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EDITED BY
Ana Luísa Rodrigues,
University of Lisbon, Portugal

REVIEWED BY
Tzu-Chiang Lin,
National Kaohsiung University of Science and Technology, Taiwan
Magdalena Ramos Navas-Parejo,
University of Granada, Spain

*CORRESPONDENCE
Anabel Ramos-Pla
anabel.ramos@udl.cat

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Bibliometric analysis of the flipped classroom pedagogical model: Trends and strategic lines of study

Isabel del Arco[1], Pere Mercadé-Melé[2], Anabel Ramos-Pla[1]* and Òscar Flores-Alarcia[1]

[1]Faculty of Education, Psychology and Social Work, Department of Pedagogy, University of Lleida, Lleida, Spain, [2]Faculty of Economics, Department of Applied Economics, University of Málaga, Málaga, Spain

The Flipped Classroom (FC) emerged at the beginning of the 20th century as an alternative pedagogical model to the traditional classroom. It consists of inverting (flipping) some teaching-learning procedures, transferring some activities outside the classroom and reformulating the roles of the teacher and the student. The aim of this study is to identify the main existing trends and emerging strategic lines of research with respect to the FC pedagogical model. To this end, a bibliometric study was carried out by analyzing the international scientific production found in the Web of Science (WoS) database. A total of 2,194 articles were reviewed during the period from 2007 to 2021. The results showed an increase in publications on FC from 2013 onwards, reaching a significant peak in the scientific literature in the last 2 years. Scientific evidence is presented on the didactic virtue of the model, together with the increase in the degree of student satisfaction and motivation. New lines for the future are suggested, such as: providing evidence of the improvement in academic performance and solid and profound learning results in its application to different fields of knowledge, educational contexts, or with different types of students. Also, to investigate the co-responsibility of students by stimulating autonomy and self-regulation.

KEYWORDS

flipped classroom, teaching models, higher education, academic performance, role of the teacher

Introduction

At the start of the 20th Century, a new pedagogic model emerged, which proposed a different view of the education process, in tune with the new digital society of knowledge. This is the Flipped Classroom (FC) model, which transfers the first stages of the teaching and learning process (know and understand), as defined by the Taxonomy from Bloom, out of the classroom, as these stages require simpler skills (Anderson and Krathwohl, 2001; Campión, 2019). In the same manner, time is left for the classroom, where the teacher and students come into play, for the next stages in the same teaching-learning process, which require more complex skills (application, analysis, evaluation,

and creation) (Parra Giménez, 2017). From an integrated approach, higher level skills are acquired in the classroom while the lower skill ones are acquired outside of it, with the application of the FC model.

The interest on the implementation of this model in different disciplines (mathematics, engineering, social sciences, health sciences, humanities, etc…), and on different education levels and stages (primary education, secondary education, and university) (Hao, 2016; Ramos-Pla et al., 2021a,b), came from different education research studies which tried to combine scientific evidence on the educational results obtained (Akçayir and Akçayir, 2018).

Some studies have provided evidence that the level of academic motivation, satisfaction, and performance of the students significantly improved as compared to traditional classes (those in which the teachers do the explanations in class and the students must carry out activities outside the classroom) (Roehl et al., 2013; Gilboy et al., 2015; Hung, 2015; O'Flaherty and Phillips, 2015; Flores et al., 2016; del Arco et al., 2019, 2021; Bicen and Beheshti, 2022). Other studies point out to the FC model as a clear alternative in the area of education due to its incorporation of technologies, which provide innovative and dynamic opportunities where the student is the protagonist of learning (Forsey et al., 2013; Serrano Pastor and Casanova López, 2018; Jorge-Vázquez et al., 2020; Ramos-Pla et al., 2021a,b). Others, from the point of view of the teacher, analyze the resistance to change in light of the challenges brought on by the re-design of teaching according to the FC model (Ash, 2012; Bennett et al., 2015; Sánchez et al., 2020).

Also, it is interesting to point out how the inverted approach has been considered a cost-effective formula to cater to students in a more individualized manner in the classroom.

It seems that the advantages and challenges of this pedagogic model have led to its analysis in the past few years. With the confinement of global education, due to the health-based pandemic in the past year, the flipped classroom has gained an important prominence. At this point, it is important to ask ourselves, what has been the path of the flipped model in the scientific literature? In what fields of knowledge had the flipped model preferably focused on? And, aside from the studies conducted, what emergent themes that are incorporated to what has been already studied?

Thus, the objective of the present study was to identify the main existing trends in the scientific literature, and the emergent strategic research lines on this subject.

The pedagogic model of the flipped classroom

The pedagogic model of the Flipped Classroom (FC) began to be studied and implemented in classrooms in the year 2000 (Lage et al., 2000). However, it was starting in 2009 that it began to gain popularity among teachers (Bergmann and Sams, 2009, 2012; Awidi and Paynter, 2019). The main reason for this is that the FC model tends to have a very positive effect on the performance of the students (Enfield, 2013; Velegol et al., 2015; Betihavas et al., 2016; Lai and Hwang, 2016; Akçayir and Akçayir, 2018; Cho and Lee, 2018; Hew and Lo, 2018; Lundin et al., 2018; Tang et al., 2018; Namaziandost and Çakmak, 2020). Also, it is recognized that the FC model is implemented worldwide in diverse disciplines in different levels of education (Ackerman and Maslin-Ostrowski, 2004; Freeman et al., 2014; Hao, 2016; Lo and Hew, 2017; Akçayir and Akçayir, 2018; Chang et al., 2019; Tomas et al., 2019; Albahuoth, 2020).

The FC model is an alternative approach which flips the traditional classroom to provide an answer to the new methodological formats (Cheng et al., 2019; del Arco et al., 2019). Thus, the key concepts are studied before coming to class, and teachers guide the learning in the classroom, modifying the use that is normally made of the classroom (Hamdan et al., 2013; del Arco et al., 2022). In this manner, the students are co-responsible and manage their own learning process and rhythm (Lai and Hwang, 2016; Akçayir and Akçayir, 2018). This allows the students to develop competencies such as cooperative

TABLE 1 Search protocol.

Study period	2007–2021
Database	Web of Science
Keyword	Flipped classroom
Inclusion criteria	a. Journal articles.
	b. Publications in the last few years (2007–2021).
	c. Document in any language.
Exclusion criteria	d. Conference proceedings, book chapters, or other type of publications.
	e. Restricted access to the publication.
	f. Duplicated articles.
Last date accessed	October 2021

Source: Created by authors from Web of Science.

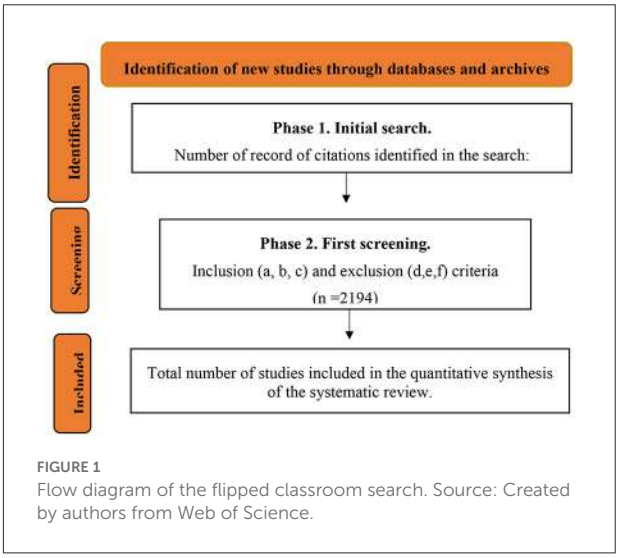

FIGURE 1
Flow diagram of the flipped classroom search. Source: Created by authors from Web of Science.

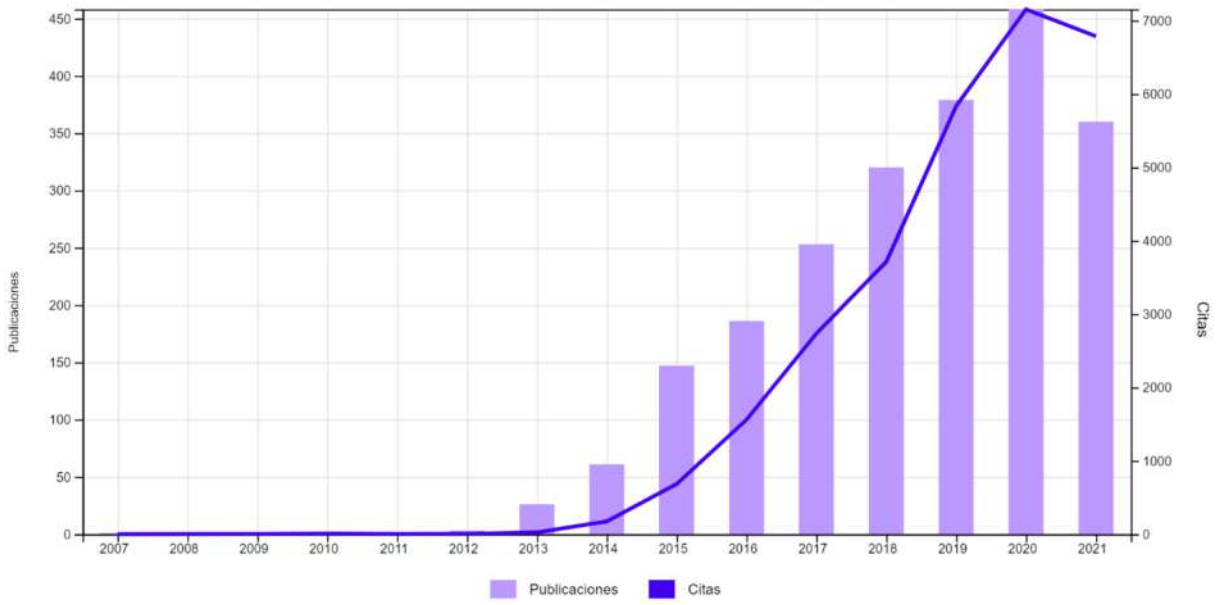

FIGURE 2
Number of publications and citations. Source: Web of Science.

TABLE 2 Publications and citations from 2015 to October, 2021.

Years	N. of publications	Citations
2015	147	684
2016	186	1,561
2017	253	2,734
2018	320	3,713
2019	379	5,836
2020	458	7,154
2021	360	6,788

Source: Created by authors from Web of Science.

TABLE 3 Main areas of research.

Areas of research	Number of articles	% de 2194
Education Educational Research	1,821	83.00%
Computer Science	491	22.38%
Psychology	406	18.51%
Behavioral Sciences	381	17.37%
Health Care Sciences Services	211	9.62%
Engineering	169	7.70%
Communication	132	6.02%
Business Economics	111	5.06%
Nursing	107	4.88%
Information Science Library Science	85	3.87%
Mathematics	71	3.24%
Science Technology Other Topics	70	3.19%
General Internal Medicine	69	3.14%
Chemistry	59	2.69%
Linguistics	58	2.64%

Source: Created by authors from Web of Science.

learning, the selection of information, critical thinking, and the self-assessment of learning (del Arco, 2015).

Authors such as Abeysekera and Dawson (2015), Flores et al. (2016), Akçayir and Akçayir (2018) and del Arco et al. (2019), recognize that FC is a pedagogic model, as it encompasses a set of approaches, and also, they underline that:

- Knowledge is transmitted outside of the classroom.
- Class time is used to conduct dynamic activities, and to detect conceptual errors.
- Students must perform activities before, during, and after class.
- The assessment is key in the FC model, and it must be comprehensive, responsible, reflective, shared, and competence-based. Thus, the key objective of the assessment is to establish a relationship with the learning process and the promotion of quality questions, as well as learning through mistakes (Tourón and Santiago, 2015).

Also, in the study by Hamdan et al. (2013), it was indicated that pedagogic models in which knowledge is transferred outside of the classroom, such as a FC model.

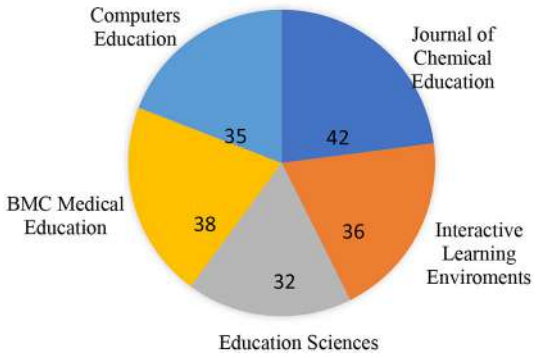

FIGURE 3
Main journals in which the greatest number of flipped classroom publications were found. Source: Created by authors from Web of Science.

Normally, traditional models do not adapt to the needs or interests of students (Betihavas et al., 2016; Talbert, 2017). However, pedagogic models such as the one analyzed in the present study, allow for an alternative type of learning, in which the students are placed at the center of the teaching-learning process (Bergmann and Sams, 2012; Abeysekera and Dawson, 2015; O'Flaherty and Phillips, 2015; Gillette et al., 2018; Strelan et al., 2020).

It should also be added that the FC model is adapted to the prevailing online learning modality and use of new technologies (Herrera Mueses et al., 2019; Namaziandost and Çakmak, 2020; Stöhr et al., 2020), especially due to the COVID-19 pandemic. In this sense, online learning allows for distance learning, where technology is the medium of the learning process (Nguyen, 2015; Contreras et al., 2017; Hew and Lo, 2018; Han and Rokenes, 2020). del Arco et al. (2019) described the benefits provided by the use of technological tools in the FC model:

- Establishment of moments of cooperation and reflection.
- Management of activities that are corrected quickly by the teachers.
- Development of activities with automatic correction.
- Proposing resources in different formats.

Although synchronous and asynchronous classes can be combined in online learning, the situation due to the COVID-19 pandemic provided evidence of the need to conduct comprehensive teaching-learning processes, which combine the previously-mentioned class modalities (Chen et al., 2014; Namaziandost and Çakmak, 2020; Stöhr et al., 2020).

On the other hand, studies also exist which describe the limitations and challenges of the FC model (Schlairet et al., 2014; Lai and Hwang, 2016; Sun et al., 2017; Han and Rokenes, 2020):

- A greater amount of time invested by the teachers to design classes through the use of the model presented.
- Behaviors that are not very regulated by some students.
- Failure of some students in organizing themselves to work and understand the contents outside of the classroom.

Ultimately, although the FC model has a series of limitations just as in other models, it allows the increase in the productivity of the face-to-face time, as well as the increase in the motivation and satisfaction of students (Talbert, 2017; Awidi and Paynter, 2019; Strelan et al., 2020). Also, if the FC model is combined with active methodologies such as challenge-based learning (CBL) or cooperative learning, the efficiency of the teaching-learning process increases substantially (Hmelo-Silver, 2004; AbuSeileek, 2012; Betihavas et al., 2016; Lai and Hwang, 2016; Sohrabi and Iraj, 2016; Cheng et al., 2019; González-Gómez et al., 2019; Namaziandost and Çakmak, 2020). Thus, active methodologies such as the ones previously cited, are also associated to the better performance of students.

Methodological design

Unit of analysis

The results of a descriptive, cross-sectional-retrospective bibliometric analysis are presented, conducted through the analysis of scientific documents published on the flipped classroom model during the 2007–2021 period. This period of time was selected because before 2007, practically no scientific production on this subject existed.

Bibliometry was utilized, as this science is based on statistical procedures applied to a review of the scientific literature and the authors who produced them. These statistical procedures focus on the normal statistical behavior through time, of the different bibliometric indicators considered (Pacheco-Mendoza and Alhuay-Quispe, 2019).

Procedure

In our analysis, a search was conducted for articles on the subject: TS = flipped classroom in the main collection of Web of Science (on 16 October 2021), as this database is the oldest and most prestigious on bibliographic references and journal citations, and one of the most utilized for bibliometric analyses.

A total of 4,657 publications were found. Next, these were filtered according to type of document, considering articles published in journals in the period between 2007 and 2021 in any language. The exclusion criteria eliminated all the publications from conference proceedings, book chapters, reviews, duplicated articles, as well as the publications with restricted access, which made difficult obtaining the article. Starting with the application of the inclusion and exclusion criteria, a total of 2,194 articles

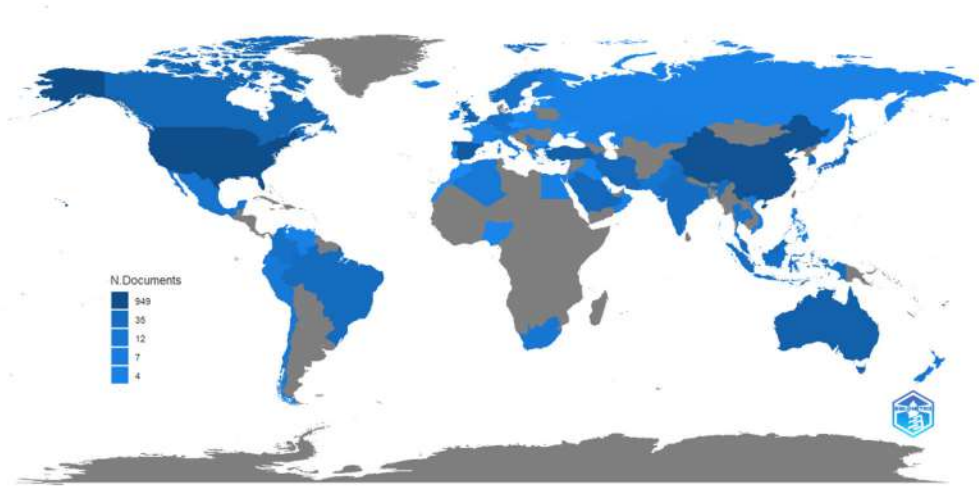

FIGURE 4
Main countries which published on flipped classroom. Source: Bibliometrix in R.

were obtained, which were the subjects of analysis in the present study (Table 1).

Figure 1 shows a flow diagram which describes the different phases of refinement, following the PRISMA 2020 flow diagram guidelines for systematic reviews (Page et al., 2021).

Results

Evolution of the flipped classroom publications and citations during the 2007–2021 period

Figure 2 shows the number of publications in the different years, as well as the number of citations. An increase in the number of publications on the flipped classroom was observed starting in 2013, with a maximum number of 458 publications reached in 2020. The same was observed for the citations. More specifically, starting in 2015, an exponential increase was observed. We can say that the progression in 2021 was similar to that in 2020.

Table 2 shows a data extraction starting in 2015, when a greater production was found. It must be noted that the mean number of citations per publication was 28,706 citations, which corresponds to an H-index of 74.

Area of research and journals with the greatest number of flipped classroom publications and geographical distribution

The analysis of the areas of research in which a greater number of publications related to the Flipped Classroom were found showed that the most important were "Education Educational Research," which encompassed 83% of the publications, followed by the area of "Computer Science," with 22.38% (Table 3). This study subject is directly associated with education research and working with technologies.

In agreement with the areas of education research in which the flipped classroom studies are framed, it is in education-related journals where most of the publications were found. Thus, the top places were occupied by journals related with Education and Health, followed by journals about Education and Technologies, and lastly, generalist journals on Education Science. Figure 3 shows the journals in order according to the flipped classroom articles published: the journal with the most articles was the Journal of Chemical Education, followed by BMC Medical Education, Interactive Learning Environments, Computers Education and Education Sciences. It should be pointed out that the most important in the area of Education was the journal Interactive Learning Environments.

As for the geographical distribution of the publications as a function of the different countries, the most important were the USA, China, and Spain (Figure 4). In this sense, the software analyses the country of the different affiliations of the authors.

Delving into this section, a figure was created of the keywords in the titles of the studies (keywords plus, ID), between the countries, and between the keywords from the authors (keywords, DE).

Setting aside the keyword Flipped Classroom, which is the primary term and which appears in the literature from all the countries analyzed, is should be noted that for the USA, the concepts (ID) performance and model were the most important, as well as the (DE) active learning and learning. For China, the most important ID were education and students, and the DE learning and education. Lastly, for Spain, the first ID were

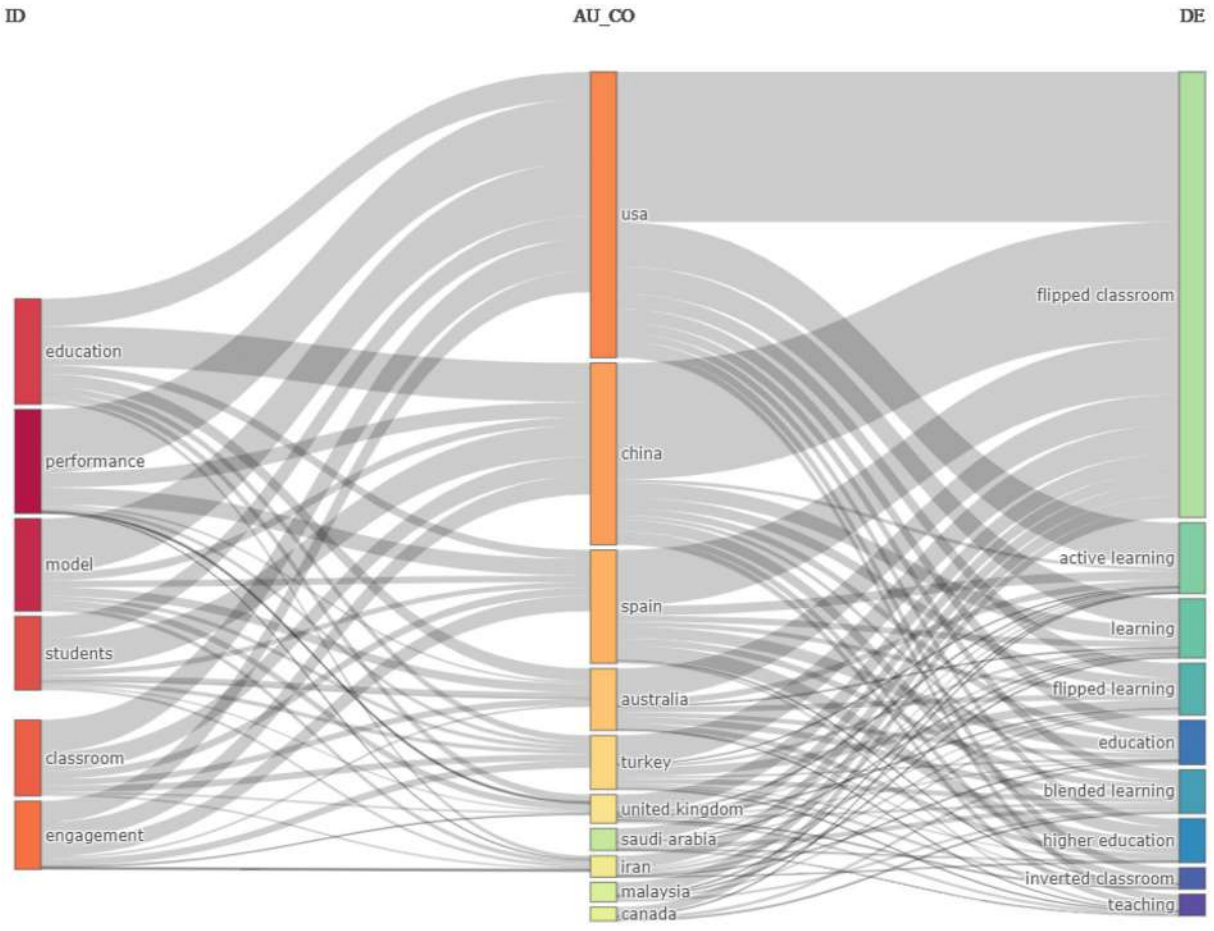

FIGURE 5
Three-Fields Plot between keywords plus (left field), the most productive countries (middle field) and the authors' keywords (right field). Source: Bibliometrix in R.

performance and engagement, and the DE higher education and education (Figure 5).

Most important authors: Citations and progress

As for the authors with the most publications, referring to the term Flipped classroom, they are shown in Table 4.

In this phase of the study, an analysis was performed of the publications which were cited the most and a summary of their contributions are shown in Table 5.

After analyzing the most-cited texts, and considering the results obtained from the search equation, they are organized as a network, and it can be verified that there was a progression in time in the incorporation of authors other than those found in the English speaking context, where the flipped classroom originated from, thereby showing the expansion of the model (Figure 6).

The subjects addressed by the authors with the most publications were recurring: the promotion of self-regulated learning of the students through this model, and the effects on the learning acquired.

Flipped classroom clusters during the 2007–2021 period

Next, the information from the 2,159 articles was downloaded and analyzed with the VosViewer software. The type of analysis was co-occurrence, and the unit of analysis were the author's keywords. Also, a Thesaurus file was added to homogenize concepts (Table 6).

In the previous table, it is observed that the main keywords were "flipped classroom," followed by "active learning," "blended learning," and "higher education" (Figure 7).

As for the different maps provided by the VosViewer software, these were programmed so that they showed only the keywords that had a minimum of 16 occurrences in the different articles. Thus, the following maps were obtained:

A cluster analysis was also performed, that is, elements were grouped together in the same cluster, with the same specific characteristics that differentiate them from other clusters. The clusters provide us with information about groups that are homogeneous amongst themselves. To identify them, 6 key concepts were chosen (the primary term Flipped Classroom was not considered), and under these criteria, the following are highlighted:

- Cluster 1: New teacher/student roles in the Flipped Model (in red): where the six key concepts are: academic achievement, engagement, flipped learning, motivation, gamification, and teacher education. The Flipped Classroom concept appears in this group as the most common, but given its use as the main term, it is excluded.
- Cluster 2: Innovation and Quality improvement (in green). It is composed by the following concepts: improving classroom teaching, innovation, learning analytics, learning strategies, secondary education, and self-regulation.
- Cluster 3: Flipped Model during the pandemic (in dark blue): it is composed by the concepts blended learning, COVID-19, e-learning, technology and video lectures.
- Cluster 4: Collaborative work in the Flipped Classroom model (in yellow): it is composed by the concepts: collaborative learning, cooperative learning, curriculum, and student centered learning.
- Cluster 5: Methodological strategies compatible with the Flipped Model (in purple): the following are underlined: education, learning, simulation, and problem-based learning.
- Cluster 6: Flipped Classroom in Higher Education (in light blue): the following are highlighted: higher education, instructional design, inverted classroom and MOOCS.

Independently of the cluster it belongs to, when we analyzed the concepts that were cited more often, we found terms such as: "engagement," "student-centered learning," "inverted classroom," "improving classroom teaching," "inverted classroom," and "teaching-learning strategies" (Figure 8).

New strategic lines of research

When analyzing the most repeated words in publications since 2017, we highlight terms such as: "higher education," "flipped learning," "self-regulation," "motivation," "academic performance," "Innovation," "learning outcomes," and "academic achievement" (Figure 9). Thus, we can establish, as the current lines of research on the Flipped Classroom model, every aspect associated with obtaining scientific evidence on the efficiency of the model, with respect to the academic performance and the learning results. Another current line is associated with the student's commitment and self-regulation.

TABLE 4 Main authors who published and cited the most on flipped classroom.

Authors	Citations	Number of articles
McLaughlin Jacqueline	831	10
Hwang, Gwo-Jen	566	11
Lai, Chiu-Lin	490	5
Hew, Khe Foon	422	13
Io, Chung Kwan	404	10
Hung, Hsiu-Ting	362	5
Chen, Nian-Shing	323	6
Kinshuk	323	6
Zainuddin, Zamzami	274	9
González-Gómez, David	231	13

Source: Created by authors from Web of Science.

Discussion

Bibliometric analysis is based on the search for statistically regular behavior over time in the different elements related to the production and consumption of scientific information. It can be said that it helps to visualize the progression of research and the generation of knowledge, allowing future lines of interest to be defined.

With a search methodology based on inclusion and exclusion criteria and in different phases of refinement, a series of publications could be analyzed following a series of established bibliometric indicators: citations, productivity, content, etc. We find studies of this type such as those of Duque and Cervantes-Cervantes (2019), Fernandez et al. (2020), Neria-Piña and Reyes Guerrero (2021), and Gómez et al. (2022).

Thus, the descriptive bibliometric study helped us to identify the most important articles, and the matters addressed in the study of the flipped classroom model, and to discover the current and future trends on this subject. The first significant result was the exponential growth in the last 5 years of publications on flipped classroom studies and experiences. Although the first publications were found in the English-speaking context, the interest on the subject quickly spread to Asian countries (China), and the publication from Spain were also notable.

TABLE 5 Analysis of the most-cited FC publications.

Publication	Citations	Summary
J. McLaughlin, M. Roth, D. Glatt, N. Gharkholonarehe, C. Davidson, G. LaToya, *et al.* The flipped classroom: A course redesign to foster learning and engagement in a health professions school Academic *Medicine*, 89 (2) (2014), pp. 236–243 https://doi.org/10.1016/j.iheduc.2015.02.002	1,397	The objective of this far-reaching review was to provide a general overview of the research on the relationship between the appearance of the flipped classroom and the associations with pedagogy and the education results, by identifying the missing aspects in the literature which could provide information for future designs and assessments. The most important aspects: -The flipped classroom has the ability to create permanent skills for students in the 21st century. -Misunderstanding of the key elements needed for the success of the flipped classroom. -Under-utilization of the conceptual frameworks and the design of the flipped classroom. -Need for more solid proof to evaluate the results of the students in the flipped classrooms.
Lai, C. L., & Hwang, G. J. (2016). A self-regulated flipped classroom approach to improving students' learning performance in a mathematics course. *Computers & Education*, *100*, 126–140.	570	The objective was to analyze a self-regulated flipped classroom approach to help students program their time outside of the classroom, to efficiently read and understand the content to be learned before class, so that they are able to interact with their classmates and the professor in class for a more in-depth discussion. To assess the efficacy of the approach proposed, a quasi-experimental design was utilized in a mathematics class in primary school. The study concludes that: - The approach helped the students to efficiently plan their time outside of the classroom. -An experiment was conducted in a mathematics class in a primary school. -The approach improved the learning performance, the self-efficacy, and the self-regulation of the students. -The approach helped the students to determine the objectives of learning and the performance.
HEW, K.F., LO, C.K. Flipped classroom improves student learning in health professions education: a meta-analysis. *BMC Med Educ* 18, 38 (2018). https://doi.org/10.1186/s12909-018-1144-z	541	The objective was to present a meta-analysis that specifically examined the effect of the flipped classroom as compared to the traditional classroom, on the learning of the students. This study examined the results of the comparative articles through a meta-analysis, to summarize the general effects of teaching with a flipped classroom approach.
Hwang, GJ., Lai, CL. & Wang, SY. Seamless flipped learning: a mobile technology-enhanced flipped classroom with effective learning strategies. *J. Comput. Educ.* **2,** 449–473 (2015). https://doi.org/10.1007/s40692-015-0043-0	520	The objective is to present challenges, as well as the definition, the characteristics, and the education objectives of flipped learning; also, a model of flipped learning is proposed without flaws, by integrating the characteristics of the mobile communication and wireless technologies on the flipped classroom model to provide a guide for researchers and teachers for the development of efficient flipped learning activities and plans to help students learn without flaws in the different contexts.
Lo, C.K., Hew, K.F. A critical review of flipped classroom challenges in K-12 education: possible solutions and recommendations for future research. *RPTEL* **12,** 4 (2017). https://doi.org/10.1186/s41039-016-0044-2	445	The objective of the present review is to provide a general view of the flipped classroom studies in K-12 education. It is concluded that the use of a flipped classroom approach in K-12 education had a neutral or positive impact on the performance of the students, as compared to the traditional classroom.
McLaughlin, J. E., Griffin, L. M., Esserman, D. A, Davidson, C. A, Glatt, D. M., Roth, M. T, Mumper, R. J. (2013). Pharmacy student engagement, performance, and perception in a flipped satellite classroom. American *Journal of Pharmaceutical Education*, 77(9), Article 196.	485	The objective was to determine if the "flipping" of a traditional basic pharmacy course that was synchronously taught in 2 satellite campuses would improve academic performance, the commitment and perceptions of the students. It was concluded that the pharmacy flipped classroom could improve the experiences of the satellite students in a basic pharmacy course through the reflective design of the course, the enriched dialogue, and the promotion of the student's autonomy.

We can state that starting in 2013, there was a greater scientific production, and the mean number of citations per publication was 28,706.

In light of the results obtained, the themes/concepts that were most analyzed in the different publications were: new teacher/student roles in the Flipped Classroom model, Flipped Classroom model and education innovation, Flipped Classroom

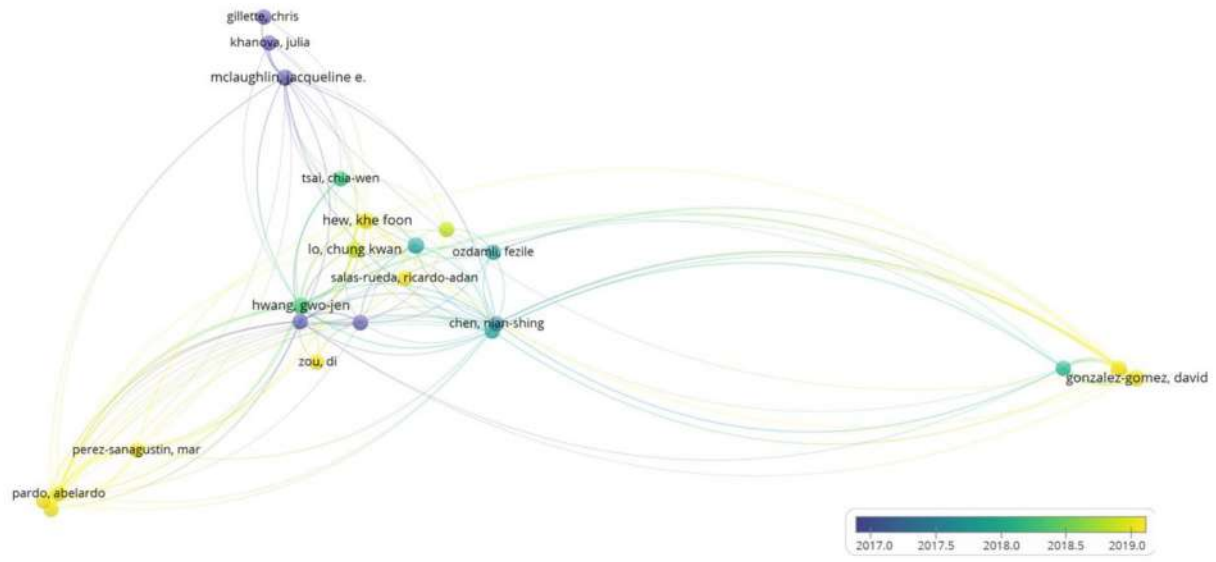

FIGURE 6
Web of progress of publications of the most-cited authors. Source: Created by authors with VosViewer.

model during the pandemic, Flipped Classroom model and collaborative work, Methodological strategies compatible with the Flipped Classroom model, and the Flipped Classroom model in Higher Education. The articles in the present review encompassed a broad range of disciplines, but the most important areas of research were "Education educational research," followed by the "Computer science". Also, the journal Interactive Learning Environments was highlighted as one of the most pioneering in Flipped Classroom subjects with the area of Education.

The predominance of the Flipped Classroom model in some areas of research could be because this model cannot be applied to all school subjects. This was also stated by authors such as Strayer (2012), who conducted a comparative study between a flipped classroom and a traditional classroom for an introductory course in statistics. The results of this study showed that the students who participated in the flipped classroom were less satisfied than the students in the traditional classroom.

When analyzing the most-cited keywords, and the keywords from authors who had published the most, the following study dimensions can be considered as those that garnered the most interest:

- The effectiveness of the Flipped Classroom Model, with special emphasis on the academic performance and the learning results. This, these are studies which focused on the virtues of the model. Many articles were published on the satisfaction of the main learning protagonists. More specifically, most of the publications were focused on the positive perceptions of the flipped classroom students, and in light of these results, some authors warned that we must consider the "Hawthorne" effects, as pointed out by

TABLE 6 Concepts that were most repeated in the keywords.

Keyword	Occurrences	Keyword	Occurrences
flipped classroom	1,167	motivation	41
active learning	210	online learning	41
blended learning	162	learning	38
higher education	119	problem based learning	35
flipped learning	101	self-regulation	35
education	82	gamification	34
e-learning	69	curriculum	33
medical education	69	student-centered learning	32
teaching/learning strategies	63	COVID-19	31
inverted classroom	54	nursing education	31
video lectures	49	student engagement	31
collaborative learning	48	technology	30
teaching methods	48	engagement	28
pedagogy	45	MOOCS	27
teaching	43	learning analytics	25
educational technology	42	student perceptions	25

Source: Created by authors from Web of Science.

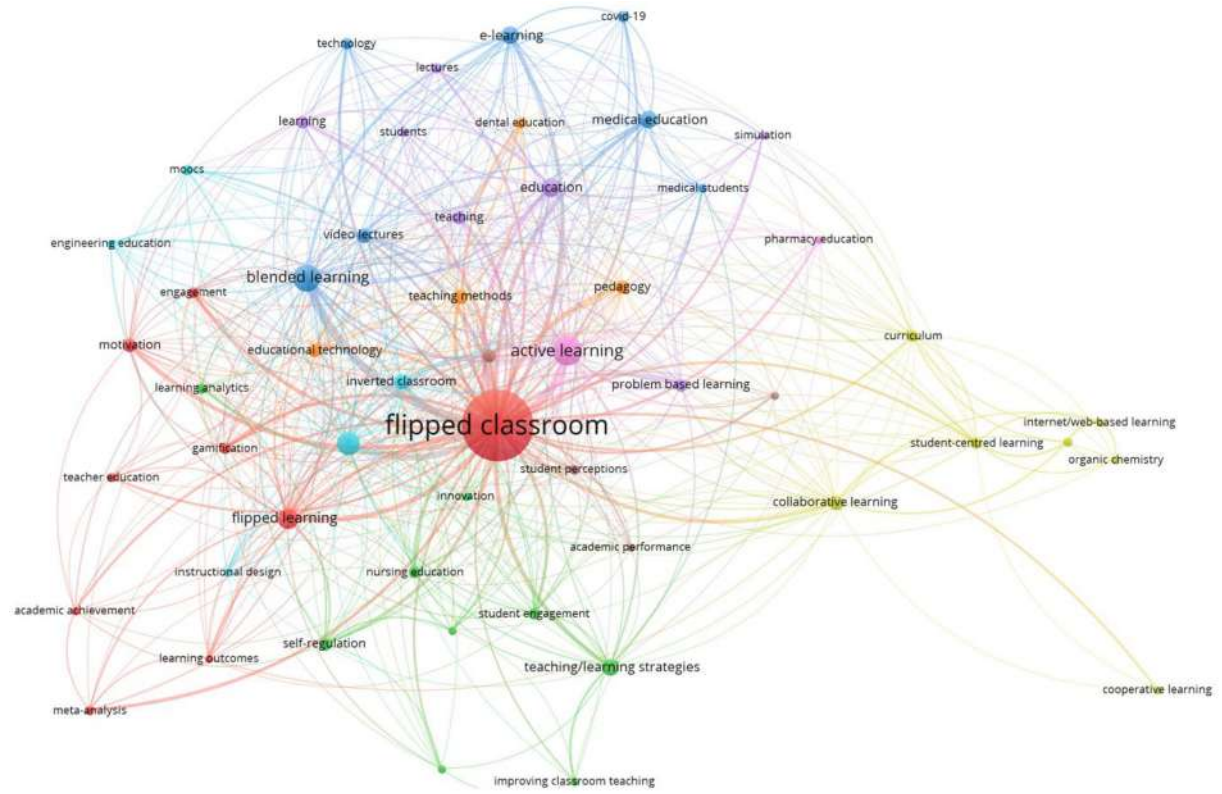

FIGURE 7
Network map. Source: Created by authors with VosViewer.

Forsey et al. (2013). These effects are generated when any change is made to the operational procedures in teaching processes, which can lead to increases in productivity and the satisfaction of the participants, due to the novelty of the changes.

- Despite the great number of publications on the effect of the model, many authors believed that there were not many significant studies that strongly demonstrated, with scientific evidence, that the flipped classroom was more effective than the traditional classroom. Most of the publications mentioned an improvement in the satisfaction and motivation of the students in favor of the flipped classroom, with a relative improvement in academic performance (Hung, 2015), but it has not been demonstrated that it has a direct effect on deep and consolidated learning through time (O'Flaherty and Phillips, 2015).
- If the keywords are grouped into research clusters, we found differences in the following subjects: (1) New teacher/student roles in the Flipped Classroom model; (2) Flipped Classroom model and education innovation; (3) Flipped Classroom model during the pandemic; (4) Flipped Classroom model and collaborative work; (5) Methodological strategies compatible with the Flipped Classroom model and (6) the Flipped Classroom model in Higher Education.
- The model acquired importance in Higher Education, with special emphasis during the pandemic, when the number of publications on this subject increased. It must be remembered that educational systems worldwide were forced to modify the face-to-face classes for virtual ones. When dealing with emergency teaching, the flipped classroom model offers learning opportunities that are more flexible, and which can provide a response to problems of accessibility to face-to-face traditional teaching (Santillán-Aguirre et al., 2021). This model shifts from a classroom that is focused on the teacher, to a classroom that is focused on the student, increasing the opportunities for active learning, where the students become co-responsible for their own learning (Hamdan et al., 2013).
- During the pandemic, the Flipped model was applied to different fields of knowledge: law (Torralbo Muñoz, 2021) economics (Argandoña-Mendoza et al., 2020), engineering (Riquelme et al., 2021), etc. Nevertheless, despite the appearance of different publications on the use of the flipped model on emergency teaching during the pandemic,

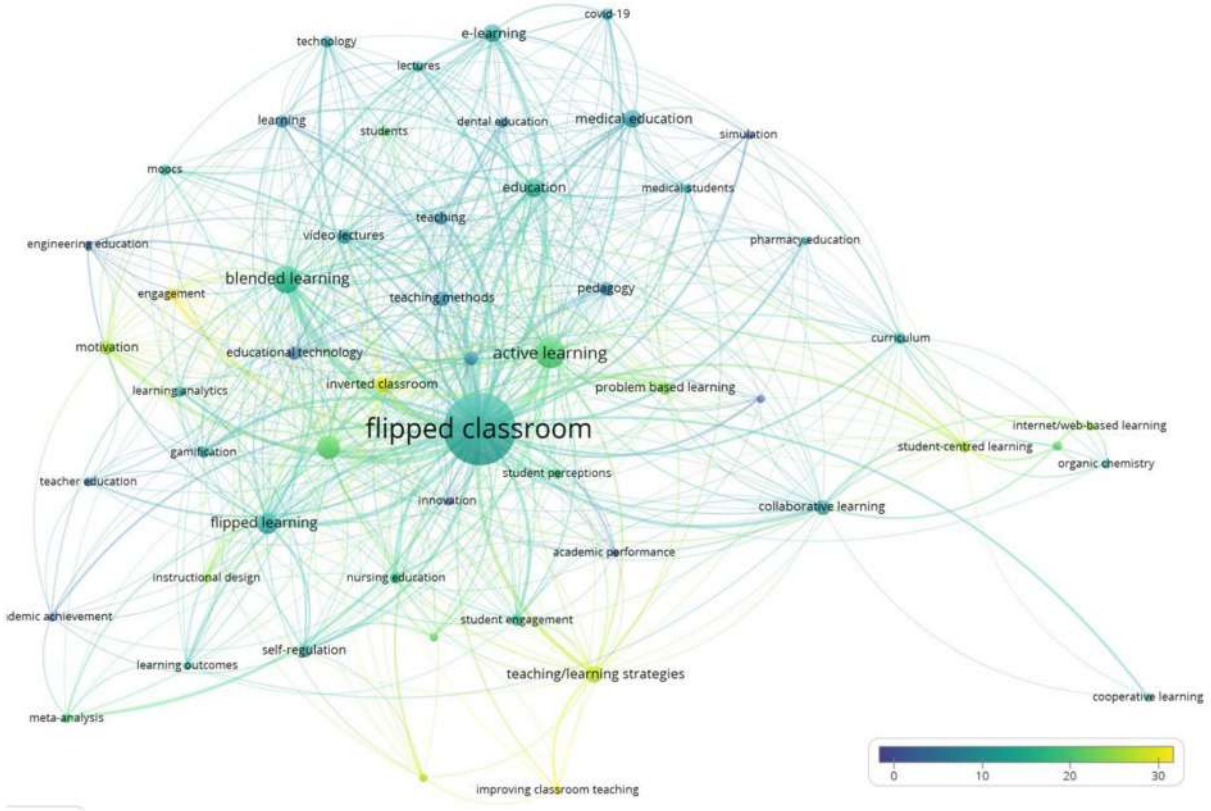

FIGURE 8
Map according to number of citations. Source: Created by authors with VosViewer.

studies are still lacking which validate the efficacy of the model and its resiliency for its application when faced with emergency situations. In most of the cases, an educational experience was described, and qualitative data of satisfaction and greater motivation of the student was provided, along with some data about the improvement in assessment processes.

- Terms such as "higher education," "flipped learning," "self-regulation," "motivation," "academic performance," "innovation," "learning outcomes," or "academic achievement" were the most investigated in the last few years. This demonstrates the interest in obtaining scientific evidence on the virtues of the model, and especially to demonstrate the effect on the academic performance and the learning results.
- In the last 5 years, we witnessed the appearance of the concept of self-regulation of learning and the addressing of the commitment of the student in the process. Self-regulation implies the capacity of the student to participate independently and proactively to reach the learning objectives. It is evident that in the Flipped Classroom model, more opportunities are offered for the students to become involved in their own learning, with them being the model's focus, and active participation in their education, as well as their assessment, can also be achieved (del Arco et al., 2019; Thi Thai et al., 2020).

Conclusions

The FC pedagogic model started to gain popularity due to teachers (Bergmann and Sams, 2009, 2012), but it was not until the year 2013 that an exponential increase was observed in the publications which emphasized showing evidence of the virtues of the model (Awidi and Paynter, 2019). All the studies define the FC model as an example of active learning which places students in the center of the teaching-learning process. It requires a change in the culture of learning, as the student must be actively involved in the construction of knowledge thanks to opportunities afforded by the model for their participation in their own learning and their own assessment (Bergmann and Sams, 2012; Abeysekera and Dawson, 2015; O'Flaherty and Phillips, 2015; Gillette et al., 2018; Strelan et al., 2020).

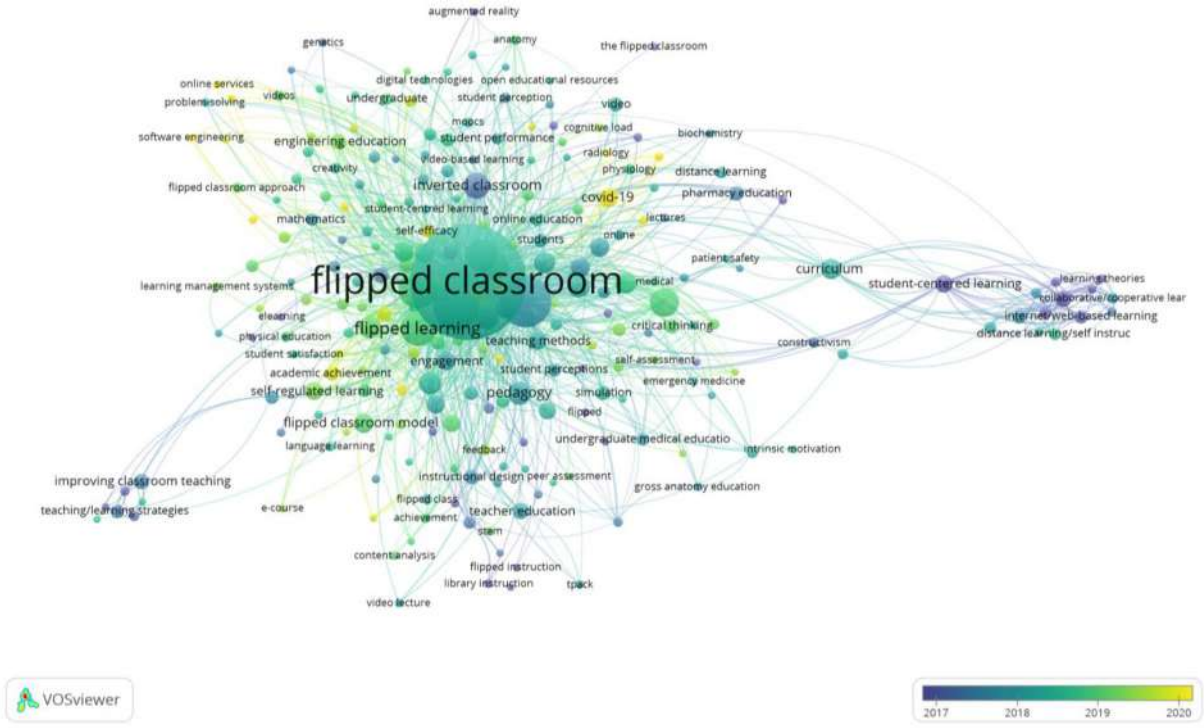

FIGURE 9
Map according to time. Source: Created by authors with VosViewer.

Meanwhile, the teacher acquires the role of mediator, thus becoming authentic education professionals, who pay close attention to the conceptual and procedural acquisition of the contents presented in the classroom, by developing observation, feedback, and assessment skills (Thi Thai et al., 2020).

The most-cited concepts, engagement, student-centered learning, inverted classroom, improving classroom teaching, inverted classroom and teaching-learning strategies, provide clues on the interest of the researchers to describe the model and provide scientific evidence on how to increase active learning through the decreased role of direct instruction in the classroom and the unidirectional interaction of teachers with students.

Despite the scientific literature being important in the past few years, many aspects still need to be analyzed, which are defined as lines of future work: evidence of the improvement of the academic performance and results of solid and profound learning with its application in different fields of knowledge. Also, every aspect related with the co-responsibility and commitment of the students in their own process of learning, to stimulate independence and self-regulation.

It is also interesting to open new paths on the effective applicability of this model with special education students. It is necessary to conduct more qualitative and quantitative studies to analyze the potential of the FC model in different educational stages, different contexts, different fields of knowledge, or different types of students (Bergmann and Sams, 2012; Hamdan et al., 2013; Bicen and Beheshti, 2022).

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

Author contributions

Conceptualization, formal analysis, and data curation: IA and PM-M. Methodology: IA and AR-P. Validation, investigation, writing-original draft preparation, writing—review and editing, and visualization: IA, PM-M, ÒF, and AR-P. Supervision: IA. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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