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Exploring research trends in the implementation of the flipped classroom model in educational research: A review of literature

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ABSTRACT

Flipped learning is an educational method that utilizes technology to provide instruction outside regular class hours, enhancing student engagement and learning outcomes. Bibliometric studies have been increasingly used to assess the status of research in a field. However, no study has explored research trends in implementing the flipped classroom model (FCM) in educational research. Hence, this research explored trends in implementing FCM in educational research using bibliometric analysis. For this purpose, I analyzed the data from 1,093 publications indexed in the Web of Science database using VOSviewer software. The results showed that publications on flipped classrooms increased annually, and most studies were conducted in 2020. In addition, the results also revealed that Interactive Learning Environments journal published the most articles, and most of the publications were conducted in the USA. The institution with the most publications is the University of Hong Kong, while the researcher with the most publications is Gwo-Jen Hwang. Furthermore, the results also revealed 10 clusters demonstrating research trends in flipped research in the education field. Based on the findings, recommendations for practice and research are made.

Keywords: bibliometric analysis, flipped classroom, flipped learning, technology

INTRODUCTION

With the evolution of technology, education is undergoing a complete transformation, with the integration of technological tools in every field. Technology facilitates the work of both students and teachers, and positive results emerge from its use in education. Technology provides benefits such as new opportunities for teachers and students, interaction between students outside of school, cooperation in group activities, and the permanence of learning by having students in a more active learning environment (Thongmak, 2013). With the advancement of educational technology, learning methods have evolved, emphasizing the importance of activities, learning-to-learn applications, and individual learning. Research has emphasized that learning is no longer only in the classroom, but anywhere there is internet access (Liu, 2017). Due to this situation, blended learning combines the advantages and strengths of traditional learning with web-supported learning (Song & Kapur, 2017). Blended learning aims to provide the necessary skills with the help of technology and to provide the highest success. Blended learning involves an enriched virtual model (Horn & Staker, 2017). This virtual model includes the flipped classroom model (FCM). It proposes that course activities and learning, typically conducted in a school setting, are completed from home using computers and the Internet. Through FCM, students are more engaged during lessons due to increased activity time. This leads to a more enjoyable learning process and greater retention of knowledge (Webb, 2019).

The bibliometric analysis method is considered one of the systematic and comprehensive research studies. It is an approach that quantitatively reveals the general status of publications related to a particular discipline or field (Horn & Staker, 2017). Bibliometric analysis provides the opportunity to reach various findings by analyzing the characteristics of various field publications. Thus, it plays an enormous part in elucidating the direction of research undertaken on a certain topic. Studies in a particular field can obtain different results from those of other fields. Bibliometric studies are important in gathering, selecting, synthesizing, organizing, and summarizing the results. In this respect, an excellent bibliometric study allows researchers to access much information simultaneously. However, I found limited studies analyzing FCM in the literature. Most previous studies on flipped classrooms have focused on meta-analysis studies (e.g., Hew et al., 2021; Orhan, 2019; Peng et al., 2022). However, while meta-analysis studies provide comprehensive information about previous studies on flipped classrooms, detailed information about the research and journals with the most publications on flipped classrooms and co-citation networks of authors, articles, and journals are not available from the meta-analysis studies. In addition, bibliometric studies have the paramount potential to contribute to the literature by revealing the research trends of prior research. While meta-analysis studies are expressed as

Table 1. A list of previous bibliometric studies on flipped classroom

Researcher	Study objective	Scope	n	Database	Years
Bozdag (2021)	To analyze research publications on application of FCM studies in biology education, focusing on bibliographic characteristics.	Biology education	53	Scopus	2013-2021
Zamar and Segura (2022)	To identify initial stages, diffusion, & current status of flipped learning methodology.	Higher education	654	Scopus	2013-2021
Mamun at al. (2022)	Assessing current state of flipped learning research in engineering education.	Engineering education	106	WoS	2013-2020

Note. n: Number of studies

synthesizing previous studies, bibliometric studies are the statistical examination of specific characteristics of publications or documents such as subject, citation, author, and source and present big data to examine research trends in a specific research topic. As a result of this particular case, it is necessary to conduct bibliometric studies in the area of flipped classrooms. In the literature, we found a few studies that focused on flipped classrooms and used the bibliometric method to examine the research trends. To explain the rationality of this paper, in **Table 1**, I provide information on previous bibliometric studies conducted on FCM in educational research. These studies include Bozdag et al. (2021), Mamun et al. (2022), and Zamar and Segura (2022).

Bozdag et al. (2021) used bibliometric methods to examine publications on FCM studies in biology education. They analyzed only 53 publications from biology education and used only the data from the Scopus database. Similarly, Mamun et al. (2022) limited their study to engineering education and examined only a limited number (n=106) of publications related to flipped and engineering education (n=106). Zamar and Segura's (2022) research limited their focus group to higher education students and analyzed only the data regarding flipped and higher education from the Scopus database. This research shows that previous research analyzed only publications on flipped in biology education, higher education, and engineering education and has not examined the use of flipped in educational research. An analysis examining studies in **Table 1** demonstrates that the existing studies in flipped and bibliometrics focus on a limited scope of publication concerning flipped classrooms. Bozdag et al.(2021) and Zamar and Segura (2022) only used the data from the Scopus database, while the study by Mamun et al. (2022) used only the Web of Science (WoS) database. No existing study in the literature comprehensively covers FCM and all educational research. Therefore, it is evident that there is a need for further study that bibliometrically analyzes the studies on flipped classrooms in the field of education. To date, no holistic study has conducted a bibliometric analysis of studies on educational research that covers all areas of education and flipped classrooms in the most prestigious database, WoS database. Therefore, this research aimed to conduct a bibliometric analysis of educational studies that utilized FCM. The results from this research are valuable for scholars and educators and examine research trends in flipped education literature. Moreover, no filter options for any participant group were used in the research. This research's bibliometric analysis allows identifying important trends, such as the most cited publications, new topics, and influential authors. In addition, the results provide a retrospective evaluation of publications on flipped classrooms in educational research and help assess the quality and influence of research conducted over time. By doing so, the findings enable researchers to recognize gaps in existing research and identify areas that require further exploration.

METHOD

This study aimed to review publications on flipped classrooms published in English using bibliometric analysis in WoS core collection database. Bibliometric analysis analyzes documents according to certain characteristics by applying mathematical and statistical methods to publications (Hallinger, 2019) and can guide scientific publications and provide a road map for researchers (Aydin, 2014).

Data Collection

To determine the publications, I used "flipped," "flipped classroom," and "flipped learning" keywords in WoS database. After searching the database with these keywords, 12906 articles were found. When the articles were analyzed, the researcher did not select publications unrelated to FCM in the database. Thus, the number of publications decreased by 4,283 articles. Later, I limited the publication year to the last 10 years from 2013 to 2022, the document type to the article, the publication language to English, and the subject area to social sciences. After using these filters, 1,130 articles were reached. I searched in October 2023, and the studies related to this year were not included since 2023 was not yet completed, which would affect the analysis and make interpretation difficult. 1,130 articles were analyzed by the researcher and another researcher who had previously worked on flipped classrooms. Two researchers read the abstracts of 1,130 articles and decided to exclude 37 articles based on inclusion criteria (IC) and exclusion criteria (EC). When two researchers were conflicted while examining the articles, they discussed the studies based on the criteria. Based on this discussion, we agreed to include or exclude a publication for analysis. Thus, I included 1,093 articles in the analysis (see **Figure 1**, which shows the research process).

I used ICs and ECs, as follows:

- **IC1.** Articles in the educational research category
- **IC2.** Articles that employed FCM in the educational process across all levels of school
- **IC3.** Articles published in the English language.
- **EC1.** Articles not in the educational research category
- **EC2.** Articles that did not employ FCM as a method of learning or teaching.

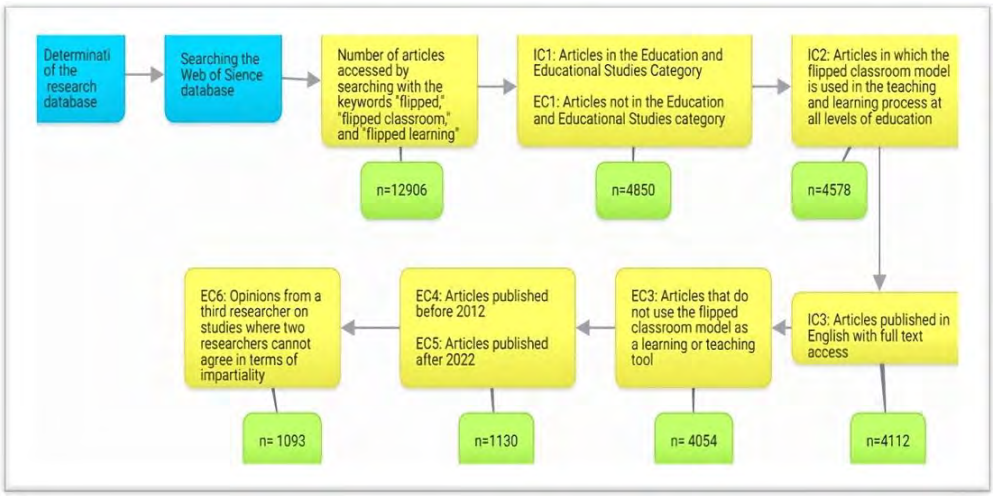

Figure 1. Research process (Source: Author's own elaboration)

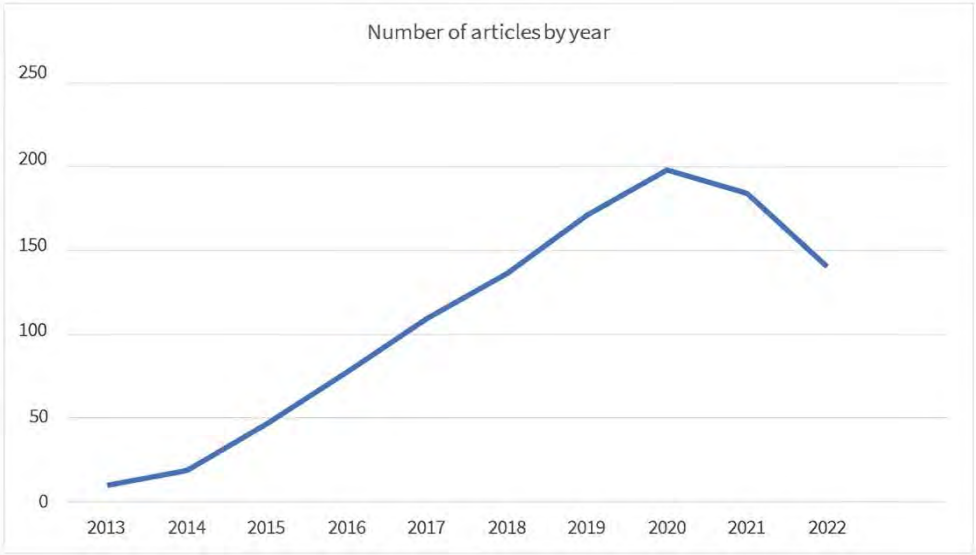

Figure 2. Distribution of studies by years (Source: Author's own elaboration)

- **EC3.** Articles published before 2012
- **EC4.** Articles published after 2022

Data Analysis

The data analysis included two methods. The first method used was descriptive statistics from WoS database. I obtained the distribution of studies by years, document type, top-10 journals with the most articles, top-10 countries and universities with the most articles, authors with the most studies, fields of study, keywords of articles, most cited researchers, research and journal information from WoS database. The second method was bibliometric analysis. Bibliometric analyses were conducted using the VOSviewer program. The bibliographic information of 1,093 articles was downloaded from WoS as a TAB file. This TAB file was then uploaded to the VOSviewer (1.6.19) software. The most cited journal, study, researcher, and most used keywords were analyzed using VOSviewer software.

RESULTS

Figure 2 shows the distribution of studies between 2013 and 2022. **Figure 2** shows the number of studies in the last 10 years. The results revealed that most studies were conducted in 2020, and the least were conducted in 2013. **Figure 2** demonstrates that the number of studies in the field of FCMs increases as the years progress. Especially in 2020, this increase reached its highest point.

Table 2 shows the number and percentages of document types. **Table 2** show that most studies (97.060%) are articles. Published articles are followed by early access (1.680%), book chapters (0.970%), and proceeding papers (0.530%). Of the 1,129 studies analyzed, 1,093 were articles, 19 were early access, 11 were book chapters, and six were proceeding papers.

Table 2. Document types of studies on flipped classrooms

Document types	Record count	Percentage (%)
Article	1,093	97.060
Early access	19	1.680
Book chapters	11	0.970
Proceeding paper	6	0.530

Table 3. Top-10 journals published most articles

Journals	Number of articles	Percentage (%)
Interactive Learning Environments	46	4.200
Education Sciences	42	3.800
BMC Medical Education	34	3.100
Education and Information Technologies	32	2.900
Educational Technology and Society	29	2.600
International Journal of Emerging Technologies in Learning	27	2.400
Computer Applications in Engineering Education	26	2.300
Educational Technology Research and Development	20	1.800
International Journal of Engineering Education	20	1.800
International Journal of Instruction	19	1.700

Table 4. Top-10 most cited publications

Rank	Publication title	Authors	Year	Type	Country	n	Links	Focus
1	The use of flipped classrooms in higher education: A scoping review	Jacqueline O'Flaherty	2015	Article	Australia	1,018	33	Review/scoping study
2	Motivation and cognitive load in the flipped classroom: Definition, rationale and a call for research	Lakmal Abeysekera	2015	Article	Australia	766	24	Empirical study/flipped approaches might improve student motivation & help manage cognitive load
3	Comparing the effectiveness of an inverted classroom to a traditional classroom in an upper-division engineering course	Gregory Mason	2013	Article	USA	509	23	Empirical study/compare effectiveness of a flipped classroom with a traditional classroom
4	The experience of three flipped classrooms in an urban university: An exploration of design principles	Min Kyu Kim	2014	Article	USA	433	31	Developing a flipped classroom design framework
5	Enhancing student engagement using the flipped classroom	Mary Beth Gilboy	2015	Article	USA	428	18	Empirical study/show how to implement flipped classroom
6	It's not about seat time: Blending, flipping, and efficiency in active learning classrooms	Paul Baepler	2014	Article	USA	390	21	Empirical study/compare effectiveness of a flipped classroom with a traditional classroom
7	Flipping the classroom for English language learners to foster active learning	Hsiu-Ting Hung	2015	Article	Taiwan	329	23	Empirical study/possible effects on gradual performance, learning attitudes, & engagement levels
8	Flipped classroom model improves graduate student performance in cardiovascular, respiratory, and renal physiology	Johnathan Tune	2013	Article	USA	312	20	Effectiveness of traditional lecture-based curriculum vs. flipped classroom curriculum
9	The value of using an e-text in a flipped course	Jacob Enfield	2016	Article	USA	249	15	Methodology book/flipped classroom
10	The flipped classroom: A meta-analysis of effects on student performance across disciplines and education levels	Peter Strelan	2020	Article	Australia	135	28	Meta-analysis on student performance

Note. n: Number of citations

Table 3 shows top-10 journals in WoS database with the highest number of studies in the flipped classroom between 2013 and 2022. When the studies published in **Table 3** are analyzed, the Interactive Learning Environments journal ranks first with 46 articles (4.209%). This journal is followed by (3.843%) Education Sciences Journal with 42 articles, (3.111%) BMC Medical Education with 34 articles, (2.928%) Education and Information Technologies Journal with 32 articles, (2.653%) Educational Technology Society with 29 articles, (2.470%) International Journal of Emerging Technologies In Learning Reading Teacher with 27 articles, (2.379%) Computer Applications in Engineering Education, Educational Technology Research and Development and International Journal of Engineering Education with 20 articles each (1.830%), and International Journal of Instruction with 19 articles (1.738%).

Table 4 briefly explains the most cited studies in flipped classrooms, authors, years, document type, country of publication, number of citations, method, and research purpose. It was shown that the top-10 most influential studies on FCM are articles. Six studies were published in the USA, three in Australia, and one in Taiwan. It was determined that different researchers conducted all of the first 10 published studies. It was shown that researchers named Jacqueline O'Flaherty, Min Kyu Kim, Peter Strelan, and Lakmal Abeysekera are at the center of the network. Seven of the top-10 most cited studies are experimental studies. The studies aimed to measure the effect of different variables, such as academic achievement and attitude.

Table 5. Countries of corresponding authors

Countries	Number of articles	Percentage (%)
USA	292	26.800
China	147	13.500
Turkey	101	9.2 00
Taiwan	92	8.400
Spain	81	7.400
Austria	66	6.000
England	49	4.500
Malaysia	30	2.700
Iran	29	2.600
South Korea	29	2.600

Table 6. Institutions that had most publications

Universities	Number of articles	Percentage (%)
University of Hong Kong	24	2.200
National Taiwan University of Science Technology	20	1.800
University of North Carolina	17	1.500
State University System of Florida	15	1.300
Bartin University	13	1.100
California State University System	13	1.100
Monash University	13	1.100
University of North Carolina Chapel Hill	12	1.100
Central China Normal University	10	0.900
Education University of Hong Kong	10	0.900

Table 7. Researchers with most studies

Authors	Number of articles	Percentage (%)
Gwo-Jen Hwang	12	1.100
Lo Chung Kwan	10	0.900
Khe Foon Hew	7	0.600
Khe Hew	6	0.500
Jacqueline E. McLaughlin	6	0.500
Jeong Jin-Su	6	0.500
David Gonzalez-Gomez	6	0.500
Fatma Gizem Karaoglan Yilmaz	6	0.500
Renee M. Clark	5	0.400
Zamzami Zainuddin	5	0.400

In the most cited scoping study, O'Flaherty (2015) found that while there is much indirect evidence that the flipped approach improves academic performance and student and staff satisfaction, there is little hard evidence that FCM contributes to the development of other 21st century skills in undergraduate and graduate education. In another highly cited study, Min (2014) proposed a flipped classroom design framework and nine design principles. Strelan (2020), in a meta-analysis, revealed that the flipped classroom had a modestly favorable impact on student performance and raised students' academic achievement.

Table 5 shows the top-10 countries, where studies on flipped classrooms. **Table 5** shows that the country with the highest number of articles published, with 292 (26.838%), is the USA. China follows the USA with 147 articles (13.511%), Turkey with 101 articles (9.283%), Taiwan with 92 articles (8.456%), Spain with 81 articles (7.445%), Austria with 66 articles (6.066%), England with 49 articles (4.504%), Malaysia with 30 articles (2.757%), and South Korea with 29 articles (2.665%). **Table 5** shows the top-10 universities in WoS database, where flipped classroom studies were published between 2012 and 2022.

Table 6 reveals that the university with the highest number of studies is the University of Hong Kong, with 24 articles (2.206%). National Taiwan University of Science Technology follows this university with 20 articles (1.838%), University of North Carolina with 17 articles (1.563%), State University System of Florida with 15 articles (1.379%), Bartin University with 13 articles (1.195%), California State University System, Monash University, University of North Carolina Chapel Hill with 12 articles (1.103%), Central China Normal University and Education University of Hong Kong with 10 articles each (0.919%).

Table 7 shows the authors who conducted the most studies in flipped classrooms. **Table 7** shows that Gwo-Jen Hwang is the researcher with the highest number of studies, with 12 articles (1.103%). Lo Chung Kwan follows Gwo-Jen Hwang with 10 articles (0.919%), Khe Foon Hew with seven articles (0.643%), Khe Hew with six articles each (0.551%), Jacqueline E. McLaughlin, Jeong Jin-Su, David Gonzalez-Gomez, Fatma Gizem Karaoglan Yilmaz, Renee M. Clark, and Zamzami Zainuddin with five articles each (0.460%).

Table 8 shows the keywords of the articles on flipped classrooms. **Table 8** demonstrates that the article's most used keyword is "flipped classroom." The keywords "active learning," "blended learning," "flipped learning," "higher education," "student engagement," and "collaborative learning" follow the keyword "flipped classroom.

Table 8. Keywords in co-occurrence analysis

Keywords	Occurrences	Total link strength
Flipped classroom	736	625
Active learning	127	190
Blended learning	110	176
Flipped learning	142	145
Higher education	64	109
Student engagement	26	49
Collaborative learning	26	46
Online learning	27	46
Motivation self-regulated learning	30	43
Medical education	29	43

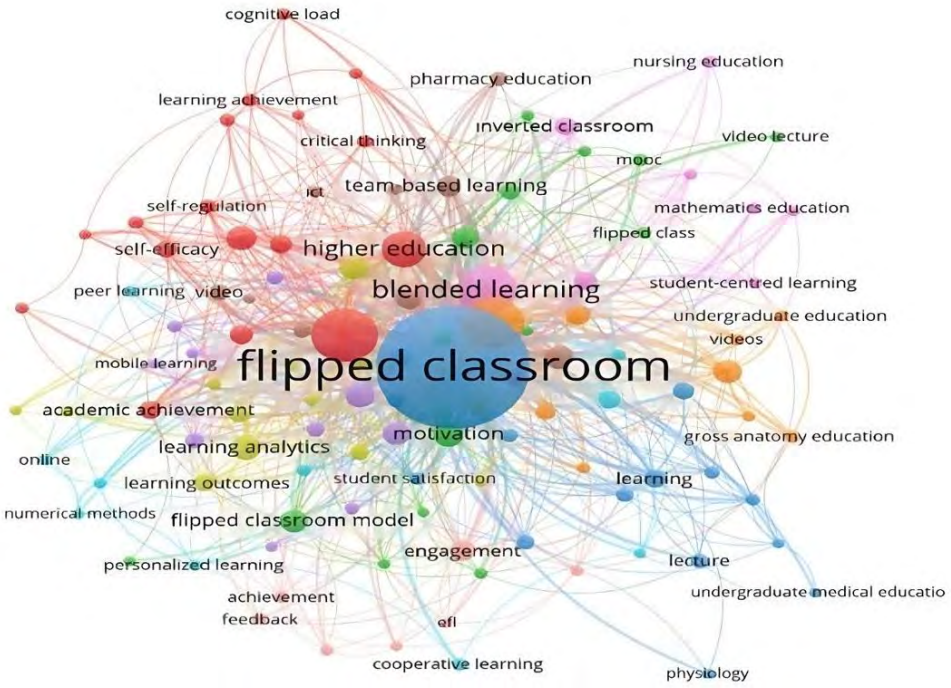

Figure 3. Keyword analysis (Source: Author's own elaboration, using VOSviewer software, version 1.6.20)

Figure 3 shows the keyword network included in the articles on the field of the flipped classroom. In **Figure 3**, keywords are divided into 10 different clusters. Among the 2,242 keywords in the studies, the number of keywords used five or more times is 114. These 114 keywords are divided into 10 clusters. From each cluster, the keywords "flipped classroom," "flipped learning," keywords similar to these words, and general terms such as "education" and "teaching" were extracted. When words come together, there is a power of connection between words (Eck & Waltman, 2020). Due to this situation, the terms remaining in the clusters were classified by naming them according to the message they wanted to give.

Emerging Themes from Literature

Some of the 10 clusters obtained from keywords were combined according to the strength of the connection between the words. Different clusters emerge based on the combination of keywords. Each cluster consists of terms that occur together to varying degrees. Themes are formed from terms frequently occurring within each cluster, indicating the most studied terms. Each cluster is formed using the semantic relationship between the frequently occurring terms and the texts most frequently referenced in this review.

Cluster one: Academic achievement & affective factors

The first cluster, indicated by the red lines, consists of the keywords "academic achievement," "cognitive load," "critical thinking," "science education," "self-efficacy," "self-regulated learning," and "traditional classroom." As can be understood from the keywords, the effect of flipped classrooms on academic achievement is an area that has been emphasized a lot. There are many studies on the effect of the flipped on academic achievement (Abeysekara & Dawson, 2022; Alamri, 2019, Demir & Oksuz, 2022; Polat & Karabatak, 2022; Tutal & Yazar, 2019; Yamarik, 2019). For example, Polat and Karabatak (2022) found that students' academic achievement increased significantly in middle school. Demir and Oksuz (2022) found that the flipped classroom was more effective on academic achievement.

Studies focusing on affective factors were found to focus on students' motivation (Abeysekara & Dawson, 2022), self-regulation skills (Jung et al., 2021), attitude (Foldnes, 2017), self-esteem (Wittmann & Wulf, 2023) and the effects of flipped classroom teaching

on these variables. Jung et al. (2021) found that flipped classrooms significantly affected students' use of higher-order cognitive skills. Foldnes (2017) found that FCM effectively develops students' positive attitudes toward the course. Wittmann and Wulf (2023) found that students' self-esteem increased through FCM, positively affecting their academic achievement. Abeysekara and Dawson (2022) found that the flipped approach increased student motivation.

Cluster two: Effects on language & mathematics education

The second cluster, indicated by the green lines, consists of the keywords "action research," "English as a foreign language," "game-based learning," "language learning," "mathematics," "motivation," and "perceptions." In this cluster of keywords, the effects of FCM on language and mathematics education and their motivations during these educations are emphasized. There are numerous studies on the effects of FCM in language education (e.g., Chang & Lin, 2019; Santikarn & Wichadee, 2018; Tseng et al., 2016; Webb & Doman, 2020; Webb et al., 2019). For example, Santikarn and Wichadee (2018), in their study on the effect of FCM on English learning performance and perceptions of the course, found that students' English scores increased satisfactorily, and they developed positive perceptions of the course. Hung (2015) found that FCM facilitated learning English and motivated students positively to learn. In addition, there are many studies on the effects of FCM on mathematics education (Bhagat & Chang, 2016; Esperanza et al., 2021; Hung et al., 2019; Lo & Hew, 2017, 2020). Lo and Hew (2020) revealed that students in flipped classrooms performed significantly better than traditional students.

The studies focusing on flipped and mathematics education focused on students' mathematical reasoning (Kilavuz, 2023), academic achievement (Lo & Hew, 2020), performance (Wei et al., 2020), continuity of learning (Foldnes, 2017), and the effects of flipped classroom teaching on these variables. In his study, Kilavuz (2023) found that FCM positively affected students' mathematics reasoning skills. Lo and Hew (2020) found that FCM promotes students' mathematics achievement and cognitive engagement. In their study, Wei et al. (2020) reported a significant enhancement in students' mathematics learning ability by implementing the flipped classroom strategy. According to Foldnes (2017), flipped classes effectively decreased absenteeism.

Cluster three: Effects of distance education

The third cluster, shown with blue lines, consists of the keywords "COVID-19", "formative assessment," "online teaching," "physiology," "mathematics," "student perception," and "student satisfaction." As can be understood from the keywords, this cluster consists of the contribution of FCM to distance education and its impact on students. In the literature, there are many studies on the contribution of FCM to distance education and its impact on students (Haftador et al., 2021; Jensen et al., 2022; Lo & Hew, 2020; Tang et al., 2022; Warugaba, 2016). Jensen et al. (2022) wanted to compare a hybrid teaching model, the flipped classroom, with a fully online classroom. The study results showed that students' performance in the online course decreased compared to the flipped classroom. Tang et al. (2022) found that students disliked online education during COVID-19, but the combined online education model with flipped learning improved students' learning. Latorre (2021) found a high consensus among students that flipped learning developed skills. These skills include character-building, collaboration, communication, citizenship, critical thinking, and creativity.

Fourth, fifth, sixth, eighth, & tenth cluster: Education & training stages, methods, & performance

Education and training stages, methods, and performance clusters are discussed together as they represent different stages of education. The fourth cluster, shown with yellow lines, consists of the keywords "collaborative learning," "evaluation," "instructional design," "learning outcomes," "video lectures," and "learning analytics." The keywords show that the effects of FCM on different stages of education are generally emphasized. In addition, keywords were given for the effects of FCM on different teaching methods and students' performances. There are many studies in the literature on the concepts of educational stages, methods, and performance (Agulair et al., 2021; Colon, 2017; Garcia et al., 2021; Li & Hou, 2022; Motameni, 2018; Thongkoo et al., 2019; Torres et al., 2022; Xu et al., 2021; Zarrinabadi & Ebrahimi, 2019). Colon (2017) found that FCM improved students' group work skills and contributed to collaborative learning. Agulair et al. (2021) reported that FCM significantly impacted students' intrinsic motivation, higher exam grades, and reduced absenteeism.

The fifth cluster, indicated by the purple lines, consists of the keywords "academic performance," "e-learning," "learning performance," "peer instruction," "student motivation," and "student engagement." As can be understood from the keywords, the fifth cluster consists of the effect of flipped classrooms on performance and factors affecting performance. Rodríguez (2018) found that the course achieved higher student motivation, engagement, and better results after using FCM in engineering education. Overall, Cevikbas and Kaiser (2022) found that mathematics education can benefit from flipped learning pedagogy as it can potentially strengthen student engagement and mathematics learning in a social environment. The keywords "adaptive learning," "assessment," "learning management system," "numerical methods," "personalized learning," and "project-based learning" constitute the sixth cluster indicated by the light blue lines. The sixth cluster consists of keywords indicating the effect of FCM on various learning methods. Teng (2017) found that FCM improves student performance. Martin (2022) found statistically significant differences in improving academic performance with flipped classroom methodology. Chua and Islam (2021) found that students who participated in a hybrid project-based learning-flipped classroom significantly increased basic formative knowledge, improved problem-solving abilities, and produced artifacts that performed better concerning the design skill set. Shih and Tsai (2017) showed that FCM can increase learning motivation and interest and promote diverse development and teamwork.

The eighth cluster, shown with brown colored lines, consists of the keywords "teaching methods," "multimedia," "pharmacy education," "problem-based learning," "teaching methods," and "team-based learning." The eighth cluster consists of the relationship between FCM and the fundamental concepts of teaching methods. The tenth cluster, shown with light brown colored lines, consists of the keywords "achievement," "Bloom's taxonomy," "content analysis," "feedback," and "interaction." The key concepts that make up the tenth cluster are the concepts that express the teaching process. There are many studies in the

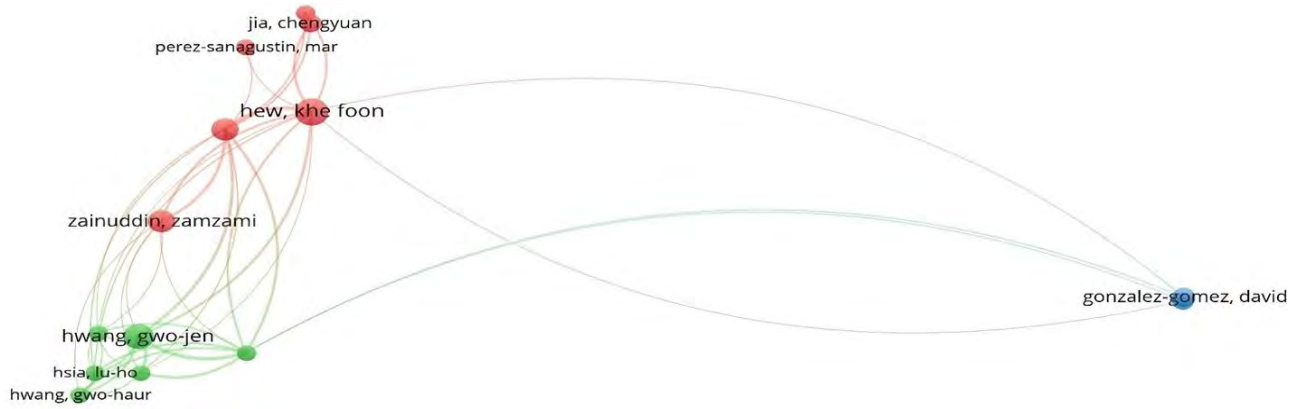

Figure 4. Collaborations of most cited researchers (Source: Author's own elaboration, using VOSviewer software, version 1.6.20)

literature related to the contribution of FCM to the teaching process and methods (Gallardo et al., 2022; Gunyou, 2015; Isherwood et al., 2020; Jaramillo & Vargas, 2018; Morton & Golbort, 2017; Mudd & Silbert, 2016; Shabani et al., 2020; Tran et al., 2022; Wong et al., 2014). Morton and Golbort (2017) found that students were more successful in studies requiring high cognition in the teaching process than in the traditional classroom. In their study, Isherwood et al. (2020) noted that FCM contributes to teaching methods; videos encouraged more effective learning and increased students' participation.

Cluster seven & nine: Connection between different domains

The seventh cluster, shown with orange lines, consists of the keywords "engineering education," "grow anatomy education," "medical education," "undergraduate "personalized learning." The keywords in the seventh cluster reveal that FCM is used in the education of different fields. The ninth cluster, shown with pink colored lines, consists of the keywords "blended learning," "mathematics education," "nursing education," "problem-based learning "technology- enhanced learning." The ninth cluster consists of keywords for teaching methods in different fields. There are many studies in the literature on the use of flipped classroom education in different fields (Baytiyeh & Naja, 2017; Chua, 2021; Docherty et al., 2022; Etemi et al., 2020; Gamez et al., 2021; Jun & Lim, 2018; Ozyurt, 2017; Park et al., 2018; Rodríguez, 2020). Park et al. (2018) found that as a result of the application of FCM to engineering students, positive feedback was received, and students' academic achievement increased. Jun and Lim (2018) stated that implementing the flipped classroom in medicine made students come to class ready and increased participation in the lessons. Golaki et al. (2022) found no significant difference between the groups in their experimental study.

Other studies were found to be conducted in the fields of medicine (Herrero & Quiroga, 2020), nursing education (Harrington et al., 2015), science education (Dogan et al., 2021), anatomy education (Cheng et al., 2017). Most medical students indicated that the flipped classroom approach was highly appealing and facilitated their learning more efficiently. They highlighted that the use of the flipped classroom method resulted in a significant enhancement of medical students' understanding of pathophysiology. Harrington et al. (2015) found that a flipped classroom was effective among nursing students. Dogan et al. (2021) revealed that flipped classroom practices positively affected academic achievement in science courses. Cheng et al. (2017) suggested that the flipped improved histology learning in medical students.

Figure 4 shows the most cited researchers. The results revealed that Khe Foon Hew ranks first with 960 citations, followed by Lo Chung Kwan with 874 citations, Gwo-Jen Hwang with 587 citations, Zamzami Zainuddin with 467 citations, Lai Chiu-Lin with 401 citations, Jacueline E. McLaughlin with 305 citations, Chi-Jen Lin with 179 citations.

Table 9 shows WoS database's top-10 most cited journals. **Table 9** shows that the most cited journals are the Internet and Higher Education. Educational Technology and Society, Interactive Learning Environments, Computers & Education follow the Internet and Higher Education. The results in **Table 9** demonstrate that seven of the top-10 most cited journals are included in the SSCI index, two in SCI, and one in the ESCI index. **Table 9** shows that all of the top-10 journals are open-access. Journals with more than 200 citations were grouped into four clusters. The first cluster with red network consists of Computer Applications in Engineering Education, Computers & Education, Education and Information Technology, Innovations in Education and Teaching International, and International Journal of Emerging Technologies in Learning; the second cluster with green network consists of BMC Medical Education, Educational Technology & Society, Interactive Learning Environments, the third cluster with blue network consists of American Journal of Pharmaceutical Education, Education Sciences, Educational Technology and 10 clusters with yellow network consists of Turkish Online Journal of Distance Education.

DISCUSSION

This study aimed to examine the articles on FCM in WoS database with the bibliometric analysis method. The results showed that research on flipped classrooms has increased rapidly since 2013, and most of the research was conducted in 2020. This result is similar to those of Orhan (2019). In his study, Orhan (2019) determined that the number of studies conducted in flipped classrooms since 2012 has increased regularly and rapidly, and most studies were conducted in 2020. In 2020, all levels of education have switched to distance education (Budak & Korkmaz, 2020) due to the COVID-19 pandemic. Since 2020, studies in distance education have increased rapidly for researchers (Bozkurt, 2020).

Table 9. Most cited journals

Rank	Journal name	n	TCS	IF	OA	Category	Q	PF
1	Computers & Education	1,640	249	12.0	Yes	Education/SSCI	Q1	13 issues/year
2	The Internet and Higher Education	1,611	314	8.6	Yes	Education/SSCI	Q1	Four issues/year
3	Educational Technology & Society	1,361	308	4.0	Yes	Education/SSCI	Q1	Four issues/year
4	Interactive Learning Environments	992	267	5.4	Yes	Education/SSCI	Q1	Seven issues/year
5	Computer Assisted Language Learning	809	170	7.4	Yes	Education/SSCI	Q1	Eight issues/year
6	IEEE Transactions on Education	642	127	2.6	Yes	Education/SCI	Q1	Five issues/year
7	ETR&D-Educational Technology Research & Development	612	192	5.4	Yes	Education/SSCI	Q1	Six issues/year
8	Education Sciences	450	158	2.8	Yes	Education/ESCI	Q1	12 issues/year
9	Education and Information Technology	447	209	5.5	Yes	Education/SSCI	Q1	12 issues/year
10	Journal of Computers in Education	447	116	4.6	Yes	Education/SCI	Q1	Four issues/year

Note. n: Number of citations; TCS: Total connection strength; IF: Impact factor; OA: Open access; Q: Quartile; PF: Publication frequency; & ILE: Interactive learning environments

Interactive Learning Environments and Education Sciences are in first and second place when the journals published in the "flipped classroom" field in WoS database are examined. The journals with the highest number of publications are generally journals with publications in educational technology. A notable finding from the study is that the journals with the most publications are considered respectable and significantly impact online learning and educational technology. There are several possible explanations for this. One of the explanations may be that high-impact journals have a more rigorous peer review process, and researchers may have submitted studies they trust to these journals. A significant portion of the studies were published in the USA. China follows the USA. Likewise, when we look at the universities publishing in the field of "flipped classrooms," "The University of Hong Kong" ranks first, "The National Taiwan University of Science Technology" ranks second, and "The University of North Carolina" ranks third. In addition, Gwo-Jen Hwang, Lo Chung Kwan, and Khe Foon Hew conducted the most research on flipped classrooms. These results show that the USA and China greatly value FCM.

When the articles were examined in the fields of study, I found that most were in educational research. Engineering is multidisciplinary, and computer science interdisciplinary applications and linguistics follow educational research. The fact that educational research is in the first place and that FCM is generally used in the studies conducted in this field is in line with the definition. In FCM, Course activities and learning that traditionally occur in the school setting are now conducted remotely from home using computers and the Internet. Conversely, homework assignments and applications are completed in the physical classroom (Kilavuz, 2023). However, the existence of studies in the fields of engineering education, computer applications, linguistics, and economics has been revealed in this study. Therefore, it can be said that FCM can be used in more than one field.

The keyword most commonly used in research in WoS database is "flipped classroom," which is used in most studies. This keyword is followed by the keywords "active learning," "blended learning," and "flipped learning." When the keywords were analyzed, a wide variety of concepts were encountered. This situation revealed that the researchers investigated many different variables with the flipped classroom. 10 clusters were formed from the keywords in the study. The researcher named each cluster, and examples of studies appropriate to the cluster were given. The cluster names were given by removing the key concepts of the study, such as "flipped classroom," "flipped learning," "education," and "teaching." The clusters of academic achievement and affective factors, language and mathematics education and its effects, distance education and its effects, education-teaching stages, student performance, learning methods, cross-domain teaching methods, cross-domain teaching methods, and teaching process were obtained from the keywords. Cluster names emerged from the relationship between keywords. Because when words come together, the power of connection between words is formed (Eck & Waltman, 2020). The studies conducted in general were studies on the effect of flipped classrooms on academic achievement (Abeysekara & Dawson, 2022; Colon, 2017; Latorre, 2021; Teng, 2017). The research examined academic achievement as a primary focus due to the distinct stages involved in the flipped classroom paradigm, which allows students ample time to complete necessary tasks. Again, language education emerged as a cluster because of the advantages of FCM. Language education is a field enriched with activities and applications and becomes easier to learn (Isik, 2008).

The most cited studies showed that six of the top-10 studies were from the USA, three from Australia, and one from Taiwan. It is an important result that all of the top-10 most cited studies are articles. O'Flaherty (2015) reached a high level of citations with 1018 citations and was the most cited study. O'Flaherty's (2015) study may be the most cited because it is an important scoping study in the field of FCM. Among the top-10 studies, seven of them are empirical studies. Experimental studies were done to examine the impact of FCM on educational variables (Baepler, 2014; Gilboy, 2015; Hung, 2015; Kim, 2014; Lakmal, 2015; Mason, 2013; Tune, 2013). These variables are academic achievement, perception level, satisfaction, and motivation (Cakir et al., 2021). The most cited journals are focused on educational technology. Because the first thing researchers look at is the journal's reputation, and the second is the speed of publication (Al & Sencan, 2016). In addition, it appears that all of the top-10 journals have an impact factor of Q1. It is also important that the majority of the journals are open-access. Previous research has shown that open access will expand the readership (Beck et al., 2020).

CONCLUSIONS

This study aimed to examine the articles from WoS database with a bibliometric analysis method to reveal research trends in using FCM. The results demonstrated that the number of studies regarding the use of flipped classrooms in learning and teaching

has increased rapidly since 2013 and reached its peak in 2020. The results revealed that, in general, scholars published research on flipped classrooms in open-access journals. My findings also revealed that the journal that published the most publications regarding flipped classrooms is Interactive Learning Environments. The results also showed that the USA is a leading country, and The University of Hong Kong was the institution that had the most publications. The results from keyword analysis revealed that educational research on FCM focused on academic achievement and affective factors, effects on language and mathematics education, effects of distance education, education, and training stages, methods, and performance, and connection between different domains. I believe the results from this research could be a basis for future research and explore research trends regarding flipped teaching. Given that no study analyzed the use of FCM in educational research that covered all areas of education using the bibliometric analysis method, the results from this research are valuable for researchers who work on flipped classroom teaching and present new findings about research trends and topics for scholars about the use of the flipped teaching in educational research. This research offers a comprehensive and enlightening perspective on the flipped classroom teaching model, which is valuable for researchers and educators in this field.

Recommendations

In future studies, bibliometric studies can provide more in-depth findings. Further investigation should be undertaken to analyze and evaluate the current state of flipped learning education research. Hence, the research progress on FCM may be tracked by comparing the data acquired in this study with future studies on "flipped classrooms." Future studies should consider including different databases to analyze the flipped learning research. In addition, further studies can expand the research results by adding a systematic review to the bibliometric analysis method to present a more comprehensive literature evaluation.

Limitations

One primary limitation of this study is that it includes only papers listed in WoS database from 2012 to 2023. The articles that are non-indexed in WoS but indexed in the other databases may cause a limitation for this research. Therefore, I suggest that the readers consider this limitation while reading the results in this paper. The second limitation is that the articles published in 2024 were not involved in the analysis of this research. Because of this reason, I could not be involved in the latest studies. The third limitation is that I included articles published in the English language. This research did not analyze the other publications published in other languages. The final limitation is that I analyzed the articles in the database. However, I did not include other publications in this research, including conference proceedings, book chapters, books, editorials, and letters to editors. These parameters could potentially impact the outcomes of this research.

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