

## Research Article

# Bibliometric analysis of studies on the Flipped Classroom Model in biology teaching



Hüseyin Cihan **Bozdağ** <sup>a,1,\*</sup>, Suat **Türkoğuz** <sup>a,b,2</sup>, İsa **Gökler** <sup>a,3</sup>

<sup>a</sup> Biology Teaching Doctoral Program, Institute of Educational Sciences, Dokuz Eylül University, Alsancak, No: 144 35210, Cumhuriyet Blv, 35220 Konak, İzmir, Turkey

<sup>b</sup> Department of Science Education, Faculty of Education, Dokuz Eylül University, Alsancak, No: 144 35210, Cumhuriyet Blv, 35220 Konak, İzmir, Turkey

<sup>c</sup> Biology Department, Faculty of Science, Dokuz Eylül University, Alsancak, No: 144 35210, Cumhuriyet Blv, 35220 Konak, İzmir, Turkey

<sup>1</sup> chnbzd@gmail.com\*; <sup>2</sup> suat.turkoguz@gmail.com; <sup>3</sup> isa.gokler@gmail.com

\* Corresponding author

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### ABSTRACT

The global acceleration of studies on the Flipped Classroom Model (FCM) has revealed the necessity of literature review analyzes that shed light on research activities by examining the research data as a whole. Therefore, in this study, it is aimed to examine academic publications on the FCM studies applied in biology teaching in terms of bibliographic variables. For this aim, the bibliometric analysis method was preferred in the study, which was carried out with a case study approach for an in-depth examination. Within the scope of the study, 53 publications obtained from the Scopus database for the entire time period were examined. In order to analyze these publications as a whole, the Scopus database and the VOSviewer program was used. According to the results, it is determined that the most preferred keywords are flipped classroom, active learning, online learning, flipped learning and biology, the most commonly used terms in the title and abstract section are students, courses, classroom, study and flipped classroom, the most common types of publications are article and papers, the most active country in terms of the number of studies is the USA, and the publication language is generally English. This study will help researchers and educators identify trends and issues that can guide future work involving the FCM.



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## INTRODUCTION

The 21<sup>st</sup> century, which is called the digital age we are in, has brought rapid, continuous, and renewed changes in technology. With each passing day, a new technology comes to the fore. It is rapidly integrated into our lives and the use of technology becomes indispensable for people. As a matter of fact, these rapid developments in technology have been reflected in education systems, as in all fields that are intertwined with technology, and have required a continuous renewal in learning and teaching activities (OECD, 2016). Therefore, the focus of educational process designs is directed to the use of information and communication technologies. This has led to the emergence of learning models that enable the integration of traditional education practices with learning activities supported by digital technologies. Today, it is seen that applications based on the Flipped Classroom Model (FCM), which allows the teaching-learning environments

to be enriched with digital educational materials and redesigned in accordance with the conditions of the age, are frequently preferred.

The FCM is a very popular model included in the Blended Learning approach where online education materials and face-to-face instruction are combined. **In its simplest form, the FCM, which is defined as “lesson at home, homework at school”, is the reversal of the lessons** in the classroom with the learning activities outside the classroom (Awidi & Paynter, 2019; Flipped Learning Network [FLN], 2014). In the FCM, the teaching component of traditional face-to-face Education has been moved from the classroom learning area to the individual learning area outside the classroom (Abeysekera & Dawson, 2015). During the learning phase, the educational course materials are provided for students online before the lesson time. This enables more effective use of classroom time. Therefore, the classroom group learning space turns into a dynamic and interactive learning environment for both teacher and student (Abeysekera & Dawson, 2015; Awidi & Paynter, 2019; Bergmann & Sams, 2012; FLN, 2014). In this way, classroom session becomes a process that includes group-based problem-solving activities based on peer instruction and active learning as well as develops high-level thinking skills (Abeysekera & Dawson, 2015; Bates, Almekdash, & Gilcrest-Dunnam, 2017; Swearingen, 2016). Moreover, online learning material offered outside of classroom time also offers learners the chance to choose when and where to learn, and to progress at their own pace (Hayirseven & Orhan, 2018; FLN, 2014).

The FCM has attracted great attention in the literature due to its contribution to the provision of permanent learning by considering the needs and abilities of the learners (Akçayır & Akçayır, 2018). In the studies in the literature, it is observed that the **FCM's effects on student participation** (Clark, 2015; Stone, 2012; Subramaniam & Muniandy, 2019), motivation (Abeysekera & Dawson, 2015; Awidi & Paynter, 2019; Glynn, 2013; Schmidt, 2014), attitude towards learning (Bell, 2015; Glynn, 2013; Malto, Dalida & Lagunzad, 2018), critical thinking (DeRuisseau, 2016; Kong, 2015; Saunders, 2014), problem-solving skills (Chiang, 2017; Hwang & Chen, 2019), self-regulated learning skills (El-Senousy & Alquda, 2017) and, learning outcomes (Ibrahim & Callaway, 2014; Jdaitawi, 2019).

On the other hand, the speedup of the studies for the FCM in recent years has accelerated the studies. This occurred based on literature review which shed light on research activities in the field by examining global research data as a whole. As a matter of fact, periodic examination of scientific studies in any field of science is important to determine the development level of science as considerable as the subjects which are mainly emphasized. In this context, the bibliometric analysis method has become quite popular in recent years. Bibliometric analysis is known as a numerical analysis of the publications produced by people or institutions in a certain period in specific region and the relations between these publications (Ulakbim, 2021). In this way, bibliometric analyzes present a visual map of studies in a particular field in the literature as well as a projection among complex information to the readers.

Research findings contained in certain studies can be found using bibliometric analysis in term of FCM (Al-Shabibi & Al-Ayasra, 2019; Bhagat & Spector, 2018; Çakir, Sayin & Bektas, 2021; Demirer & Aydın, 2017; Julia et al., 2020; Kushairi & Ahmi, 2021; Tsai & Wu, 2020; Yang, Sun & Liu, 2017; Zainuddin et al., 2019). This enables the global scientific outputs of the FCM to be evaluated and followed (Bhagat & Spector, 2018; Kushairi & Ahmi, 2021). Moreover, it is also important to share specific data as the FCM studies are carried out in different subjects. Thus, the data obtained will be clear in relevant field. The FCM outputs allow **active learning in accordance with learners' abilities and needs, particularly in biology course which is intertwined with life**. General perspective on flipped classroom research is needed by researchers to catch up the trends and developments. However, bibliometric analysis study in teaching biology is still hard to find. Therefore, this study aimed at conducting bibliometric analysis of the FCM applications in biology teaching for the variables of publication year, publication source, publication type, country, relevance, institution, research area, and author.

## METHOD

This study is a case study with qualitative approach. It examined academic publications related to the FCM studies applied in biology teaching in terms of bibliographic variables and revealed the current situation. The Scopus database was chosen to collect the data in this study. The database was accessed from the Dokuz Eylül University subscriber databases page on March 30, 2021, an online search was made, as well as the publication information was obtained.

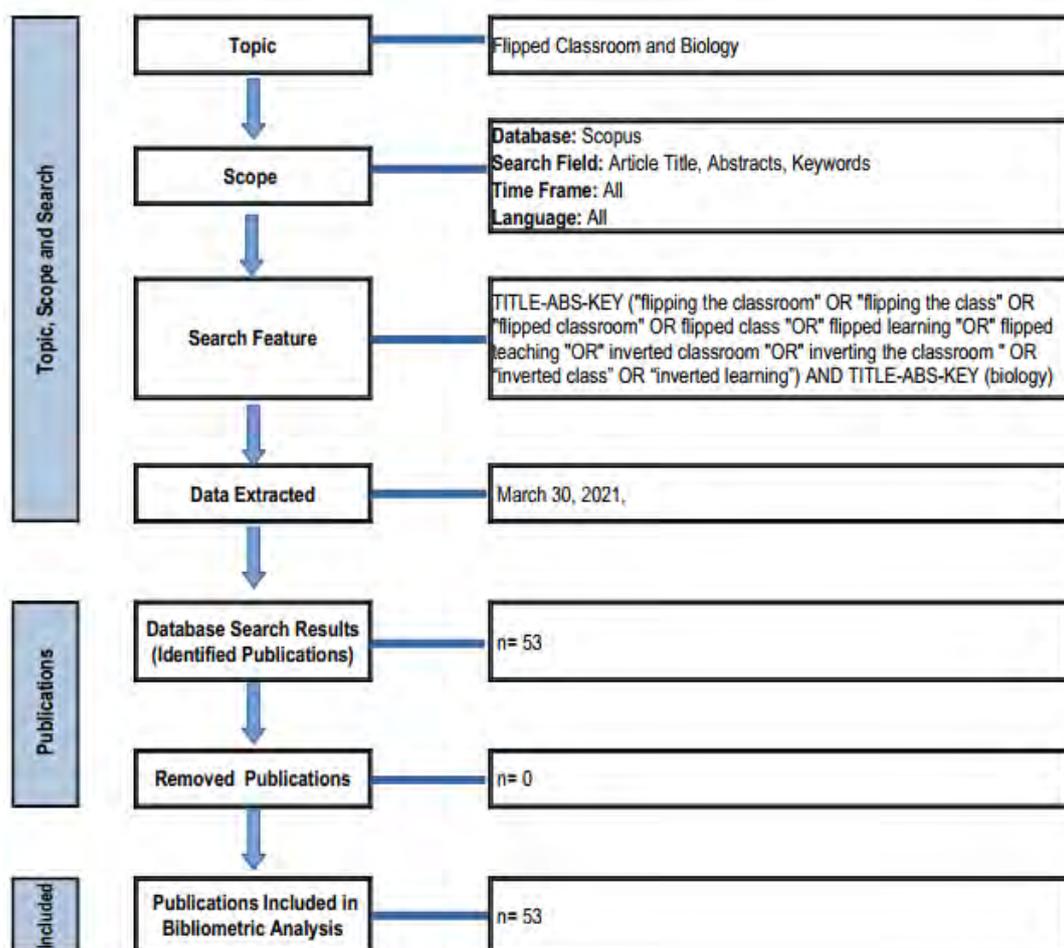


Figure 1. Data collection process

The selection of the publications gathered for this study has been constructed based on the data collection process (Figure 1). Although the terms of "flipped classroom" and "inverted classroom" were frequently used to find FCM-related literature, it was also possible to come across different terms. For this reason, a search was made on the Scopus database using different keyword combinations. Accordingly, the title, abstract, and keywords were preferred as the search field. In addition, "AND"/"OR" operators were used as logical data operators to combine different search queries and find words/word groups which are close each other. Considering the limited study data in the field of biology teaching, a specific time frame was not determined as the scope or research time frame. Scanning was carried out for the entire time period.

As many as 53 publications including the FCM applications in biology teaching were reached. In order to analyze these publications as a whole, the "Analyze Results" menu provided by the Scopus database was used. For the analysis of the data, among the bibliographic indicators presented under the analysis results menu, publications by years, publication sources by years (such as journals, conferences, etc.), publications by country, publications according to their fields and types of publication were chosen. Bibliometric maps were used to visualize bibliometric data using numerical methods. VOSviewer package program was used to make the bibliometric mapping. Within the study scope, the data obtained from the Scopus database was downloaded as a comma-separated values file (.csv) and transferred to the VOSviewer program, and visual network maps were created and analyzed.

## RESULTS AND DISCUSSION

In this study, 53 studies of the FCM applications in biology teaching which were published and accessed in the "Scopus" database were analyzed descriptively. These analyzes were carried out using the VOSviewer program. In the review, "publications by years", "publication sources", "publication types", "the most publications and cited sources", "the most publications and cited institutions", "publications by research fields", "the most cited publications", "network map of terms or concepts that are frequently repeated in titles and abstracts", "network map of keywords", "bibliometric coupling network map for authors", "bibliometric coupling

network map for publications", "bibliometric coupling network map for countries" and "co-citation network map for authors" were preferred by scientists.

Studies on the FCM in biology teaching were first started in 2013 and there has been a significant increase in the number of publications since 2015, and the increase has continued until 2020. Although there are no bibliometric analysis findings regarding the FCM applications in biology teaching in the literature, a sharp increase in the number of publications has been observed in the bibliographic analyzes of the FCM studies in general since 2015 (Demirer & Aydın, 2017; Julia et al., 2020; Kushairi & Ahmi, 2021; Tsai & Wu, 2020; Yang, Sun and Liu, 2017). Therefore, the findings obtained overlap with the study data in the field sources.

The analysis results of the both FCM-related publications in biology teaching with the VOSviewer package program and the Scopus database are presented together. The distribution of the publications accessed from the Scopus database by years is given in Figure 2.



Figure 2. Data on publications by years

It can be seen from Figure 2 that the FCM studies applied in biology teaching were started in 2013 for the first time. It is also clear that there has been significant increase in the number of publications from 2015 to 2020. A sharp decrease of the number was observed in 2021. This is assumed that the undergirding reason of the decrease was COVID-19 pandemic which effected all areas around the world since 2020.

Generally, publication types are classified into several categories such as scientific article, conference paper, book chapter, review, and so forth. The publications accessed from the database gained were examined according to the source and type. The majority of the publications were published in scientific journals (39 [73%]), followed by conference article (9 [17%]), book series (3 [6%]), and books (2 [4%]). In accordance to the type, the publications were mostly published as journal article (35 [66%]), followed by conference papers (10 [19%]), and book chapters (3 [6%]), as well as review (3 [6%]). These findings are in line with the Kushairi and Ahmi (2021) who reported that the publications were published intensively in scientific journals and conference categories. Similarly, Çakir, Sayin and Bektas (2021), Kushairi and Ahmi (2021), as well as Yang, Sun and Liu (2017) who carried out bibliometric analysis of the studies for the FCM by using different databases and research resources, reached the conclusion that articles and conference papers mostly stand out in the category of publication type.

The publications accessed from the Scopus database have been evaluated from the aspect of the most cited. The results of the evaluation are served in Table 1 (the most cited publications) and Table 2 (the most cited institutions).

Table 1. The most cited publications

Publication Sources	Total publication	Total citation
<i>CBE—Life Sciences Education</i>	4	340
Proceedings of the 44th ACM Technical Symposium on Computer Science Education	2	120
Computers and Education	1	75
Journal of Science Education and Technology	3	71
British Journal of Educational Technology	1	17
Advances in Physiology Education	3	9
Biochemistry and Molecular Biology Education	3	4

Based on Table 1, it is obvious that the top five publication sources were CBE Life Sciences Education (340), Proceedings of the 44<sup>th</sup> ACM Technical Symposium on Computer Science Education (120), Computers and Education (75), Journal of Science Education and Technology (71), and British Journal of Educational Technology (17).

Furthermore, the evaluation of the publications within the scope of the study on the basis of the most cited institutions is presented in Table 2. As seen in Table 2, it is obvious that Bringham Young University and Universidade Potiguar were the leading institutions which were cited by readers. The total citations of Bringham Young University and Universidade Potiguar were 344 and 316 respectively.

Table 2. Most cited institutions

Institutions	Total publication	Total citation
Bringham Young University	2	344
Universidade Potiguar	1	316
University of California	2	84
Skidmore College	1	78
The University of Western Australia	1	75

The data obtained from FCM studies in biology teaching are limited so that they are considered as the data which do not meet the many field sources. Meanwhile, global data obtained from bibliometric analysis studies for the FCM were served without specific field limitation. The publications were mostly carried out in social sciences (Kushairi and Ahmi, 2021), health, medical research (Bhagat and Spector, 2018), education research, chemistry, and medical (Yang, Sun and Liu, 2017). Yet, as the findings are evaluated together, this can be interpreted that the researches were under different popular titles over the years. Furthermore, the increase in studies on education has led to the predominance of social science research (Kushairi and Ahmi, 2021) and studies on the FCM have concentrated in the field of social sciences in recent years.

The classification of the publications within the scope of the study according to research fields are presented in Figure 3. Based on the figure, it is clear that the highest number of publications were conducted on Social Sciences which then followed by the researches done on Biochemistry, Genetics, and Molecular Biology fields. However, as a publication can be included in more than one research field category, the total number of publications examined can be more than the total number mentioned before.

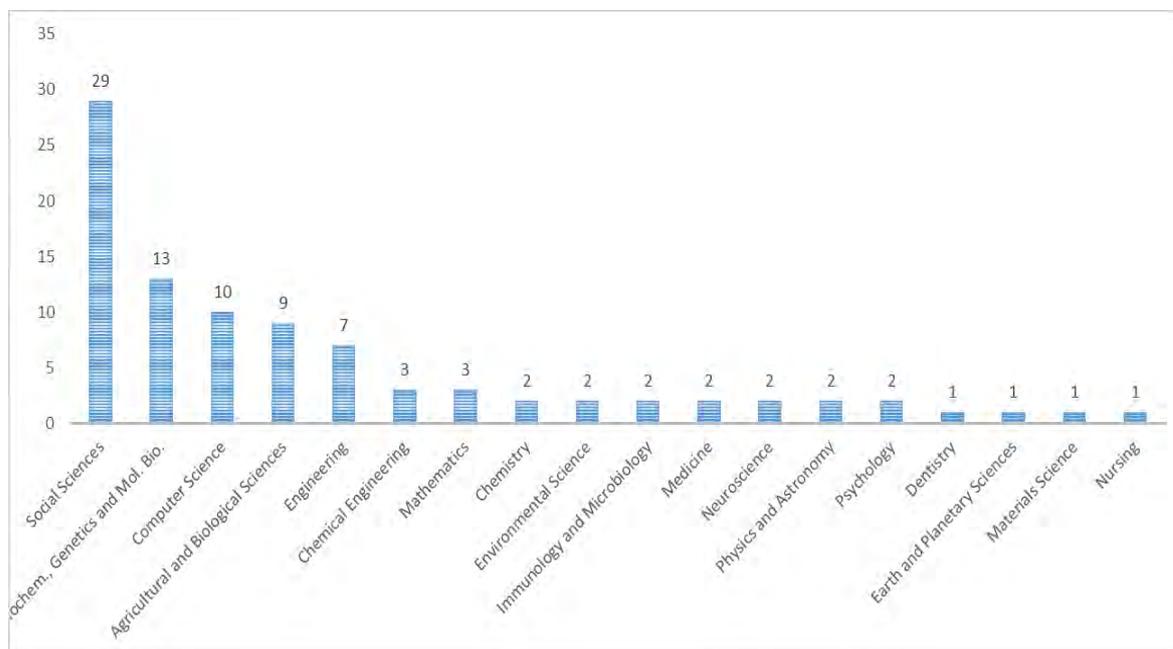


Figure 3. Publication classification based on research fields

Bibliometric analysis also enables the determination of the most productive researchers in a particular subject area. The most cited authors and publications among the 23 publications examined within the scope of the study are presented in Table 3.

Table 3. The most cited authors and publications

Author	Publication title	Publication source	Total citation
Jensen, Kummer ve Godoy (2015).	Improvements from a flipped classroom may simply be the fruits of active learning	<i>CBE—Life Sciences Education</i>	316
Porter, Bailey Lee ve Simon (2013)	Halving fail rates using peer instruction: a study of four computer science courses	<i>Proceeding of the 44th ACM technical symposium on Computer science education</i>	78
Awidi ve Paynter (2019)	The impact of a flipped classroom approach on student learning experience	<i>Computers &amp; Education</i>	75
Lockwood ve Esselstein (2013)	The inverted classroom and the CS curriculum	<i>Proceeding of the 44th ACM technical symposium on Computer science education</i>	42
Sletten (2017)	Investigating flipped learning: Student self-regulated learning, perceptions, and achievement in an introductory biology course	<i>Journal of Science Education and Technology</i>	40

Based on Table 3, it is seen that the most cited publication about the FCM applications in biology teaching is "Improvements from a flipped classroom may simply be the fruits of active learning" written by Jensen, Kummer and Godoy (2015). This is followed by studies conducted by Porter, Bailey Lee and Simon (2013) who wrote the publication entitled "Halving fail rates using peer instruction: a study of four computer science courses". The article entitled "The impact of a flipped classroom approach on student learning experience" written by Awidi and Paynter (2019) was in the third place. The citation of the three publications reached 316, 78, and 75 in sequence

The title and abstract sections of the publications are the most important parts that can clearly express the publication content and purpose. In this context, among the publications obtained from Scopus database, an evaluation was made in terms of the titles and abstracts of the publications. In this study, the minimum frequent of the word used was 3. According to this setting, it was determined that 201 of 1579 terms or concepts passed the threshold value. The visual network map related to the terms or concepts frequently used in the publication title and abstract sections created with the VOSviewer package program is presented in Figure 4.

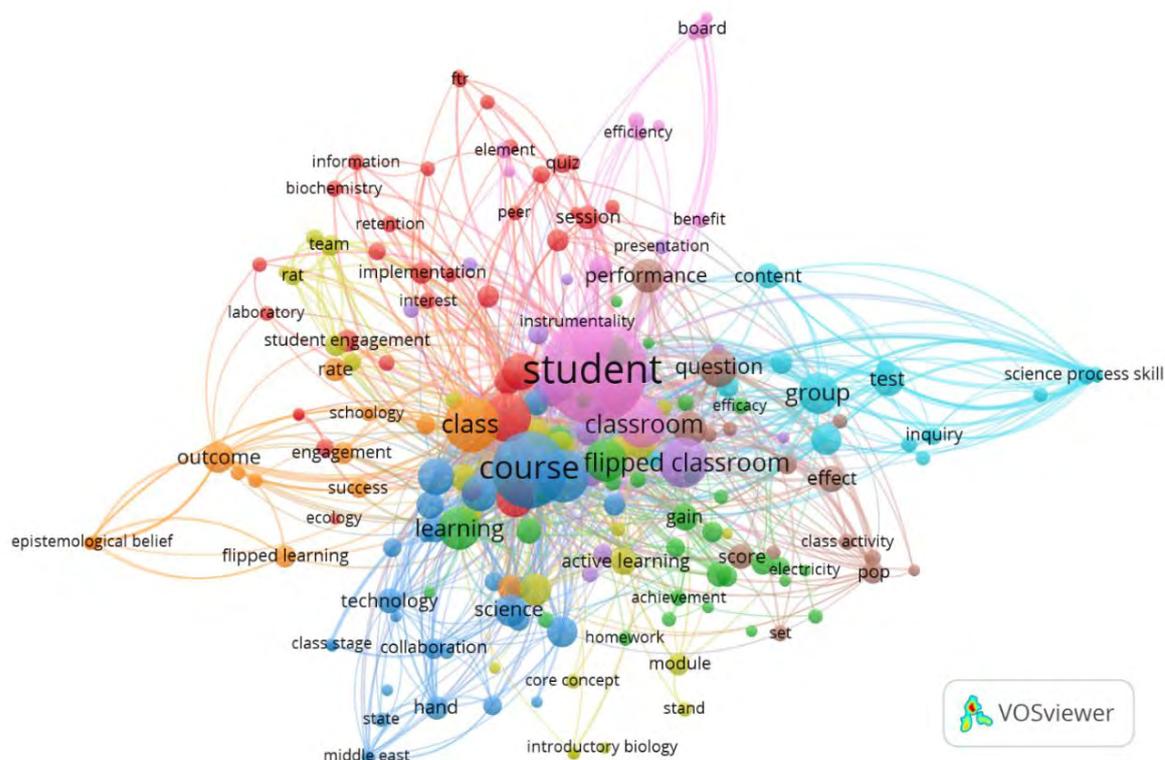


Figure 4. Network map of frequently repeated terms or concepts in the title and abstract sections

In the visual network map, nodes represent terms or concepts, and the distance between them refers to the relationship for each term (Sedighi, 2016). Thus, based on Figure 4, it can be determined that there are nine clusters which represent nine themes. There are five terms or concepts mostly found in the title and abstract sections of the publications i.e. student, course, class, classroom, flipped classroom. It can be inferred that keywords determined in publications is crucial criterion to stand out search trend as crucial as increasing the visibility. In the other words, the analysis of frequent keywords used in certain scope is also important. Keywords are important to stand out the research trends, thus, as they reflect the essence of the study (Julia et al., 2020; Kushairi & Ahmi, 2021). The most frequently repeated keywords in the bibliometric analysis of the FCM are concentrated on the flipped classroom, active learning, and blended learning (Bhagat & Spector, 2018; Çakir, Sayin & Bektas, 2021; Julia et al., 2020; Kushairi & Ahmi, 2021; Tsai & Wu, 2020; Yang, Sun & Liu, 2017; Zainuddin et al., 2019).

In addition to keywords, the title and abstract sections are important in scientific publication as they have great impact on search trends (Zainuddin et al., 2019). Therefore, in this study, the combination of frequently preferred terms in both the title and abstract sections of the publications were analyzed. As the comparison, Kushairi and Ahmi (2021) identified five clusters in the similar field, namely, student participation, teaching model, classroom management, evaluation group, and completion group.

To this section, a threshold value has not been determined in order to evaluate all keywords in publications together. In the VOSviewer package program, 168 keywords were reached by performing the "co-occurrence" analysis. However, since the program warned that some of the determined keywords were not related to each other and that the largest associated data set consists of 130 words, so that the ongoing analyzes were carried out over the 130 words set. The visual network map created with the VOSviewer package program based on the keywords frequently used in publications is presented in Figure 5.

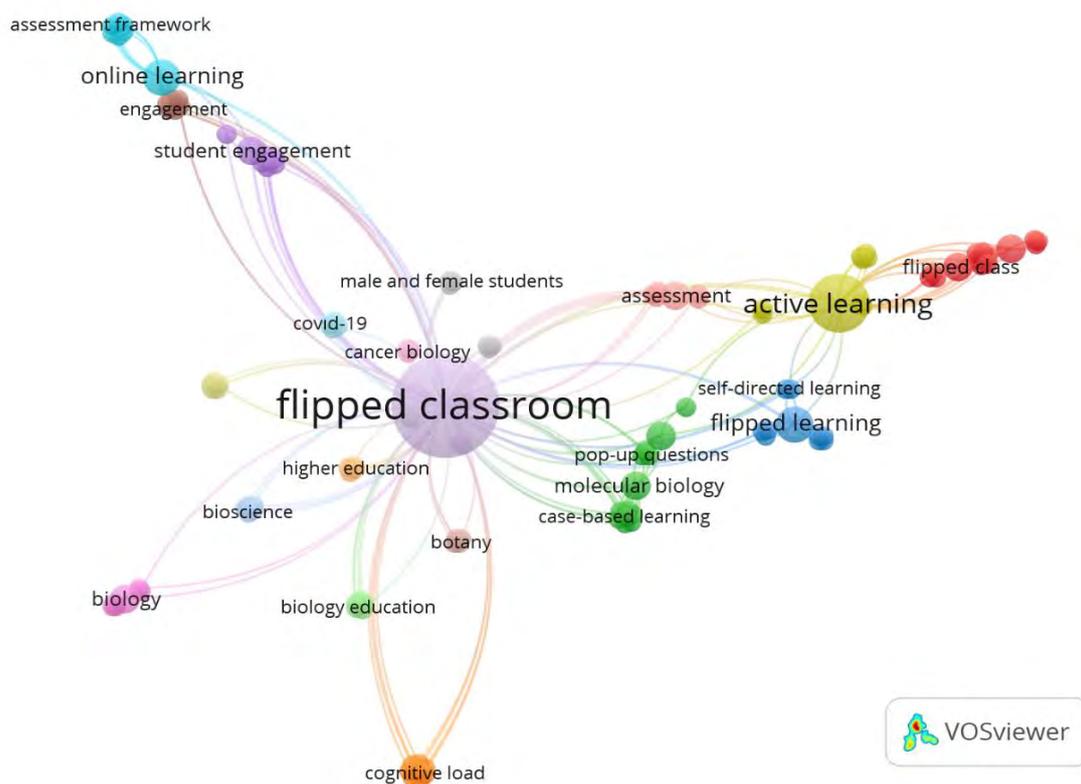


Figure 5. Network map of the most frequently keywords used

Figure 5 shows that the first five keywords which are most preferred in publications related to the FCM applications in biology teaching are: flipped classroom, active learning, online learning, flipped learning and biology respectively.

In the context of bibliographic analysis, the analysis results obtained from VOSviewer program (see Figure 6) showed that the minimum citations number within the scope were "5". According to this setting, it was determined that 45 of 158 authors passed the threshold value. The visual network map of the authors with bibliographic connections and the relationship between them is presented in Figure 6. Citation analysis based on bibliographic coupling is mostly preferred. This can be described as citing the same publication by two different scientific publications.

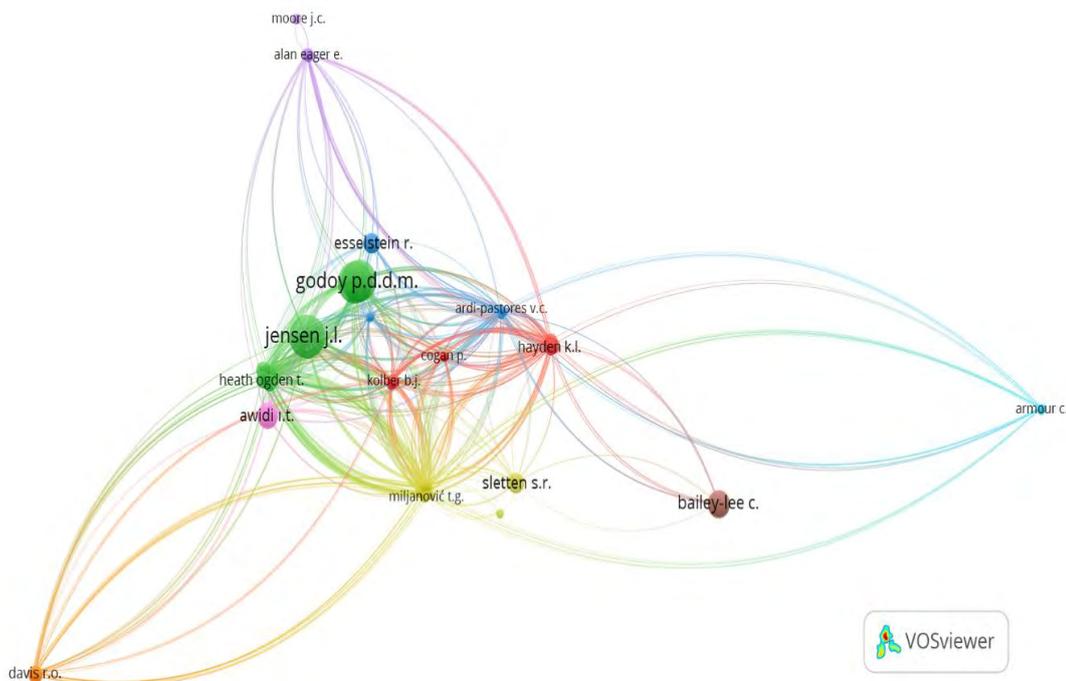


Figure 6. Bibliometric coupling network map for authors

Figure 6 showed that there is an intense and strong relationship among authors. Among the 45 authors included in the analysis, the most cited authors were Jensen J.L. (2 publications, 344 citations), Godoy P.D.D.M (1 publication, 316 citations), Kummer T.A. (1 publication, 316 citations), Bailey-Lee C. (1 publication, 78 citations), Porter L. (1 publication, 78 citations), Simon B. (1 publication, 78 citations), and Awidi I.T. (1 publication, 75 citations), respectively.

Within the scope of bibliographic coupling analysis, the minimum number of citations to create a visual network map of publications was 5. The threshold value has passed 17 out of 53 publications and the analysis results are presented in Figure 7.

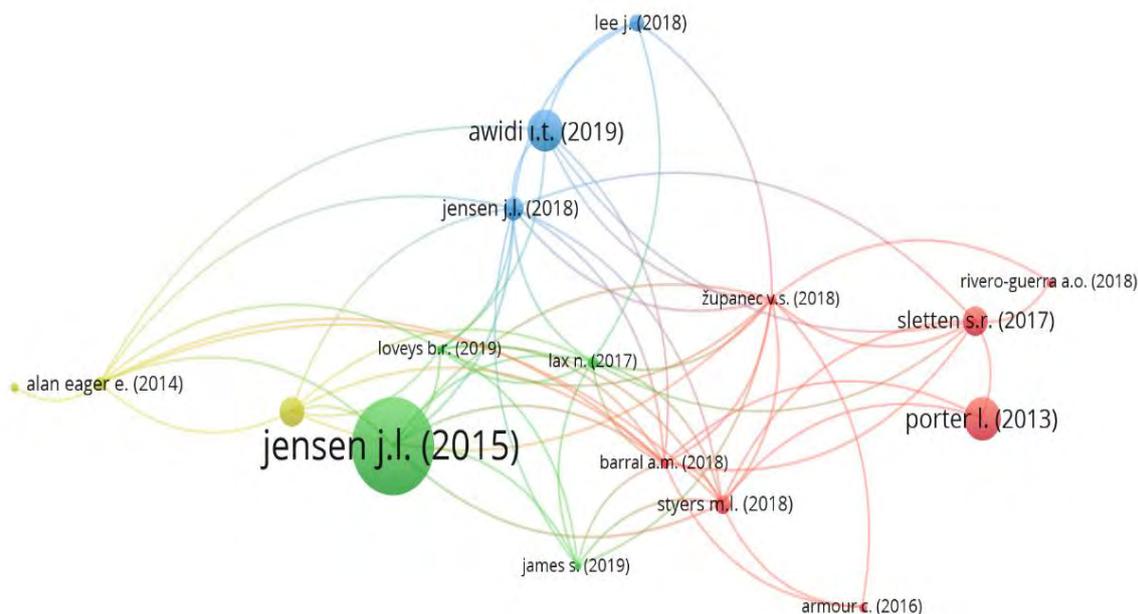


Figure 7. Bibliometric coupling network for publications

Figure 7 summarizes the relationship between the publications based on coloring method. The connection established between two publications that have cited to the same scientific study is defined as a bibliometric coupling. Generally, there are four colors shown in the figure i.e. green, blue, red and yellow. Furthermore, the

same colors interact more intensely within themselves. These publications are heavily centered on the studies conducted by [Jensen, Kummer, and Godoy \(2015\)](#), [Porter, Bailey Lee and Simon \(2013\)](#), and [Awidi and Paynter \(2019\)](#). As a matter of fact, the data obtained overlap with the data in Table 3, which includes the first five publications with the most citations. Since the obtained findings contain bibliometric analysis data for the FCM applications in the field of biology teaching, it is considered that they will contribute to the literature focused on this aspect.

The analysis done on the 53 publications included the countries where the publications were published. Accordingly, the minimum number of publications and number of citations was 1 within the scope of bibliographic matching analysis for countries. According to this setting, 14 out of 53 countries have passed the threshold value and the analysis result is presented in [Figure 8](#).

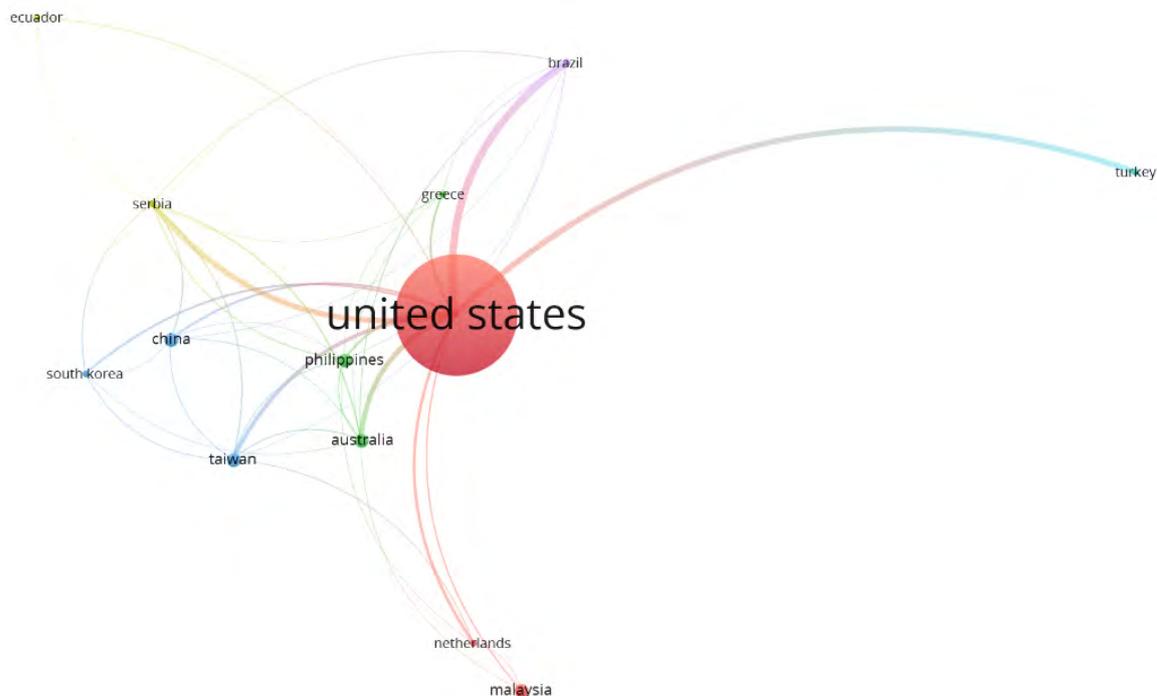


Figure 8. Bibliometric coupling network based on countries

[Figure 8](#) depicts that the highest number of studies focused on the FCM in biology teaching were carried out in the United States of America (USA). All countries seem to be affected by the USA according to the connection status between the countries. Accordingly, the first five countries according to the number of publications and citations are listed as United States (29 publications, 590 citations), Brazil (1 publication, 316 citations), Australia (2 publications, 80 citations), South Korea (1 publication, 17 citations), Serbia (1 publication, 6 citations), respectively. In term of language used, of the 53 publications evaluated, 51 articles were published in English and the two remain were published in Spanish.

These findings are accordance with the other publications which reported that FCM applications in Biology teaching were published in the United States with a very high density ([Al-Shabibi and Al-Ayasra, 2019](#); [Bhagat and Spector, 2018](#); [Çakir, Sayin and Bektas, 2021](#); [Julia et al., 2020](#); [Kushairi and Ahmi, 2021](#); [Tsai & Wu, 2020](#); [Yang, Sun, & Liu, 2017](#)) and the most widely used publication language was English. This is assumed because of the fact that the research efficiency is literally occurred in the center of certain countries which are related to the technological development ([Bhagat and Spector, 2018](#)), thus, in turn, provide adequate resources for academic studies and high motivation of the academicians ([Julia et al., 2020](#)).

Another citation analysis used to determine to what extend a scientific publication affects other publications in the field is co-citation analysis ([Van Eck, 2011](#)). Considering that 53 publications included in the scope of the study refer heavily to the studies on the FCM and biology teaching, the co-citation analysis method was done using VOSviewer program. The minimum co-citation number of authors was determined as "5". Thus, there were 97 co-citation authors which passed the threshold from a total of 3068 authors. However, due to the program warning that some of these authors are not related to each other and that the largest data set were composed of 95 authors, the ongoing analyzes were carried out on 95 co-citation authors. In this context, the visual network map of co-citation authors frequently used in publications is presented in [Figure 9](#).

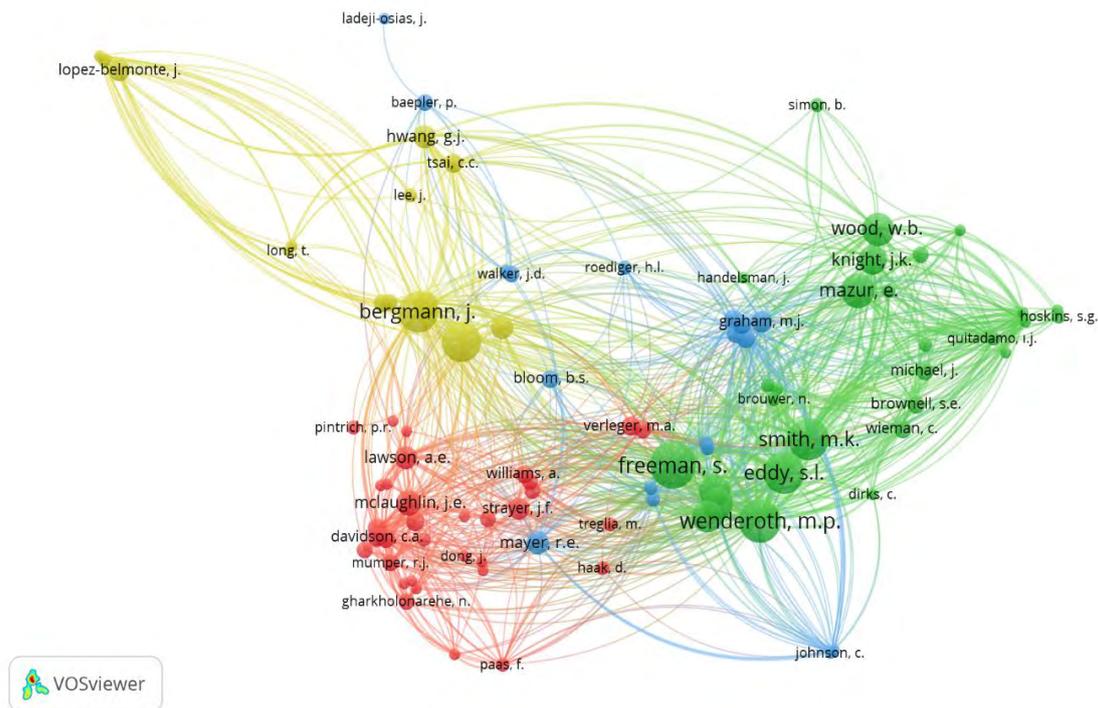


Figure 9. Co-citation network for authors

Based on Figure 9, it is seen that the interaction and connection between the authors who are commonly cited in related publications are quite intense and strong. It is clear that the most cited authors were Freeman S. (26 citations), Wenderoth M.P. (24 citations), Eddy S.I. (23 citations), Smith M.K. (23 citations), Bergmann J. (22 citations) and Sams A. (22 citations).

Co-citation, in terms of citing two different publications in a scientific study, enables authors to reach publications which have strong effect on related publications. Therefore, the analysis of co-citation in the field related to the certain publication within the scope of the study is crucial. However, in this study, there is no co-citation data about the authors among the study findings which include bibliometric analysis of the FCM studies. This has been the undergirding reason that review could not be made. As the findings obtained were evaluated on the basis of both biology teaching and the FCM, it was found that the authors named Freeman S., Wenderoth M.P., Eddy S.I. and Smith M.K. were cited for active learning practices in biology teaching. Meanwhile, the authors named Bergmann J. and Sams A. were cited for the FCM applications. As a matter of fact, the co-citation of researchers named Bergmann and Sams (2012), who mediated the introduction of the FCM concept to the education world, were seen as an expected result in this study.

Eventually, today's learning generation, who mostly are digital native, is more prone to the use of digital technologies in educational environments. Therefore, the FCM applications which use potential online resources and technology have gained momentum in the field of education in recent years. The FCM has become a preferred model in biology teaching as it is in every education field. The learners progress at their own pace. This allows them to practice what they have learned in their classroom environment which revealed the positive effects of dynamic and interactive FCM applications in biology teaching on academic achievement, attitude, motivation, and participation (Awidi & Paynter, 2019; Malto, Dalida & Lagunzad, 2018). Despite this, the FCM applications for biology teaching have remained limited in the literature. Therefore, it is necessary to examine the bibliometric analysis results which allow the sharing of universal research data. By conducting this study, a broad perspective on the FCM applications in biology teaching was presented to the researchers

## CONCLUSION

Based on the study conducted, it can be concluded that: 1) the publication in FCM implementation in biology teaching has been started since 2013 and has been increasing until 2020; 2) the top five publication sources found were CBE Life Sciences Education, 44<sup>th</sup> ACM Technical Symposium on Computer Science Education, the Computers and Education, Journal of Science Education and Technology, and British Journal

of Educational Technology; 3) the most publication types chosen by authors were scientific journal and proceeding; 4) the highest number of publications were published in USA; 5) the most cited publication was "Improvements from a flipped classroom may simply be the fruits of active learning" written by Jensen, Kummer and Godoy (2015); 6) the most cited institution was CBE—Life Sciences Education; 7) the most used keywords were flipped classroom, active learning, online learning, flipped learning and biology respectively.

The FCM can be a solution for the teaching-learning process in biology teaching where students are at the center of the learning process and take a more active role in the classroom. For this reason, studies for the FCM in the field of biology teaching can be increased by enriching the researches in the field of application. In this way, it is possible to support a very limited number of study data in the literature. Furthermore, bibliometric analysis of the FCM applications in biology education initiated with this study can be expanded by using other databases.

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