search

Metadata Filtering and Storage

After the articles are obtained, the next stage of filtering is carried out regarding articles lacking or that do not match the keywords. Articles that are not appropriate can be deleted by removing the check mark at the right end of the article. In this research, no articles were deleted because all articles were deemed to be in accordance with the keywords desired by the researcher. After all articles are considered to have passed the screening stage, all PoP (Publish or Perish) output is saved in the RIS (Research Information System) form by clicking the "save result" button and then selecting "result as RIS/Manager...". This RIS data can be saved using the appropriate file name. This RIS data will be processed using Vosviewer. The research citation matrix can be seen in Figure 3.

Citation metrics		Help
Publication years:	2020-2023	
Citation years:	4 (2020-2024)	
Papers:	200	
Citations:	10457	
Cites/year:	2614.25	
Cites/paper:	52.29	
Cites/author:	4604.30	
Papers/author:	86.76	
Authors/paper:	2.93	
h-index:	49	
g-index:	92	
h _i ,norm:	31	
h _i ,annual:	7.75	
h _A -index:	31	
Papers with ACC >= 1,2,5,10,20:	200,199,164,101,45	

Figure 3 Research topics: Citation metrics

The situation matrix of the search results using PoP with the keywords "flipped classroom," "project-based learning," and "physics learning" shows that there are 200 articles that have been published. The total number of citations received is 10,457, with an average of 2,614.25 per year and 52.29 citations per article. Distribution of the number of articles over the last five years can be seen in Table 2, where the highest number of

publications occurred in 2020 with 76 articles, while the lowest number of publications was recorded in 2024 with 0 articles or no articles published, while in 2023 there were 16 articles.

Table 2 Number of research topic publications Flipped classroom, PjBL, and physics learning

Publication year	Number of publications
2020	76
2021	60
2022	48
2023	16
2024	0
Total	200

Bibliometric Analysis

VOSviewer is used in this research to support bibliometric analysis by visualizing the results of the analysis. VOSviewer is software that can be used to create bibliometric maps ([Lestari, 2023](#); [Omar & Kamaruzaman, 2024](#)). The initial step in bibliometric analysis with this application is to select the "create" option, then select the "create a map based on bibliographic data" option, continue by clicking "next," select "read data from reference manager file (supported file types: RIS, EndNote, and RefWorks)," and click "Next".

The next step was to enter the metadata that had been saved. Previously, the data was saved in RIS format, so on the "select file" menu, select the "RIS" option and upload the file by clicking the three-dot "..." icon at the far left. Then, specify the location where the file is located. RIS is saved; click "OK," then, once the file has been found, click "Next."

The next step in VOSviewer is to select the file type (choose fields) after inserting the RIS file. In this step, select the "title and abstract fields" option to determine the fields included in the analysis. Click the check mark on "Ignore structured abstract labels," which means that VOSviewer will ignore structured abstract labels that may exist in the RIS data. A structured abstract is an abstract that has a special format or structure specified, but some of these labels may not be relevant for bibliometric network analysis. Then, click "ignore copyright statement," which means that VOSviewer will ignore copyright statements that may be contained in the article metadata. This is done because copyright statements are not relevant for bibliometric network analysis, which aims to understand patterns and relationships between articles and keywords. Once everything is correct, the next step is to click "next."

RIS data is processed using VOSviewer with a binary calculation pattern. The frequency of words appearing in the title and abstract is set to 3 times. Assuming it is enough to describe the frequency of use of words in the title and abstract. Based on the frequency reference data (3 times), 67 terms were obtained that were deemed appropriate to the topic, but these terms could still be selected again by removing the tick marks on words that, according to the researchers, were less appropriate. After all the terms are appropriate for the topic being looked for, click the "Finish" menu, and VosViewer visualizes the mapping we are looking for.

Vosviewer Results

The output of VOSviewer includes visualizations in the form of network mapping, overlay visualization, and density visualization. Visual networks interpret the relationships between clusters, items, and their interconnections. The visual overlay illustrates the research track record of recent years and the temporal trends in research ([Sun et al., 2024](#); [Sun et al., 2023](#)). Visual density conveys the concentration of studies within specified domains ([Kurniadi & Hozairi, 2023](#); [Kartakusumah et al., 2023](#)). The visualization of the analysis results can be seen more clearly in Figure 4.

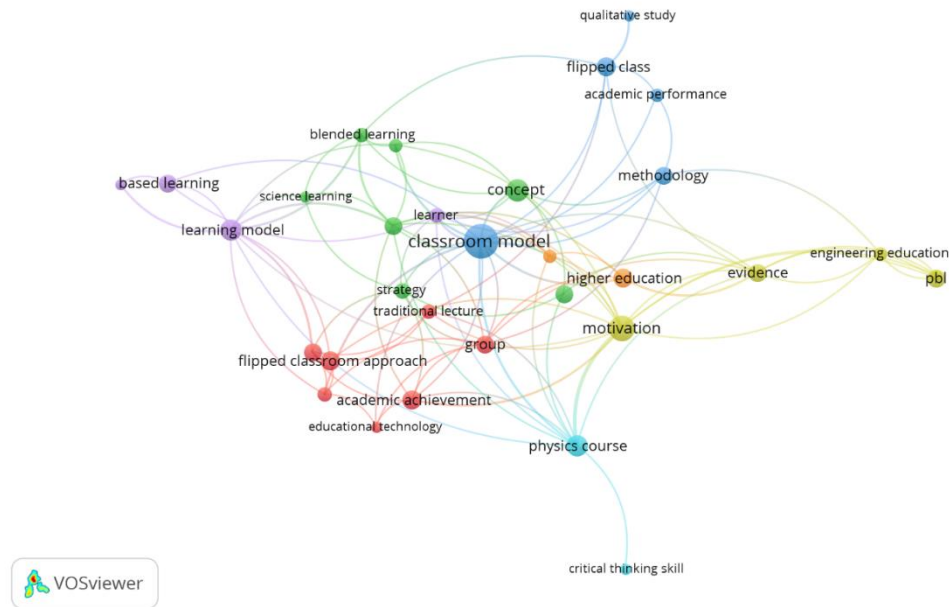


Figure 4 Network visualization

When reading network visualization, several important aspects need to be considered: nodes (rounds), edges (lines), color, and node size. Node size represents the number of articles or the frequency with which a particular keyword appears in the analyzed data. Larger nodes indicate keywords or articles that appear more frequently or are more important in research (Fitri, 2023; Yildiz, 2023). In Figure 9, it can be seen that the articles that are in the spotlight or often appear in bibliometrics discuss the topic of classroom models because they have the largest nodes. Then, it will be followed by medium-sized nodes such as articles about motivation, the flipped classroom approach, and concepts. The remainder consists of terms or topics that may be rare or not closely related to the main keyword, so they have small nodes. Apart from that, node colors indicate grouping keywords or articles into closely related clusters. Each color represents a cluster containing keywords or articles frequently appearing together in the data.

As in Figure 4, it can be seen that this bibliometric analysis consists of seven main clusters because there are seven different colors, namely the blue cluster with the main topic: classroom model, and subtopics: methodology, academic performance, flipped class, and qualitative study. Red cluster with main topics teaching, gamification, and team and subtopics experience, role, literature, and instructor. Green cluster with the main topic concept and subtopics blended learning, strategy, and science learning. Purple cluster with the main topics of learning models, based learning, and subtopics of learning. The red cluster has the main topic, "Flipped Classroom Approach," and subtopics: traditional lecture, group, academic achievement, and education technology. Orange cluster with the main topic of higher education. Yellow cluster with main topic motivation and subtopics evidence, engineering education, and PjBL.

Overlay visualization in VosViewer displays additional information about the analyzed data's time dimensions or other characteristics. Color reflects the temporal dimension when certain topics or keywords appear in the literature. Dark or dark blue color shows that the topic or keyword often appears in the initial period of the analyzed period (Judijanto, 2024; Peng et al., 2023). In this visualization, a dark blue color around 2020 shows earlier research. While the bright or yellow color shows that the topic or keywords appear more often in the final period of the analyzed time span, the yellow color shows newer research around 2022. In Figure 5, the topic of the flipped class shows that the blue color shows that

the learning model Flipped class was widely discussed at the beginning of the analysis period. Qualitative study topics with brighter colors show interest in recent research. Topics such as PjBL with green color show that these topics remain relevant and have been discussed consistently for several years.

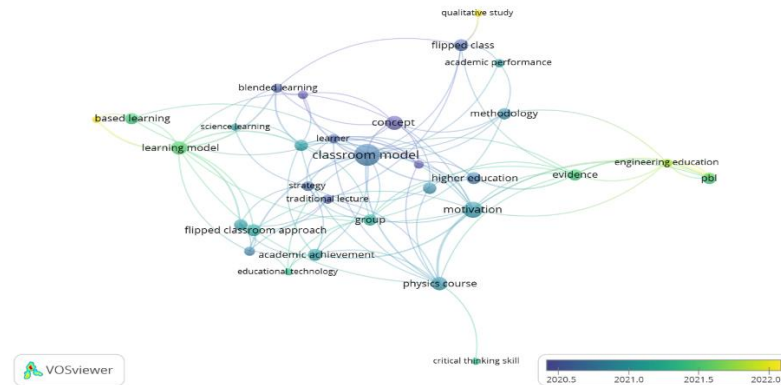


Figure 5 Overlay visualization

Density visualization in VosViewer provides an overview of the density of terms or keywords in a research dataset. The color used shows how often and how significant certain terms appear ([Permatasari, 2024](#); [Duran et al., 2020](#)). Figure 6 shows that the topic of classroom models is a very dominant topic with the highest density, meaning that much research focuses on the class approach in education. The flipped classroom approach and motivation are also dominant topics that some use in research. The topics of PjBL and flipped class are also, although relevant, less often discussed than other topics.

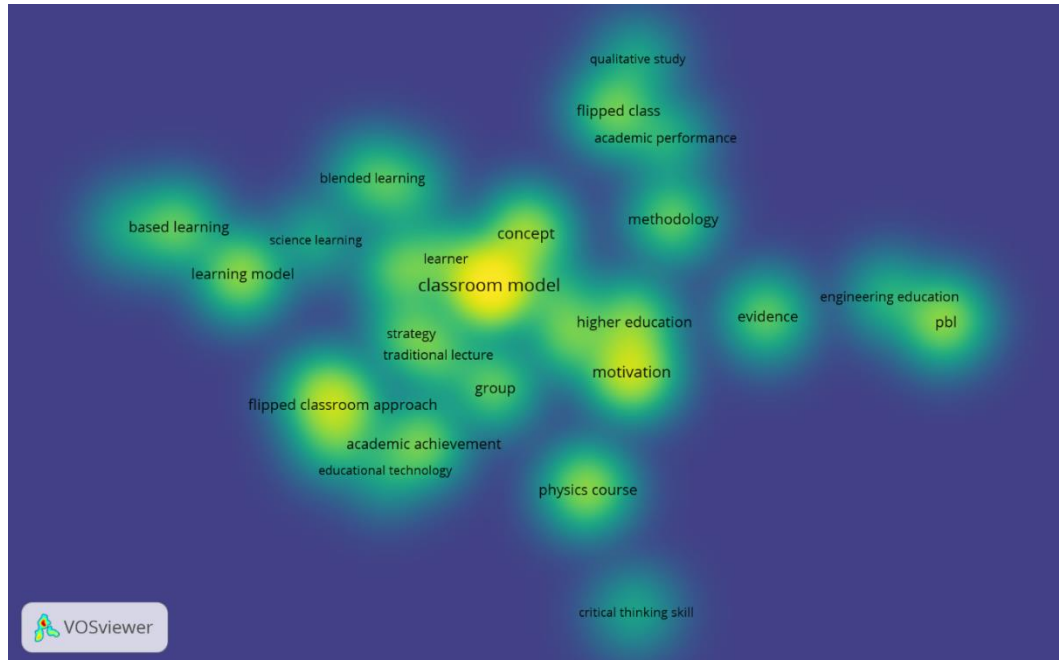


Figure 6 Density visualization

Analysis results

This study reveals that the flipped classroom and PjBL models can potentially improve student learning outcomes yet are often addressed as separate entities in educational literature ([Ying & Ayub, 2022](#); [Dogara et al., 2020](#)). Bibliometric analysis conducted using

Publish or Perish and VOSviewer supports the need for further research into integrating these two approaches.

Data from Google Scholar indicate that between 2020 and 2024, the topics of flipped classroom and PjBL have generated significant scholarly interest, with approximately 200 published articles and over 10,000 citations ([Guan, 2023](#)). However, these topics are still largely discussed in isolation. The VOSviewer network visualization shows that the two topics form distinct clusters—the flipped classroom is often associated with "classroom models," "motivation," and "academic performance," while PjBL is correlated with "blended learning strategies," "science learning," and inquiry-based methods ([Handayani et al., 2024](#); [Cahyani, 2021](#)). This separation in clustering underscores the lack of integrated research efforts ([Pradanti & Muqtada, 2023](#)).

To explore the temporal and thematic development of these research areas, three types of bibliometric visualizations were analyzed:

- Network visualization, which identifies the relationships between keywords, clusters, and articles;
- Overlay visualization, which illustrates the development and evolution of research topics over time;
- Density visualization, which highlights the concentration and intensity of research activity across themes ([Mustapha et al., 2024](#); [Fardi et al., 2024](#); [Pîrnău et al., 2024](#); [Lailiyah et al., 2023](#)).

The overlay visualization indicates that while interest in the flipped classroom increased significantly at the beginning of the observed period (2020), PjBL has remained consistently relevant across the five years of study ([Hussein, 2021](#); [Idris et al., 2024](#)). However, there is no evident convergence between the two research tracks, indicating a gap in integrated studies despite both models being individually effective in enhancing student engagement and achievement ([Naviri et al., 2021](#); [Yamin et al., 2020](#)). The density visualization further confirms that topics such as "classroom model," "motivation," and "academic performance" dominate the research space, while terms reflecting the integration of PjBL and flipped classroom appear far less frequently.

Thus, there is a compelling need for future studies that explicitly combine the flipped classroom and PjBL models ([Ningzi et al., 2021](#)). This combination can leverage the unique advantages of each method, where the flipped classroom offers structured foundational learning before class sessions, PjBL provides opportunities for learners to apply that knowledge through collaborative, inquiry-based projects ([Ekawati & Prastyo, 2022](#); [Yusuf, 2023](#)). This merger fills a clear gap in the current literature and presents an opportunity to design more innovative, holistic, and student-centered instructional strategies ([Dewi et al., 2024](#); [Rozi et al., 2020](#)).

CONCLUSION

This study concludes that while the flipped classroom and PjBL models are recognized for enhancing learning outcomes in physics education, they are discussed mainly as separate approaches, as evidenced by a bibliometric analysis of 200 articles from 2020 to 2024. Visualization through VOSviewer revealed distinct research clusters, flipped classroom linked with classroom models, motivation, and academic performance, and PjBL with blended learning and science-based strategies, highlighting a lack of integration. This gap underscores the need for further research that combines the structured content delivery of Flipped Classroom with the authentic, collaborative nature of PjBL to develop more holistic, student-centered instructional models aligned with 21st-century educational goals.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

MF conceptualized, background, and wrote; NW and DN conducted data analysis and validation.

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