Journal of Information Technology Education: Innovations in Practice

An Official Publication of the Informing Science Institute
InformingScience.org

JITEiip.org

Volume 25, 2026

FUTURE TRENDS AND CHALLENGES OF THE FLIPPED CLASSROOM MODEL IN VOCATIONAL EDUCATION: A BIBLIOMETRIC ANALYSIS

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ABSTRACT

Aim/Purpose	The classroom learning model plays an important role in vocational education by making learning more effective and engaging and by increasing vocational students' self-directed learning. However, no comprehensive assessment of the impact of the Flipped Classroom Model (FCM) on vocational education has been conducted at present.
Background	This study examines trends in publications on the FCM in vocational education over the past decade. It also identifies researchers, the most productive institutions, and emerging themes and topics. Bibliometric analysis predicts future developments, benefits, and challenges of FCM.
Methodology	This study uses bibliometric methods to identify trends, benefits, challenges, and future research directions for the application of the FCM in vocational education. The article searching process follows the PRISMA protocol through three screening stages: identification, screening, and inclusion. Articles were searched through the Scopus database and analyzed using the VOSviewer application.

Accepting Editor Martin D Beer | Received: August 30, 2025 | Revised: January 17, January 27, 2026 | Accepted: January 31, 2026.
Cite as: Rahayu, W., Setyawan, H., Ganefri, & Effendi, H. (2026). Future trends and challenges of the flipped classroom model in vocational education: A bibliometric analysis. *Journal of Information Technology Education: Innovations in Practice, 25,* Article 6. https://doi.org/10.28945/5715

Contribution	This study contributes significantly to knowledge development, particularly regarding research trends, benefits, challenges, and future research to examine the impact of the FCM in vocational education.
Findings	The research results showed an increase in publications, but this increase has not yet significantly impacted vocational education ($R^2 = 0.1847$). China contributed to this research at 41.23%, followed by Indonesia at 11.40% and Spain at 8.77%. The co-occurrence analysis identified three clusters in this topic: student learning outcomes and academic performance; the application of the FCM; and the application of educational technology and pedagogical innovation in vocational education. This learning model benefits vocational education in cognitive, psychomotor, and affective aspects and encourages teachers to design more engaging and compelling learning experiences. However, its implementation still faces challenges from the students, technology, pedagogy, and institutional perspectives.
Recommendations for Practitioners	Based on the results of the study, it is clear that there are significant implications for vocational education, both for teachers and policymakers, regarding the importance of implementing the FCM in the learning process in order to improve student independent learning. This also greatly supports students' lifelong learning skills, which are essential in the era of 21st-century technological development.
Recommendations for Researchers	Based on the study's results, researchers can also recommend examining the long-term impact of the FCM on student competence. In addition, technologies such as educational games and augmented reality can be integrated to improve students' independent learning before attending classes.
Impact on Society	The results of this study provide comprehensive knowledge about the impact of the FCM. In terms of students, it can improve knowledge, critical thinking skills, creativity, problem-solving, metacognition, practical skills, motivation, self-efficacy, and satisfaction. Students need all of this knowledge and these skills to enter the workforce. Additionally, there are positive effects on teachers as educators, including enhanced creativity, mastery of educational technology, and readiness to implement teaching methods.
Future Research	It is hoped that future research can combine article search databases from Springer, IEEE, PubMed, Dimension, Frontiers, and other leading databases. In addition, researchers can conduct pure studies of the long-term impact of applying this model on student competence and integrate it with the latest technologies currently being developed (such as game education or augmented reality).

Keywords	flipped classroom model, vocational education, quality education, learning, bibliometric analysis

INTRODUCTION

Technological advances and the industrial revolution 4.0 have brought the world of education to infinite development (Zhou, 2023). This development not only occurs in general education but also in vocational education (Sudana et al., 2019). Vocational education is education provided to students or to those ready to work, based on their competencies (Setiyawami et al., 2020). Vocational education is a form of education that focuses on mastering skills for work (Suharno et al., 2020). The competencies possessed by students are certainly inseparable from the various learning methods they get from institutions (Eka Tuah et al., 2021).

Several teaching methods and models with unique characteristics exist, with varying capacities to positively affect student learning outcomes in the education sector, especially in vocational education. One of these innovative methods is FCM, an instructional approach that inverts the conventional learning sequence by transferring the initial part of instruction from the classroom to home-based individual study (Al-Samarraie et al., 2020). Bergmann and Sams initially conceived the idea in 2012, noting its limitations compared to traditional face-to-face instruction (Bergmann & Sams, 2012). This model allows students to self-direct their own learning at home, using any combination of resources: textbooks, modules, instructional videos, simulation applications, YouTube materials, and any course-related content, prior to applying knowledge and skills in classroom activities (van Vliet et al., 2015). Today, learning resources are closely intertwined with technological integration, making technology-enhanced learning a prerequisite for quality educational improvement, especially in vocational training contexts focused on very practical skills (Lochner et al., 2016).

Vocational education has learning characteristics oriented towards the mastery of practical competencies, procedural skills, and work readiness, thus requiring a learning model that effectively bridges theory and practice (Billett, 2011). The FCM learning model is considered relevant because it utilizes digital technologies such as learning management systems, instructional videos, virtual laboratories, virtual reality, and mobile devices to move knowledge transmission activities outside the classroom, so that face-to-face time can be focused on active learning, problem solving, and project-based practices that are in line with vocational education needs (Huang et al., 2025; Wanmei, Puah, et al., 2025; Wulansari et al., 2023). Empirical studies confirm that FCM has a significant impact on learning outcomes and problem-solving skills when supported by appropriate technology and structured pedagogical strategies (Wulansari et al., 2023). Problem-solving skills are highly needed by vocational students to solve work-related problems in industry (Magagula & Awodiji, 2024). Thus, the application of FCM in vocational education should be positioned as a pedagogical approach that strengthens practical learning and is oriented towards actual work, rather than merely a technical transformation of online learning, to truly improve the quality of graduates' competencies and work readiness.

Constructivist theory underpins the FCM by emphasizing learners' active roles in constructing knowledge, competencies, and skills through structured learning experiences facilitated by educators (Do et al., 2023). In this view, knowledge is not transferred directly from instructor to student but is developed through active cognitive processes influenced by learners' prior experiences, goals, and learning contexts (Mohsina Banu & Mohd Mahmood, 2019). Therefore, learning in FCM is characterized by active engagement and meaning-making, rather than passive reception of information (Stoeckel, 2020). Students come to understand with experience within specific contexts rather than simply memorizing facts, concepts, or rules. It is thus imperative that students develop critical thinking and problem-solving skills within a sense of meaning in their learning journey. Teachers do not simply deliver content; instead, they mentor and guide and support students through their understanding, analysis, and generation of new knowledge (Loyens et al., 2009). Knowledge is constructed, not discovered, and skills are not taught, but learned (Ondog & Kilag, 2024). This is directly related to vocational education, where students must use certain skills in their fields.

The FCM has been studied rapidly in the last decade, and its implementation in vocational education is becoming more evident. Nonetheless, studies on the FCM in vocational settings remain sporadic and are inadequately mapped (Wang, 2019). Existing studies are mainly concerned with general educational settings. However, little is known about changes and development trends, collaboration among researchers, and themes specific to the vocational education area, institutional contributions, dynamics of source types, and citation patterns in this field. The aim of this study is to do a thorough mapping of the literature in order to identify the research gaps and assess the possible future advancements for FCM. Bibliometric analysis is an appropriate method for the quantitative representation of research relating to FCM in vocational education. Additionally, this study will strive to exam-

ine the level of FCM use across various vocational fields, such as engineering, healthcare and business. The analysis would also include identifying the advantages and disadvantages of using FCM in vocational training.

Thus, this bibliometric study offers three key novelties that extend beyond the scope of previous research in vocational education. First, it provides a comprehensive bibliometric analysis of Flipped Classroom research across all domains of vocational education, without limitation to specific disciplines or levels, thereby offering a holistic overview of publication trends, research themes, and scholarly contributions in this field. Second, this study systematically maps and synthesizes the reported benefits and challenges of implementing the FCM in vocational education, enabling a critical understanding of its pedagogical impact and the barriers to effective adoption. Third, based on the identified research patterns and gaps, this study highlights potential future research directions to advance vocational education research and practice at both national and international levels.

Some key questions underlying this research include:

(1) What are the trends in the growth of publications on FCM in vocational education over the past 10 years?

(2) Who are the most productive researchers and institutions in this field?

(3) What are the leading and emerging themes that are the focus of research?

(4) What are the predictions for the development of FCM in vocational education based on bibliometric analysis?

The findings from these questions will provide a roadmap for policymakers, educators, and researchers to optimize the implementation of FCM in vocational education. Additionally, this research will reveal the extent to which FCM has been adopted across various vocational fields, including engineering, health, business, and agriculture. Variation in FCM implementation across different vocational disciplines can provide insights into the most effective models tailored to the field of study. This analysis can also identify specific challenges faced in implementing FCM, such as technical, pedagogical, or psychological barriers.

From a policy perspective, the results of this bibliometric study can serve as a reference for formulating strategies to integrate FCM into vocational education curricula. For example, by identifying the latest research trends, governments and educational institutions can design more targeted teacher training programs, digital content development, and supporting infrastructure (Fan et al., 2022; Segura-Robles et al., 2020). Additionally, these findings can encourage collaboration among research institutions to strengthen innovation in FCM. Thus, this research not only contributes academically to mapping FCM literature in vocational education but also serves as a practical guide for education stakeholders to anticipate future challenges. The results of the bibliometric analysis are expected to provide new insights into the potential of FCM in preparing competitive, adaptive, and ready-to-face-the-workplace vocational graduates.

RELEVANT RESEARCH

Based on Table 1, bibliometric research on FCM to date is still dominated by global and national studies that cover all types of educational institutions without distinguishing specific pedagogical characteristics. The study by Oknaryana et al. (2025) highlights national publication and collaboration trends in Indonesia, analyzes the impact of FCM on student learning outcomes, and examines the relevance of research keywords. Meanwhile, research conducted by Dan and Mohamed (2024), del Arco et al. (2022), Limaymanta et al. (2021), and Zhang et al. (2024) consistently place the FCM in the context of general education at the global level, focusing on publication growth, international collaboration, research areas, core journals, and keyword relationship structures. This approach provides a macro view of research development, but does not delve deeply into specific institutional contexts.

This bibliometric approach provides a comprehensive overview of the intellectual structure and dynamics of FCM research development, but it still treats education as a homogeneous entity. As a result, contextual institutional characteristics, such as differences in learning objectives, competency orientation, and learning technology requirements across educational types, have not been adequately accounted for in existing bibliometric studies.

Table 1. Summary of previous relevant research

Researchers	Year of article publication	Focus on educational institutions	Focus of discussion
(Oknaryana et al., 2025)	2015–2024	All types of education in Indonesia	Publication trends, national collaboration, citation analysis matrix, analysis of the impact of FCM on student learning outcomes, analysis of learning models that can be integrated with FCM, and analysis of the relationship between research keywords.
(Zhang et al., 2024)	2012–2022	All types of education in the world	Publication trends, international collaboration, research area analysis, and research keyword relationship analysis
(Dan & Mohamed, 2024)	2014–2023	All types of education in the world	Publication trends, international collaboration, research area analysis, publication journal analysis, and research keyword relationship analysis
(del Arco et al., 2022)	2007–2021	All types of education in the world	Publication trends, international collaboration, research area analysis, publication journal analysis, and research keyword relationship analysis.
(Limaymanta et al., 2021)	2012–2020	All types of education in the world	Publication trends, international collaboration, analysis of research keywords, and analysis of the FCM framework

Furthermore, a review of previous studies shows that the FCM is generally examined as a generic pedagogical model, with success measured by indicators of learning outcomes, student engagement, and overall learning effectiveness. There are no studies that explicitly position vocational education as the main unit of analysis, even though vocational education has different learning characteristics, such as the dominance of practice, work competency orientation, and the need for integration with applied technology and industry contexts (Setyawan et al., 2025; Sukardi et al., 2024). Thus, generalizing findings from academic education to vocational education can obscure the specific pedagogical needs that characterize vocational education.

Therefore, this bibliometric study focuses specifically on vocational education to present significant innovations both conceptually and empirically. The novelty of this study lies in its attempt to map trends, dominant themes, and the direction of FCM development in the context of vocational education, including its integration with practical learning and industry-based competencies. In addition, this study will also examine the challenges and opportunities for implementing FCM in vocational education in the future. By narrowing the institutional focus, this study not only fills existing gaps in the bibliometric literature but also makes a strategic contribution to shaping the direction of developing an FCM that is more relevant and contextually appropriate for vocational education in the era of digital transformation and future industry needs.

METHODS

This study uses a bibliometric method to analyze all publications on FCM in vocational education, examining major trends, studies with significant impact, connections among concepts, emerging issues, advantages, and the direction of further research. This study is based on primary literature indexed in Scopus. Bibliometric methods are widely used and selective in analyzing and reviewing large-scale research data (Donthu et al., 2021; Limaymanta et al., 2021). This method is increasingly popular in research across various fields of science and in evaluating the rankings of institutions and universities at the global level. Given the abundance of research and the available literature, bibliometric analysis can now be examined using this approach (Ellegaard & Wallin, 2015).

This study adopts the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol to maintain transparency and consistency in the stages of searching, screening, and presenting the collected documents (Cevikbas & Kaiser, 2022; Sukardi et al., 2024). The detailed steps of the article search process are illustrated in Figure 1. The search identified 145 articles related to the predefined keywords. No duplicate records were removed prior to screening. The articles were then screened based on their publication year, ranging from 2015 to 2025. The number of articles filtered by year was 145. In the year-based screening, no articles published before 2015 were identified. Subsequently, filtering was conducted based on document type. In this document filtering, the following types were excluded: Editorial, Retracted, Conference Review, and Review. After filtering, 114 articles were included in this study. For further clarification, see the PRISMA diagram (Figure 1).

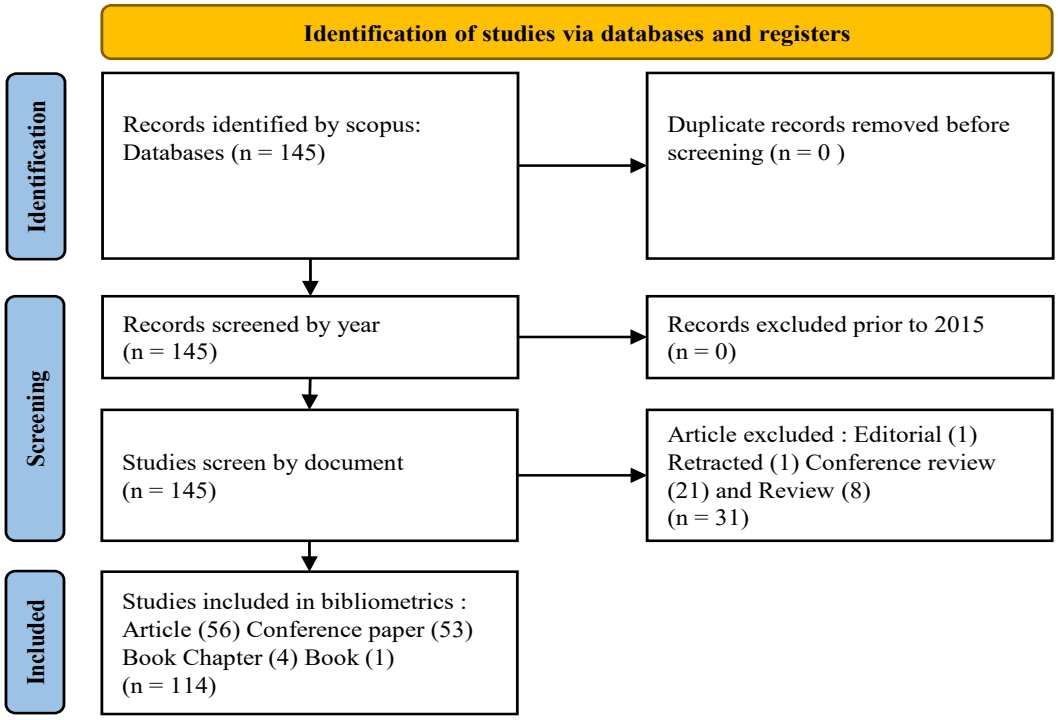

Figure 1. Research steps taken

SEARCHING STRATEGY

The data search strategy in this study was designed systematically to ensure the completeness and validity of the bibliometric data analyzed. The Scopus database was chosen as the primary source because it offers extensive coverage of international publications, high metadata quality, and is widely

utilized in bibliometric studies across various disciplines. The use of Scopus as a data source is considered appropriate for mapping global research developments and trends, particularly in the context of vocational education, on topics such as flipped learning and flipped classrooms, as has been done in various previous bibliometric studies. Meanwhile, literature searches were conducted using a combination of keywords formulated in the form of Boolean operators in the TITLE-ABS-KEY column, specifically "flipped learning," "flipped classroom," "vocational education," and "vocational school." This strategy aimed to ensure that the documents obtained were substantially relevant to the research topic, both in terms of the learning model and the vocational education context. The title, abstract, and keyword-based search approach was chosen because it has been proven to increase the precision of search results in bibliometric studies, while minimizing the inclusion of irrelevant publications (Aria & Cuccurullo, 2017; Donthu et al., 2021).

Additionally, this study does not impose publication-year restrictions, allowing all documents available in Scopus, as of July 7, 2025, to be accommodated. This policy enables a longitudinal analysis of research evolution, from the initial emergence of the FCM concept to its most recent developments. In addition, the types of documents included cover journal articles, conference proceedings, books, and book chapters, to obtain a more comprehensive picture of academic contributions in the field of education, which are often published not only in scientific journals but also in other scientific forums. Furthermore, the search was conducted without restrictions on language, country, or subject area. This approach aimed to avoid geographical and linguistic bias and capture research contributions from various relevant disciplines, including education, engineering, and the applied sciences. This inclusive search strategy aligns with best practices in bibliometric research, as it yields a representative dataset that can be used to analyze publication trends, author collaboration, keyword mapping, and global research theme development (Donthu et al., 2021; Zupic & Čater, 2015). In brief, the article search strategy used in this study is presented in Table 2.

Table 2. Strategies for searching articles in Scopus data

No	Categories	Description
1	Research database	Scopus
2	Searching for keywords	(TITLE-ABS-KEY (flipped AND learning) OR TITLE ABS-KEY (flipped AND class room) AND TITLE-ABS-KEY (vocational AND education) OR TITLE-ABS-KEY (vocational AND school))
3	Searching years	No period Limitation
4	Document type	Article, conference paper, book, and book chapter
5	Language	All language
6	Country	All country
7	Subject area	All subject areas
8	Date of Access	July 7, 2025

DATA ANALYSIS

This study analyzed data from Scopus, exported in CSV format, using VOSviewer (Version 1.6.20) and Microsoft Excel 2021. The recorded data included Author, Subject Area, Document Type, Source Title, Keyword, Affiliation, Country, Source Type, Language, and Open Access. Data analysis began with the following:

(1) Publication trend analysis of document types consisting of articles, conference papers, books, and book chapters. Then, the subject areas were analyzed by counting each and calculating their percentages. The next stage was to analyze documents per year to determine the number of FCM-related articles in vocational education that were of interest each year.

Publication trends over the years are analyzed using linear regression to predict whether research on the FCM in vocational education is increasing, stable, or decreasing.

(2) Country analysis aimed at identifying countries with the highest number of publications. Countries with the highest numbers of publications and their internationalization patterns were studied through collaboration among authors using VOSviewer (v1.6.20) with a complete counting approach, identifying the most dominant countries in FCM research in the vocational field.

(3) Institutional analysis, identifying institutions within a country by calculating the number, percentage, and number of citations.

(4) Source title analysis, which highlights the sources of articles and counts the number of articles published in each source, along with their citations.

(5) Citation analysis discusses the number of citations per author.

(6) Co-occurrence analysis, which identifies the relationship or pattern of occurrence between keywords and other elements.

(7) Benefits of the FCM in vocational education. The analysis of benefits is based on frequently cited articles and concludes that there is significant research impact. Each article is systematically studied and analyzed to identify its benefits and challenges.

(8) Challenges in implementing the FCM in vocational education. This analysis discusses all the challenges that may be encountered during the implementation of the FCM in vocational education.

RESULTS AND DISCUSSION

PUBLICATION TREND ANALYSIS

The article used the PRISMA method in this study to ensure a transparent, structured process for filtering and selecting the articles obtained (Setyawan et al., 2025). From the overall article search, 114 articles discussed FCM in vocational education. First, based on the field research document types, four types of published documents were identified, as shown in Figure 2.

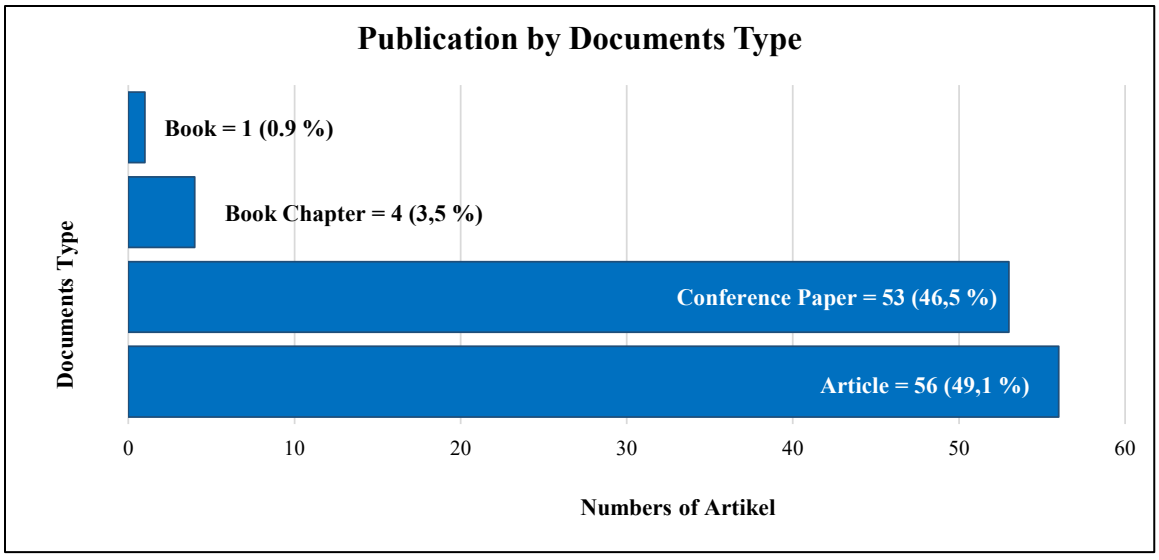

Figure 2. Number of documents by publication type

Publication data based on document type showed a dominance of journal articles (56 publications, 49.1%) and conference papers (53 publications, 46.5%), reflecting a focus on original peer-reviewed research and the dissemination of initial findings through academic forums. Meanwhile, contributions from book chapters (4 publications, 3.5%) and books (1 publication, 0.9%) are relatively small, indicating limited involvement in long-term knowledge synthesis. This distribution suggests high productivity in empirical research and scientific collaboration, but also opportunities to strengthen impact through more in-depth book or book chapter publications.

Second, an analysis of articles was conducted by subject area, and the 10 most researched subject areas are presented in Table 3. This data shows the distribution of research publications by subject area, with Social Sciences leading with 61 publications (53.51%), followed by Computer Science with 32 (28.07%), reflecting a primary focus on social and technological issues. Fields such as Engineering and Decision Sciences each contributed 7 publications (6.14%), while other fields, such as Nursing, Psychology, Business and Management, and Mathematics, made smaller contributions (below 4%). Arts and Humanities and Medicine recorded the fewest publications (2 each, 1.75%), with an additional 5 publications (4.39%) from the other category. This distribution indicates a greater research priority on social and technological fields, while other fields may require further development to enhance their academic contributions. These results also identify that the impact of implementing the FCM has begun to be felt in vocational schools, particularly in the Engineering field, which is among the categories with the highest number of publications.

Table 3. Strategies for searching articles in Scopus database

No	Subject area	N	%
1	Social sciences	61	53.51
2	Computer science	32	28.07
3	Engineering	7	6.14
4	Decision sciences	7	6.14
5	Nursing	4	3.51
6	Psychology	4	3.51
7	Business, management and accounting	3	2.63
8	Mathematics	3	2.63
9	Arts and humanities	2	1.75
10	Medicine	2	1.75
11	Others	5	4.39

Third, an analysis of publications by year was conducted, as shown in Figure 3. The results indicate that the FCM was introduced in vocational education in 2015. Previously, research conducted by Lage et al. (2000) introduced the Inverted Classroom model, which emphasized learning basic material through video lectures for at-home study, while face-to-face classes focused on active learning, such as group discussions, problem-solving, group work, and individual mentoring. However, initial research in the Department of Economics did not yet include vocational education. In vocational education, the FCM emerged and was integrated into learning starting in 2015, as developed by Dalton et al. (2016) and Guan et al. (2015), making it effective in this context. Additionally, Phusalux et al. (2015) emphasized the importance of implementing a technology-based FCM in vocational colleges to improve educational quality.

Research into the benefits of the FCM in vocational education increased over the following year, although there was a decline in 2016, with only two studies conducted. In 2017, there was a significant increase to 8 documents, which remained stagnant until 2019, when there was only one increase the

following year. In 2020, the number of published documents increased significantly again to 19 documents. However, over the following years, the number of published documents decreased to 17 in 2021 and 13 in 2022. The year 2023 showed the highest publication rate, with 20 documents, while 2024 saw a decline to 9 documents, and 2025 had 5 documents. However, the publications for 2025 are not yet fully complete, and there is a possibility of an increase in the number of documents published.

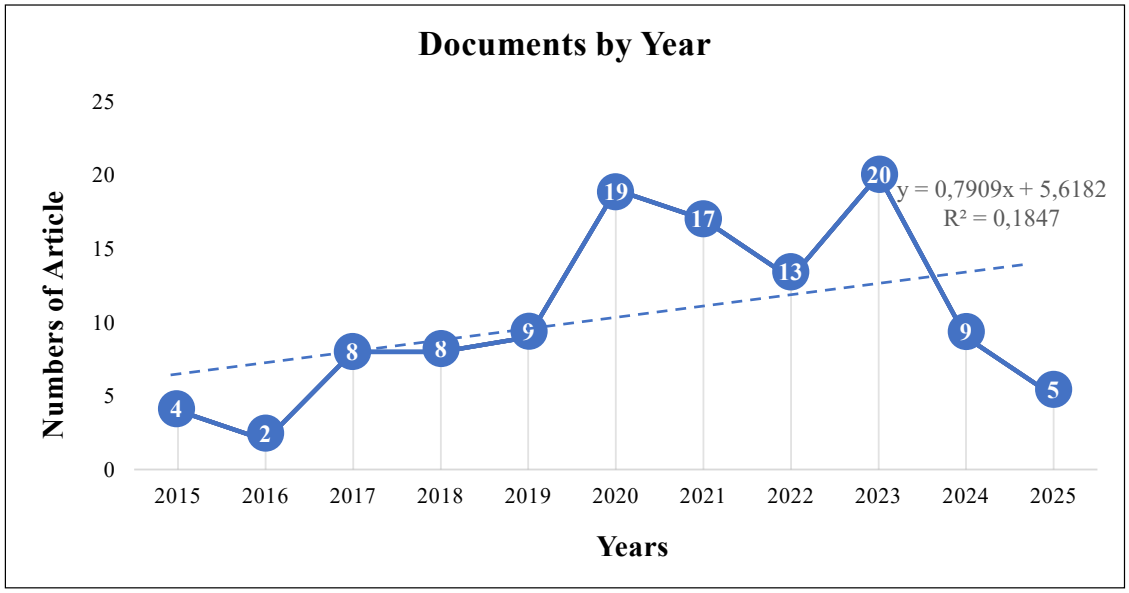

Figure 3. Number of documents by year of publication

Publication trend data by year were also analyzed using regression in Microsoft Excel and its built-in regression analysis feature. The results are shown in Figure 3. The linear trend line shown in the graph with the regression equation ($y = 0.7909x + 5.6182$) has an R^2 value of 0.1847. Based on this data, the average annual increase in research is 18.47%, indicating that publication growth does not follow a stable linear pattern. Thus, this low R^2 value reflects the characteristics of FCM research as a new study, still in the early stages of adoption in vocational education. A surge in publications occurred in 2020–2023 in response to the urgent need for technology-based learning during the COVID-19 period, which encouraged vocational education to experiment with FCM as a flexible learning approach oriented towards improving student competence (Yang et al., 2023).

Conversely, the decline in the number of publications in subsequent years indicates that the implementation of the FCM in vocational education has not been fully institutionalized and is still highly dependent on the readiness of digital infrastructure, institutional policies, and the pedagogical capacity of educators to integrate technology in a meaningful way (Lo et al., 2021; Romero-García et al., 2023; Tomory, 2023). Thus, the use of technology in vocational education is not merely the adoption of digital media for instructional purposes; rather, it must be positioned as a pedagogical tool that supports authentic learning and is oriented toward the mastery of competencies students must acquire.

Country Analysis

An analysis of FCM research in vocational education conducted across various countries shows widespread participation, with 31 countries participating. As shown in Table 4, the top 10 countries published the most scientific articles. China is the top contributor with 47 documents, accounting for 41.23% of total publications, reflecting its dominance in knowledge production in related fields of study.

Table 4. Number of documents by researcher country

No	Country	N	%
1	China	47	41.23
2	Indonesia	13	11.40
3	Spain	10	8.77
4	Malaysia	7	6.14
5	Taiwan	7	6.14
6	Germany	4	3.51
7	Russian Federation	4	3.51
8	Hungaria	3	2.63
9	United States	3	2.63
10	Ukraine	3	2.63

Several key elements account for this trend. First, China has heavily invested in education and technology, thus providing a strong infrastructure for the adoption of innovative teaching methods. Second, progressive educational policies have been instituted to reduce traditional academic burdens while directly promoting student-centered approaches, such as the FCM. Third, rapid technological adoption in China enables seamless integration of digital tools into its education system. Fourth, in educational technology, the nation demonstrates a high degree of research productivity, with numerous universities actively involved in this field. Together, these factors account for China's prominent position in advancing FCM methodologies, as shown in bibliometric analyses that popularly highlight the country's notable research output in educational innovation. Indonesia ranks second with 13 documents (11.40%), indicating its active role and increasing contribution to global research, followed by Spain (10 documents, 8.77%). Countries such as Malaysia and Taiwan have equivalent contributions (6.14%), reflecting the strategic position of Southeast Asia and East Asia in scientific collaboration and publication. Contributions from European countries such as Germany, Hungary, the United States, and Ukraine, as well as from the Russian Federation, indicate cross-regional involvement, albeit on a smaller scale. Central European countries have also initiated this research, such as the United Kingdom (2 documents), Greece (1 document), and the Netherlands (1 document). This distribution pattern highlights the disparity in scientific contributions among countries, with much of the research still conducted in Asian regions.

Next, an analysis of the network of researchers across countries was conducted, with the results shown in Figure 4. The visualization of the scientific collaboration network in the figure shows that China is the central actor with the highest collaboration intensity, as indicated by the large node sizes and the number of connections involving countries such as the United States, Malaysia, Indonesia, and Taiwan.

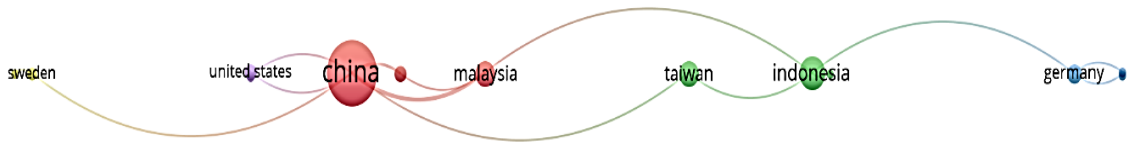

Figure 4. Network visualization of inter-country research collaboration

This strong connectivity reflects China's dominance in the global research ecosystem and its role as a significant hub for cross-border knowledge exchange. Indonesia, despite having a smaller node,

demonstrates strategic connectivity with Asian countries such as Taiwan and Malaysia, as well as with China as its leading partner. Conversely, countries like Sweden and Germany are peripheral, indicating a more limited role in this collaborative network. As shown in the data visualization, strong international collaboration indicates that FCM research is not limited to specific countries but is a global effort to uncover the benefits of this learning model in vocational education.

Institution Analysis

The analysis revealed that 207 institutions have conducted research on FCM in vocational education, and Table 5 shows the top eight organizations that have published on this topic. The data indicate that Universitas Negeri Padang in Indonesia ranks first, with three documents (2.63%) and the highest number of citations (54), signifying a substantial contribution in both quantity and academic impact. Following closely are three leading medical institutions in Germany: Universitätsklinikum ULM, Tübingen, and Heidelberg, each contributing two documents (1.75%) with the same high number of citations (19), demonstrating consistent, high-quality scientific productivity. The Egyptian institution Assiut University also contributed two documents from different departments, both with relatively low citation rates (3 and 4). Universitas Negeri Yogyakarta in Indonesia also contributed two articles, but they received little attention (only 1 citation), indicating potential that has not yet been fully recognized within the scientific community.

Table 5. Top 8 organizations with the most documents

No.	Institution	Country	N	%	Citation
1	Universitas Negeri Padang	Indonesia	3	2.63	54
2	Universitätsklinikum ULM	Germany	2	1.75	19
3	Universitätsklinikum Tübingen	Germany	2	1.75	19
4	Universitätsklinikum Heidelberg	Germany	2	1.75	19
5	Universided Politecnica de Madrid	Spain	2	1.75	8
6	Assiut University – Information Science Department	Egypt	2	1.75	3
7	Assiut University – Electrical Engineering Department	Egypt	2	1.75	4
8	Universitas Negeri Yogyakarta	Indonesia	2	1.75	1

Next, an analysis of the network between organizations was conducted, and the results are shown in Figure 5. The figure shows the institutional collaboration network in scientific production, with Padang State University as the central node, with active academic relationships with various national and international institutions.

On the left side, intensive collaboration is evident with institutions such as Batam University, IKIP PGRI Pontianak, National Kaohsiung University, as well as units like the Faculty of Engineering at Ibnu Sina Batam University and the Technology and Vocational Education unit at Yogyakarta State University, forming a strong collaborative cluster in the fields of engineering and vocational education.

On the right side, Padang State University expands its international collaboration with institutions such as the Vinh Long University of Technology and the Faculty of Computer Science at Dharmas Indonesia University, demonstrating openness to global knowledge exchange, particularly in technology and science. Although this collaboration has shown promising results, it has not yet involved all universities globally. Therefore, vocational education still requires full attention from global educational institutions to enhance the quality of the FCM's impact.

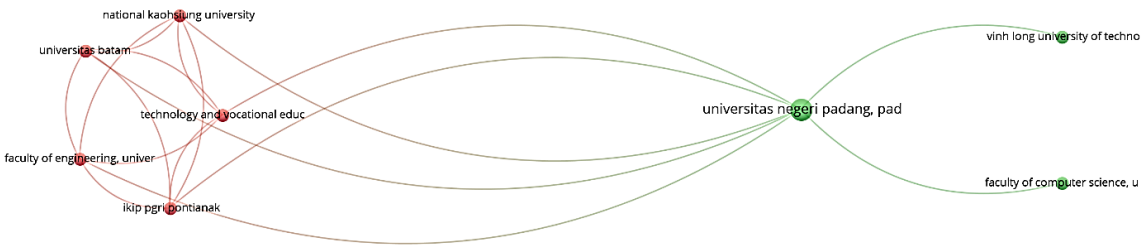

Figure 5. Network visualization of inter-country research collaboration

Source Title Analysis

The analysis results show 94 source titles that published articles on FCM in vocational education. The ACM International Conference Proceeding Series ranked first, with five documents (4.39%) and five citations, indicating its important role in disseminating research in the field of information technology and computing. The Journal of Physics Conference Series and E3S Web of Conferences each contributed four documents (3.51%), with the Journal of Physics recording a higher number of citations (7), indicating a relatively strong influence within the applied physics scientific community. Despite contributing only two documents (1.75%), Anatomical Science Education recorded the highest number of citations (38), indicating that the quality and impact of the published research outweigh its quantity. Other sources, such as Lecture Notes in Education Technology, the Chinese Journal of Nursing Education, and the International Journal of Learning, also demonstrate interdisciplinary involvement in their publications, reflecting a multidisciplinary research orientation. More specifically, the 10 source titles that published the results of this study are shown in Table 6.

Table 6. Top 10 source titles with the most documents

No.	Source	N	%	Citation
1	ACM International Conference Proceeding Series	5	4.39	5
2	Journal of Physics Conference Series	4	3.51	7
3	E3S web of Conferences	4	3.51	4
4	Chinese Journal of Nursing Education	3	2.63	4
5	Lecture Notes of the Institute for Computer Science	3	2.63	1
6	AIP Conference Proceedings	2	1.75	0
7	Anatomical Science Education	2	1.75	38
8	International Journal of Learning	2	1.75	7
9	Lecture Notes in Education Technology	2	1.75	2
10	Lecture Notes in Network and Systems	2	1.75	2

Next, a network visualization analysis of source titles was conducted, with the results shown in Figure 6. These relationships indicate the existence of citation flows and topical collaborations across disciplines, from applied sciences to social sciences and educational evaluation. Emerging Science Journal is at the beginning of the network, indicating its contribution to the early literature. It was then further developed by Humanities and Social Sciences, which serves as the central connecting node. This network structure reflects an interdisciplinary approach to scientific publishing, where findings from the basic and social sciences are used to strengthen evaluation studies while emphasizing the importance of interdisciplinary dialogue in developing more holistic, applied scientific knowledge.

Figure 6. Network visualizes source title

CITATIONS ANALYSIS

Based on the results, the total citation value is 948, with an average citation of 8.32. Although this result is considered large, many documents still have no citations (0 citations). From this data, 40 articles have no citations, and 74 have citations. In detail, there are 50 documents with citations below 10 and 24 documents with citations equal to or greater than 10, with the highest citation count being 157. The articles with the highest number of citations (10 or more) are shown in Table 7. The number of citations per document reflects a document's quality and impact on FCM research in vocational education (Mertala et al., 2024). Table 7 presents the 10 documents with the highest numbers of citations related to the application of the FCM across various educational contexts.

The top two studies by H. Chuang et al. (2018) and van Vliet et al. (2015) dominate with a significant number of citations (157 and 151), indicating the substantial impact of this approach on student learning outcomes and collaborative learning strategies. However, the study by van Vliet et al. (2015) also revealed that the positive effects on students' metacognition do not persist in the long term, raising questions about the sustainability of this model's benefits. Most studies in the Q1 category, such as Chen et al. (2020), Villalba et al. (2018), and Zhu et al. (2020), indicate that this topic is widely published in high-impact journals, reflecting the importance of the FCM in current academic discussions.

The variety of research fields, ranging from medical education (Lochner et al., 2016), epidemiology (Zhu et al., 2020), nursing (van Vliet et al., 2015), to language education (Karapetian, 2020), demonstrates the widespread adaptation of the FCM across various disciplines. However, differences in citation counts and journal rankings (Q1 to Q3) suggest that effectiveness and impact may depend on factors such as pedagogical design, student characteristics, and alignment with instructional content. For example, studies with lower citation counts, such as Karapetian (2020) and Quinn et al. (2018), may be more specific or limited to certain audiences. Overall, this data confirms that the FCM remains a relevant and widely researched approach. However, its success is highly dependent on the implementation context and the quality of its instructional design.

Table 7. Top 10 document citations

Author	Title	Source	Citation	Q
(H. H. Chuang et al., 2018)	Which students benefit most from a flipped classroom approach to language learning?	*British Journal of Educational Technology*	157	Q1
(van Vliet et al., 2015)	Flipped-class pedagogy enhances student metacognition and collaborative-learning strategies in higher education but effect does not persist	*CBE Life Sciences Education*	151	Q1
(Lochner et al., 2016)	Combining traditional anatomy lectures with e-learning activities: How do students perceive their learning experience?	*International Journal of Medical Education*	64	Q3

Author	Title	Source	Citation	Q
(Zhu et al., 2020)	Use of a flipped classroom in ophthalmology courses for nursing, dental, and medical students: A quasi-experimental study using a mixed-methods approach	*Nurse Education Today*	37	Q1
(Chen et al., 2020)	Teachers networked professional learning with MOOCs	*PLOS ONE*	26	Q1
(Sánchez-Rivas et al., 2019)	College student's perception about the pedagogical model of flipped class (Percepción del alumnado universitario respecto al modelo pedagógico de clase invertida)	*Revista Internacional de Investigación en Educación*	26	-
(Villalba et al., 2018)	Factors with influence on the adoption of the flipped classroom model in technical and vocational education	*Journal of Information Technology Education: Research*	24	Q1
(Dalton et al., 2016)	Using clinical reasoning and simulation-based education to 'flip' the enrolled nurse curriculum	*Australian Journal of Advanced Nursing*	23	Q1
(Quinn et al., 2018)	What type of learner are your students? Preferred learning styles of undergraduate gross anatomy students according to the index of learning styles questionnaire	*Anatomical Sciences Education*	22	Q1
(Karapetian, 2020)	Creating ESP-based language learning environment to foster critical thinking capabilities in students' papers	*European Journal of Educational Research*	20	Q3

Co-Occurrence Analysis

Co-occurrence analysis was conducted to examine the relationships among keywords related to the application of the FCM in vocational education. A binary counting method was used, in which each keyword was counted only once per document, regardless of its frequency of appearance, to reduce the influence of repeated terms and emphasize the distribution of keywords across the entire dataset (Mertala et al., 2024). The minimum threshold for keyword occurrence was set at three across 114 articles to ensure the inclusion of relevant and frequently used terms. Keyword clustering was performed automatically using VOSviewer, with the minimum cluster size and cluster resolution maintained at the default settings (resolution = 1.0). The analysis identified 79 keywords that met the threshold and were grouped into three distinct clusters, as illustrated in Figure 7.

The first cluster, shown in red, focuses on the impact of the FCM on vocational students' learning outcomes and academic performance. Key terms in this cluster include student performance, collaborative learning, active learning, and learning outcomes, indicating a strong research emphasis on pedagogical effectiveness. The prominence of collaborative and active learning suggests that FCM are consistently associated with increased student engagement, which contributes to improved academic performance (Dewi et al., 2025; Hu et al., 2025). This relationship highlights that the FCM extends beyond a simple reversal of instructional activities and instead promotes a student-centered and interactive learning environment (Karapetian, 2020; Sánchez-Rivas et al., 2019). The presence of educational measurement and learning outcomes as central nodes further indicates that studies in this cluster predominantly adopt quantitative approaches to evaluate effectiveness. At the same time, this cluster reflects ongoing implementation challenges, particularly in designing meaningful collaborative activities and developing assessment strategies capable of capturing the multidimensional impacts of the FCM (H. Chuang et al., 2018; van Vliet et al., 2015).

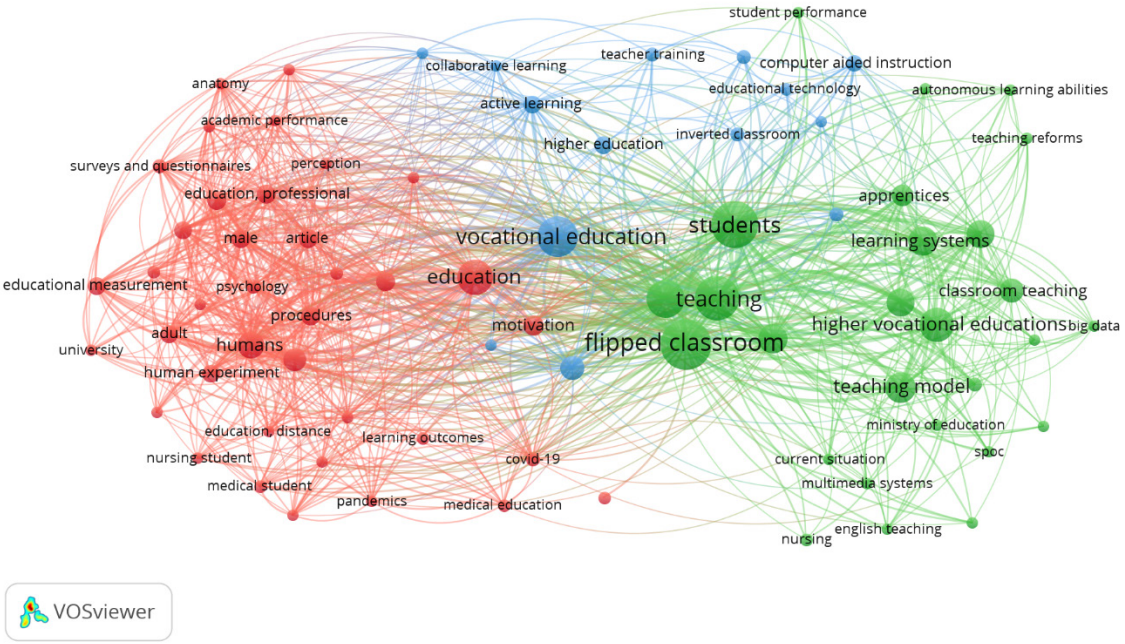

Figure 7. Visualization map of the network with clusters based on co-occurrence analysis

The second cluster covers the application of the FCM in vocational education, marked in green. This cluster broadly covers medical education, nursing students, surgery and questionnaires, education professionals, and higher vocational education, revealing the dominance of the FCM application in professional education, particularly in the health sector. The strong representation of clinical terms such as surgery and medical students indicates that this model is highly effective for training technical-professional competencies that require integration between theoretical learning (pre-class materials) and direct practice (in-class application) (Lyu et al., 2023; Yang et al., 2023). Node questionnaires that appear alongside "surgery" indicate that most studies in this cluster use survey methods to evaluate participants' perceptions of this learning model in the context of medical training. The inclusion of vocational education and professional education expands the scope of this cluster to non-health vocational fields, confirming that the FCM can adapt to various competency-based educational needs (Romero-García et al., 2023; Sun & Lin, 2022). The pattern of this cluster also suggests that the success of implementation depends heavily on the design of pre-class materials relevant to field practice and on structured feedback mechanisms, particularly in an education environment focused on mastering a specific skill (Zhu et al., 2020).

The third cluster covers the application of educational technology and pedagogical innovation integrated with the FCM in vocational education, marked in blue. This cluster broadly encompasses computer-aided instruction, educational technology, inverted classrooms, multimedia systems, and autonomous learning, underscoring the crucial role of digital technology in implementing the FCM. The dominance of technical terms in this cluster indicates that this learning model inherently relies on integrating pedagogy and technology, with multimedia systems serving as the primary enabler for effectively delivering pre-class materials (Huang et al., 2025; Yuliana et al., 2024). The concept of the inverted classroom, which emerges as a central node, emphasizes the model's main characteristic: reversing the traditional learning flow. In contrast, autonomous learning abilities indicate that educational technology in this context not only functions as a medium for delivering content but also for developing students' self-directed learning (Yang et al., 2023). The presence of computer-aided instruction and educational technology, which are closely interconnected, forms the core of this cluster, reflecting that research in this group extensively explores the design of adaptive learning systems that

facilitate personalized learning (Mubai et al., 2023). This cluster also implies research challenges related to optimizing technology to create immersive learning experiences and to develop instruments capable of measuring the impact of technology on self-directed learning in the FCM framework.

Benefits of Flipped Classroom Model on Vocational Education

Based on the articles cited in Table 7, we also found many benefits of the FCM in vocational education. The analysis results show that this learning model not only impacts students but also impacts teachers in vocational schools. Thus, this model is also indirectly used to develop teacher competencies. The benefits for students have been achieved across three domains of learning outcomes: cognitive, affective, and psychomotor, as detailed in Table 8. In the cognitive domain, the FCM has various impacts, ranging from mastery of basic information (knowledge) to higher-order thinking skills such as critical thinking, creativity, problem-solving, and metacognition. Research by H. Chuang et al. (2018), Herlambang et al. (2024), and KamalEldeen et al. (2024) shows that learning focused on conceptual knowledge is an important foundation for developing advanced cognitive competencies. Meanwhile, critical and creative thinking skills, as studied by Dalton et al. (2016), Hao et al. (2024), and Novalinda et al. (2023), are key indicators of students' readiness to face complex challenges in the 21st century. The emphasis on metacognition by van Vliet et al. (2015) also underscores the urgency of developing learning awareness to enhance self-control in thinking and decision-making.

Table 8. Benefits of FCM in vocational education

<table>
<tr><th colspan="3">Student</th></tr>
<tr><th>Cognitive domain</th><th>Psychomotor domain</th><th>Affective domain</th></tr>
<tr><td>Metacognition</td><td rowspan="5">Improving the practical skills of vocational students</td><td>Motivation</td></tr>
<tr><td>Learning outcomes (knowledge)</td><td>Self-efficacy</td></tr>
<tr><td>Critical Thinking skill</td><td>Satisfaction</td></tr>
<tr><td>Creativity skill</td><td></td></tr>
<tr><td>Problem-Solving skill</td><td></td></tr>
<tr><th colspan="3">Teacher</th></tr>
<tr><td colspan="3">Teacher creativity</td></tr>
<tr><td colspan="3">Mastery of learning technology</td></tr>
<tr><td colspan="3">Teacher readiness to teach</td></tr>
</table>

The affective and psychomotor domains presented in this data confirm that effective learning does not focus solely on intellectual aspects but also on the development of attitudes, motivation, and practical skills. In the affective domain, motivation, self-efficacy, and learning satisfaction significantly impact student engagement and academic performance. Research conducted by Dewi et al. (2025), Sánchez-Rivas et al. (2019), and Wanmei, Abdullah, et al. (2025) shows that when students feel confident, motivated, and satisfied with the learning process, they tend to be more active and take greater responsibility for their learning achievements. Furthermore, psychomotor skills studied by Dalton et al. (2016), Herlambang et al. (2024), and Zhu et al. (2020) also emphasize the importance of motor training and technical skills in specific fields, particularly in vocational and practice-based education. Additionally, Dalton et al. (2016), Karapetian (2020), Lochner et al. (2016), and Sánchez-Rivas et al. (2019) emphasize that the FCM can enhance student engagement in the learning process, thereby fostering active, student-centered learning. This overall data highlights the need to integrate the FCM to simultaneously enhance all three domains in curriculum design and learning strategies, thereby producing graduates who are intellectually capable, emotionally resilient, and practically competent.

In addition, this learning model has been used and implemented in vocational school teacher training, thereby influencing teachers' professional competencies, namely creativity, mastery of learning technology, and teaching readiness. Teacher creativity, as Tomory (2023) states, plays a key role in creating an engaging, adaptive, and contextually relevant learning environment, especially in addressing the challenges of 21st-century learning. Meanwhile, Chen et al. (2020) emphasize that mastery of learning technology is no longer an option but a necessity, given the digitalization of education, which expands access and drives pedagogical innovation. On the other hand, teacher readiness for teaching, as examined by Villalba et al. (2018), encompasses pedagogical, psychological, and professional readiness to address complex classroom dynamics. These three aspects are closely interrelated and determine the overall effectiveness of the learning process, as teachers who are creative, technologically proficient, and fully prepared will be better able to facilitate active and meaningful learning for students.

Challenges of Flipped Classroom Model in Vocational Education

After reading the 10 most-cited documents, the following challenges emerge for teachers in implementing the FCM in vocational schools. Several recent articles on this topic also emphasize these findings, and the results are summarized in Table 9. The findings reveal key challenges in implementing the FCM in vocational education, grouped into three dimensions: students, technology and pedagogy, and institutions. In the student dimension, challenges arise from variations in learning styles (Chen et al., 2020), adaptation levels (van Vliet et al., 2015), and learning motivation (Dalton et al., 2016). Students' preference for conventional learning methods often makes it difficult for them to accept the changes offered by the FCM (Lochner et al., 2016; Zhu et al., 2020). Additionally, students' technological skills are a key concern, as the effectiveness of this model depends heavily on their ability to access and use technology independently outside the classroom (H. Chuang et al., 2018; Karapetian, 2020). This lack of readiness has the potential to hinder the equitable distribution of learning outcomes, particularly in vocational education settings that emphasize practical and vocational competencies.

Table 9. Challenges in implementing the flipped classroom model in vocational education

Student	Technology and pedagogy	Institution
Student learning styles	Lack of access to technology	Institutions prepare the technology needed for learning
Student adaptation	Teachers' technological skills	
Student motivation	Learning materials	
Student learning preferences	Short-term effects	
Student technology skills	Learning time management	
	Teacher training	

Meanwhile, from a technological and pedagogical perspective, obstacles such as limited access to technology (Villalba et al., 2018), low technological skills among teachers (H. Chuang et al., 2018), and unprepared teaching materials (van Vliet et al., 2015) are crucial issues. The short-lived effects of the FCM, characterized by a decline in student enthusiasm after a specific period (van Vliet et al., 2015), as well as time management issues (Lochner et al., 2016; Zhu et al., 2020), indicate that this strategy requires careful planning and ongoing support. Additionally, teacher training is a key factor in enabling educators to design and implement this method effectively (Sánchez-Rivas et al., 2019; Villalba et al., 2018). At the institutional level, the greatest challenge is the readiness of institutions to provide the necessary infrastructure and technology to support learning (Chen et al., 2020), indicating that the success of the FCM depends not only on students and teachers but also on institutional

commitment to building a digitally integrated learning ecosystem. From these results, it can be concluded that the support of all school elements – students, teachers, technology, and institutions – is essential for effectively implementing the FCM in vocational education.

Analysis of Future Research Directions

The analysis of ongoing research in the field of FCM in vocational education uses overlay visualization results from VOSviewer, which are shown in Figure 8. From the analysis, 79 keywords appeared more than 3 times across the 114 documents. The overlay visualization generated by VOSviewer maps the development of research topics in FCM studies, particularly in the field of vocational education, based on publication data from 2019 to 2022. Lighter colors (yellow) indicate newer topics that are currently being extensively explored in recent research.

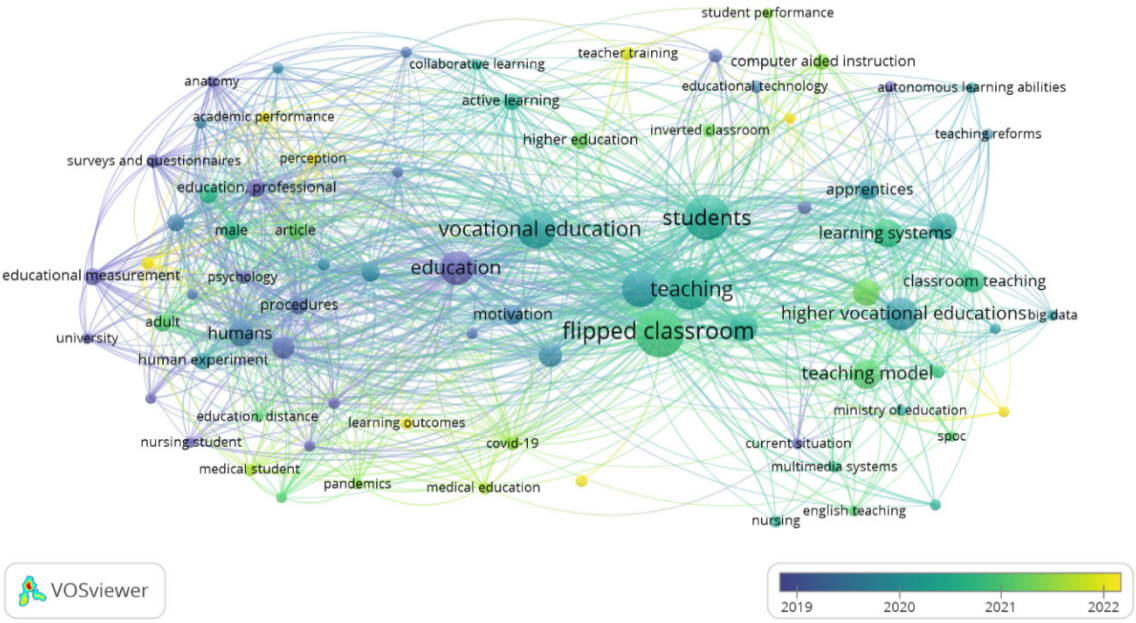

Figure 8. Visualization overlay of Vosviewer analysis results

Based on the results of this analysis, recent research moves towards integrating technology and learning innovation. Keywords such as medical education, pandemics, COVID-19, distance education, and learning outcomes are highlighted in yellow, indicating that the pandemic has been a significant catalyst for expanding the application of the FCM in vocational education, particularly in the fields of health and engineering (Lyu et al., 2023; Tan, 2020; Yang et al., 2023). Additionally, current research trends toward evaluating student learning outcomes are marked by the bright yellow color of the term "learning outcomes" in the visualization overlay (Köpeczi-Bócz, 2024; Meng, 2021). The focus on distance learning and the use of digital technology in emergencies underscores the urgency of developing flexible, adaptive learning methods. Additionally, the terms "student performance" and "academic performance" are highlighted in bright yellow in Figure 8. This indicates the importance of analyzing the impact of the FCM on vocational education students. This is further emphasized by previous research stating the importance of conducting a Long-Term Evaluation of this learning model's implementation to determine its impact more validly (Chen et al., 2020; Sánchez-Rivas et al., 2019; Zhu et al., 2020).

Furthermore, other keywords, such as educational technology, autonomous learning abilities, learning systems, and teaching models, which also appear in yellow, indicate a research trend that increasingly emphasizes strengthening technology-based independent learning systems. This indicates that researchers are increasingly focusing on how the FCM can be combined with digital approaches, such

as computer-aided instruction, big data, and multimedia systems, to address the challenges and dynamics of modern learning (Chai, 2024; Huang et al., 2025; Wu et al., 2024). Additionally, the emergence of topics such as teacher training and the Ministry of Education signifies that recent research is beginning to address policy dimensions and teacher capacity development as supporting factors for the successful implementation of the FCM (Chen et al., 2020; Romero-García et al., 2023). Previous research has also emphasized the importance of integrating educational technologies such as educational games and augmented reality to enhance students' learning processes at home or before entering the classroom (Karapetian, 2020; Zhu et al., 2020). Thus, it can be concluded that contemporary research is not only focused on classroom practices but has also evolved systematically to incorporate aspects of technology, policy, and the readiness of educational actors to implement learning innovations.

RESEARCH LIMITATIONS AND FUTURE RESEARCH

Based on the results obtained, this study is also not without its limitations. First, this study used only data from the Scopus database. Although Scopus is known as one of the most comprehensive academic databases and is widely used in bibliometric studies (Boateng et al., 2024; Li et al., 2021), relying exclusively on this single source may result in the omission of important publications available in other databases such as Web of Science, PubMed, Dimensions, or Google Scholar. This limitation may also affect the broader generalization of research findings among researchers. Both the review of benefits, challenges, and future research remain overly focused on the 10 most cited documents. This may result in an overrepresentation of studies, even though newly published documents may present innovations and updates that are more relevant and aligned with contemporary advancements.

Researchers suggest that future studies address the limitations of this study. First, it is hoped that subsequent studies will collect data from various article databases, including Springer, IEEE, PubMed, Dimension, Frontiers, and other leading databases. Second, future studies are expected to holistically examine how the FCM steps used by various researchers are implemented. This will help determine the steps researchers take to improve student learning outcomes. Future research is also encouraged to explicitly examine the impact of the FCM in vocational education using meta-analysis. Additionally, future research could focus on technologies that can be integrated into the FCM, enabling researchers to better understand the process of technology implementation and student use.

CONCLUSION

This study uses bibliometric analysis with the VOSviewer application to map the results. This analysis uses 114 documents from the Scopus database to reveal research trends, benefits, challenges, and recommendations for future research. The research findings highlight that, on average, research in this field has increased year over year. However, this increase has not yet shown a significant impact, as indicated by an R^2 value of 0.1847, suggesting the need for further research in vocational education. The most frequently encountered documents are from China (41.23%), reflecting this country's readiness to implement the FCM in vocational education. From the co-occurrence analysis, three clusters emerged: student learning outcomes and academic performance; the application of the FCM; and the application of educational technology and pedagogical innovation in vocational education.

The results of this study also show significant benefits for vocational education across cognitive, psychomotor, and affective domains. In addition to impacting students, this learning model also influences teachers in preparing lessons that are more engaging and effective. However, implementing this learning model faces numerous challenges, including issues related to students, learning technology, pedagogical factors, and vocational education institutions. Therefore, to address these challenges, there is a need for good collaboration between students, teachers, and school policymakers. The results of this study also indicate that future research should focus on integrating technology that

enables students to learn independently, such as educational games and augmented reality. Additionally, continuous evaluation is necessary to determine the valid impact of the FCM. With advancements in technology, implementing this model can enhance students' independent learning, a crucial skill for lifelong learning.

ACKNOWLEDGMENT

The researchers would like to thank the Research and Community Service, Universitas Negeri Padang, for funding this research under contract number 2107/UN 35.15/LT.2025, through the Annual Budget Work Plan.

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