Education and Information Technologies
https://doi.org/10.1007/s10639-022-11396-8

# Empirical research of emerging trends and patterns across the flipped classroom studies using topic modeling

**Ozcan Ozyurt**[1]

Received: 20 July 2022 / Accepted: 5 October 2022
© The Author(s), under exclusive licence to Springer Science+Business Media, LLC, part of Springer Nature 2022

## Abstract

This study presents topic modeling based bibliometric characteristics of the articles related to the flipped classroom. The corpus of the study consists of 2959 articles published in the Scopus database as of the end of 2021. In addition to the bibliometric characteristics of the field, research interests and trends were also revealed with the study, which was based on the topic modeling-based bibliometric analysis method. According to the results of the study, an increase in the number of publications has been observed since 2015. Nearly one-third of the studies are of United States origin. According to the findings of the topic analysis in which the research interests and trends in the studies were revealed, the articles in this field were gathered under 16 topics. Considering the number of publications of the topic, it was seen that the three most voluminous topics were "Performance and perception", "Nursing education" and "Effectiveness and motivation", respectively. It is thought that the results of the study will provide a general perspective to the researchers in this field and provide important outputs in the context of monitoring the issues that may become prominent in the future.

## Highlights

- The flipped classroom approach has an important place in the implementation of student-centered learning environments.
- This study presents topic modeling based bibliometric characteristics of the articles related to the flipped classroom.
- Descriptive analysis and Latent Dirichlet Allocation (LDA) topic modeling approach were used.
- According to the results of the study, an increase in the number of publications has been observed since 2015.

✉ Ozcan Ozyurt
oozyurt@ktu.edu.tr

[1] Department of Software Engineering, Of Technology Faculty, Karadeniz Technical University, Trabzon, Türkiye

Published online: 15 October 2022

- According to the findings of the topic analysis, the articles in this field were gathered under 16 topics.

**Keywords** Flipped classroom · Topic modeling · Research trends · Data science in education · Text mining

## 1 Introduction

Today's modern understanding of education has caused change and transformation in learning processes. As a result of the change and transformation, student-centered innovative learning approaches have become prominent. Developing information and communication technologies (ICT) have increased the demand for interactive active learning processes and ensured the inclusion of such environments in education processes (Alvarez, 2021; Latorre-Cosculluela et al., 2021; Singhal et al., 2020). Active learning increases students' interest, motivation and learning efficiency, reduces learning gaps and thus increases student success (Freeman et al., 2014; Pyatt & Sims, 2012). The flipped classroom (FC) approach has an important place in the organization and implementation of student-centered and active learning environments (Chen et al., 2014; Davies et al., 2013; Karabatak & Polat, 2020; Vivek & Ramkumar, 2021).

Although the FC approach dates back to the 2000s (Bolat, 2016), it has become more convenient and effective in recent years with the development of ICT (Abeysekera & Dawson, 2015; Touchton, 2015). ICT plays a central role in the skill set that students are expected to master during their studies. The rapid development of ICT presents both opportunities for students and teachers (Sointu et al., 2019; Zheng et al., 2020). In recent years, several new technologies with different pedagogical approaches supported by ICT have attracted attention. One of the notable trends among the current trends is the flipped classroom (Adam Beckers, 2017). In other words, the flipped classroom approach is a current trend in educational technology that has the potential to integrate digital technology into teaching and learning processes (Ng, 2015). In this context, many studies can be mentioned that focus on changing pedagogical practices and integrating ICT by applying FC. From this point of view, FC is an example of a good integration of ICT into education and training processes (Sointu et al., 2019).

The basis of this approach, called flipped classroom or flipped learning, is based on the change of classroom and home roles in traditional learning (Lee & Martin, 2020; Thai et al., 2017). In this approach, the operations and processes carried out in the classroom environment in traditional learning were transferred to the home environment, and the operations processes performed in the home environment were transferred to the classroom environment (Bergmann & Sams, 2012; Filiz & Kurt, 2015; Turan & Goktas, 2015). The learning environment is moved from the classroom environment to the individual environment, especially with the help of technology-aided tools. The classroom, on the other hand, is transformed into an

environment where previously learned information is reinforced, deficiencies are eliminated and various practices are made (Filiz & Kurt, 2015; Jacot et al., 2014; Sever, 2014; Turan & Goktas, 2015). In the FC process, the first stage of teaching shifts to individual learning instead of group learning in traditional classroom environments, and active learning comes to the fore. Thus, an important part of the processes such as giving information to students about the lesson, understanding and interpreting this information and making practices within the limited course hours are carried out of the classroom (Kong, 2014; Sever, 2014; Turan & Goktas, 2015). In this way, it paves the way for students to come to the classroom environment ready for learning experience (Kong, 2014; Sever, 2014). Besides, the studies carried out in the classroom environment, which is the second stage, turn into dynamic, interactive environments where reinforcement is realized. In this process, the teacher plays a role guiding students in learning new concepts and topics (Davies et al., 2013; Turan & Goktas, 2015).

There are many studies in the literature based on the FC approach. These studies carried out at almost every level and in every field of education, have made significant contributions to the field. In these studies, the effects of the FC approach on the learning experience were investigated from different aspects. While studies have shown mostly positive results, there are a limited number of studies with negative results. The aspects that are generally evaluated as positive in the studies can be listed as follows: learning outcomes and increasing success (Baepler et al., 2014; D'Souza & Rodrigues, 2015; Gaughan, 2014), students' taking an active role and responsibility in the learning process (Hwang et al., 2015; Mok, 2014; Özyurt & Özyurt, 2017), coming to class in a more prepared manner (Gaughan, 2014; Özyurt & Özyurt, 2017), easing the learning and providing permanent learning (Kocabatmaz, 2016; Mok, 2014; Özyurt & Özyurt, 2017; Turan & Goktas, 2015), increasing interest, motivation and attitude towards the lesson by reducing anxiety (Abeysekera & Dawson, 2015; Butt, 2014; Gaughan, 2014; Kong, 2014; Mok, 2014; Özyurt & Özyurt, 2017; Sever, 2014). In addition to these, the negative aspects, even if they are limited, are as follows: coming to the lesson without making any preparation (Bristol, 2014), mislearning can be failed to notice (Kardaş & Yeşilyaprak, 2015), spending a lot of time for studying and not getting used to this method (Kocabatmaz, 2016; Musib, 2014).

The Covid-19 outbreak has caused significant change and transformation in the field of education as in every field (Kaisara & Bwalya, 2020; Paudel, 2020). With the pandemic, face-to-face lessons have been rapidly transformed into distance and online lessons (Adarkwah, 2021; Paudel, 2020; Rizun & Strzelecki, 2020). In this change and transformation, the FC approach has also been one of the frequently applied methods. During the pandemic period, studies on FC were carried out in different areas (Elkhatat & Al-Muhtaseb, 2021; Haqiyah et al., 2021; Nerantzi, 2020; Pozo-Sánchez et al., 2021; Yen & TF, 2020). The results of these studies are generally very similar to the results of previous studies. In addition to these, it is recommended that new policies should be implemented to extend such practices (Yen, 2020).

Frequent use of the FC approach makes it necessary and important to conduct descriptive studies, which enable a holistic view of the studies in this field, As a

matter of fact, there are such studies in the literature using FC approach. Such studies have been conducted frequently as content analysis, systematic review and bibliometric analysis studies. In one study, content analysis was conducted with 20 articles about FC published between 2013 and 2015 (Zainuddin & Halili, 2016). Analysis results showed that FC has positive effects on students' learning activities such as achievement, motivation, participation and interaction. In addition, difficulties such as poor quality of FC-related videos and not being suitable for untrained instructors have been reported (Zainuddin & Halili, 2016). Another study is a systematic review study with 71 articles (Akçayır & Akçayır, 2018). In this study, it was concluded that the most frequently reported advantage of FC was the improvement of student's learning performance. Difficulties with this method are related to activities outside the classroom, such as inadequate student preparation before the lesson (Akçayır & Akçayır, 2018). Another systematic review study examining the trends and main findings of studies on FC in the field of English language teaching was conducted with 43 articles (Turan & Akdag-Cimen, 2020). A systematic review study was conducted with 24 articles on the FC approach published in nursing education. (Özbay & Çınar, 2021). In one of the bibliometric analysis studies in this area, the researchers performed bibliometric analysis with 233 FC articles. The study emphasized that FC can provide students with a more interactive environment that will provide higher learning achievement and better preparation for 21st century learning and working environments (Al-Shabibi & Al-Ayasra, 2019). Another study is the study with 346 articles. In the study, it was emphasized that the FC approach is a popular education model among researchers today (Julia et al., 2020). One of the current studies in this field is the study that makes a quantitative summary and qualitative synthesis of the FC literature from 2013 to 2020 (Al Mamun et al., 2021). With this article focusing on 106 FC studies in engineering education, a bibliometric mapping of the field was made. Finally, the bibliometric analysis study conducted with 1557 documents is considered to be the most comprehensive study in this field (Kushairi & Ahmi, 2021).

There are many such analysis studies evaluating studies in different fields of FC approach. Although the importance of each of these studies' contribution to the field cannot be denied, the lack of a study in which the FC approach is considered as a whole attracts the attention. In other words, there is no study that will provide a greater perspective to the field and describe all the studies related to FC from past to present in depth. On the other hand, content analysis, systematic review and bibliometric studies have difficulties for large datasets because of both the number of articles and the indicators from which they take their basis, and because they are relatively manual analyzes (Gurcan et al., 2021; Yang et al., 2016). To eliminate these difficulties and for in-depth analysis, topic modeling studies based on data/text mining are frequently used (Gurcan et al., 2021; Hu et al., 2014; Kang et al., 2019). In other words, topic modeling studies are regarded as ideal studies to reveal the themes and trends of studies in any field in a comprehensive framework (Gurcan et al., 2021). In this context, with the present study, it is aimed to reveal the trends and tendencies in the articles based on the FC approach from the past to the present. This study, conducted with 2959 articles, is the most comprehensive study in FC as well as the first innovative study to focus on topic modeling-based semantic

analysis. In this context, this study is necessary and important as it will look at the field from a broad perspective and describe all the works in detail. In this context, the following research questions were tried to be answered:

RQ1: What is the distribution of articles published in the field of FC by years?
RQ2: What are the prominent journals, authors and subject areas in the articles published in the field of FC?
RQ3: Which are the leading affiliation and countries in the articles published in the field of FC?
RQ4: What are the prominent topics in the articles published in the field of FC?
RQ5: How do the prominent topics in the articles published in the field of FC change over time?

## 2 Method

In this study, the descriptive characteristics of the articles in the field of FC were revealed and then the topic modeling analysis was performed. Topic modeling analysis has been frequently preferred in recent years to retrieve hidden semantic patterns in large text sets that are difficult to handle manually, such as natural language processing, information retrieval, and literature review (De Mauro et al., 2018; Gurcan et al., 2021). Latent Dirichlet Allocation (LDA) method was used in the topic modeling analysis. LDA is a generative model based on Bayes' inference that provides an effective approach to systematically analyze large collections of textual documents; therefore, it is widely used for topic modeling analysis (Blei et al., 2003; Li et al., 2019). Accordingly, LDA, a probabilistic model for content analysis based on topic modeling, was used for the semantic analysis of the empirical corpus of FC literature. LDA is based on the assumption that each document in a dataset covers more than one topic. LDA calculates the topic distribution per document, the word distribution per topic, and the topic and word assignments per document using an iterative process based on the Dirichlet distribution (Blei et al., 2003).

### 2.1 Search strategy and study selection

Scopus database was used to access articles in the field of FC. Scopus is covering more than 7,000 publishers and 240 disciplines worldwide, including Elsevier, Emerald, IEEE, Sage, Springer, Taylor & Francis, Wiley Blackwell, and others (Gurcan et al., 2021; Scopus, 2022a; Yung & Khoo-Lattimore, 2019). On the other and, Scopus is the largest abstract and citation database of peer-reviewed literature such as scientific journals, books, and conference proceedings (Scopus, 2022b). From this point of view, Scopus was deemed sufficient by the researchers. In order to include the maximum number of articles on Scopus, the title, abstract and keywords were searched. The following query was created by examining the studies in the literature by the researchers, two field experts:

TITLE-ABS-KEY ( “flipp* class*” OR “flipp* learn*” OR “flipp* teach*” OR “flipp* educat*”) AND ( LIMIT-TO ( DOCTYPE, “ar” ) OR LIMIT-TO ( DOCTYPE, “re” ) ) AND ( EXCLUDE ( PUBYEAR, 2022 ) ) AND ( LIMIT-TO ( SRCTYPE, “j” ) ) AND ( LIMIT-TO ( PUBSTAGE, “final” ) ).

With this query, all journal articles (research and review) published from the beginning to the end of 2021 was retrieved. The query was run on March 17, 2022. The search yielded a total of 2959 articles (2807 research articles and 152 review articles). The title, abstract and author keywords of these articles were added to the data set. This information, recorded in csv format, was used as an input for the topic modeling analysis.

### 2.2 Data analysis, pre-processing and fitting topic modeling

Within the scope of the study, firstly, the descriptive characteristics of the articles in the field of FC are given. In accordance with this, the number of publications by years, prominent journals, authors and subject areas were determined. Besides, prominent affiliations and countries were also identified. The numerical data obtained for answers of the first three research questions (RQ1, RQ2 and RQ3) were presented graphs and tables. Then, LDA-based topic modeling analysis was conducted to answer the fourth and fifth research questions (RQ4 and RQ5). Topic modeling analysis is a text mining application and requires some data preprocessing steps. The purpose of these processes is to obtain an processable clean dataset of raw data (Aggarwal & Zhai, 2013; Gurcan & Cagiltay, 2019). The pre-processes are divided into three stages as tokenization, removal of meaningless words and lemmatatazion. In the first stage, the texts were converted into simple words, special characters and punctuation marks in the words were cleaned. Then, stop words (meaningless words, etc.) were discarded. The words in the query have also been added to the stop word list. With this step, it is aimed to prevent domain-specific words from being repeated over and over in topics. In the last stage, words are reduced to stem with lemmatatizion. After these stages, the final corpus was created and prepared for analysis. The combination of the title, abstract and keywords was subjected to topic modeling analysis.

Text mining and topic modeling tools in Python were used for both data mining preprocessing stages and for fitting and applying LDA to FC corpus. In order to fit the LDA model to the empirical corpus, firstly, the values of the previous parameters that provide the optimization of the model were selected. The preliminary parameters of $\alpha$, which determines the distribution of topics in documents, and $\beta$, which determines the distribution of words in topics, were taken $\alpha = 0.1$ and $\beta = 0.01$ as the recommended values for topic modeling of short texts (Blei & Lafferty, 2007). An iterative and intuitive process is suggested for model fitting (Gurcan et al., 2021; Mimno et al., 2011). In order to determine the ideal number of topics (K) empirically in LDA-based topic modeling analysis, a model was created for all K values between 10 and 40. Coherence value was calculated for each K value. The coherence value was taken into account in determining the appropriate number of topics in the LDA analysis. The optimum level of the coherence value is accepted as 0.7

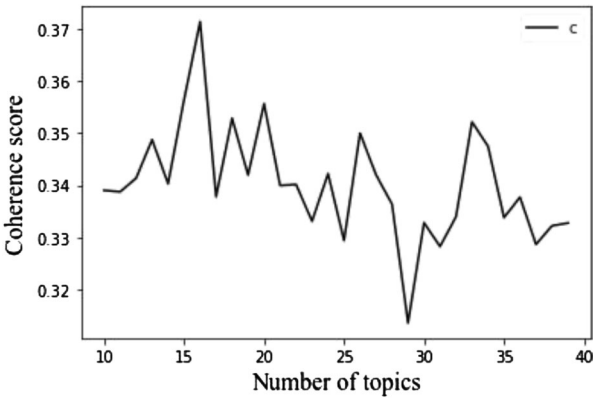



**Fig. 1** Number of topics-coherence score graph

(Blei et al., 2003). A coherence value is calculated in each model and the number of topics producing the closest result to 0.7 is considered ideal. As a result of the analysis, a model with 16 topics was decided. The graph of the number of topics-cohorence value is given in Fig. 1.

Topic modeling analysis generates topics (such as topic 0, topic 1, etc.) and terms that make up topics. Terms representing topics are produced in order according to their representation rate. Topics are labeled and named by considering these terms (Hindle et al., 2013; Gurcan et al., 2021; Özyurt & Ayaz, 2022). In this direction, the researcher named the topics by considering the terms that represent them. Then, this nomenclature was reviewed together by two educational technologists and the final versions of the topics names were decided together. In addition, the percentage of each topic per document, the distribution of words in each topic, and the distribution of topics within all articles were calculated. At the end of this whole process, first 15 terms with the highest frequency representing that topic were determined for each of the 16 topics.

## 3 Findings

The results of the study are presented under two main sections to answer the first three research questions (RQ1, RQ2, and RQ3) and the 4th and 5th research questions (RQ4 and RQ5). Accordingly, firstly, the corpus was analyzed to present the bibliographic features of the FC articles in the corpus descriptively, and the findings were given under the title of "findings of descriptive analysis". Afterwards topic modeling analysis was applied to discover the implicit topics in these articles and the findings were presented under the title of "findings of topic modeling analysis".

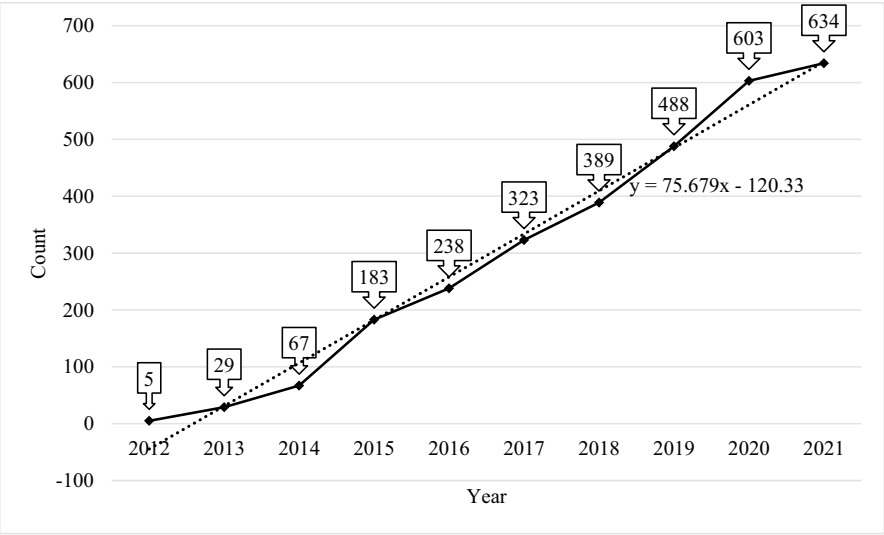



**Fig. 2** Number of publication according to years and slope graph

### 3.1 Findings of descriptive analysis

In order to answer the first three research questions (RQ1, RQ2, and RQ3), the descriptive characteristics of the articles in the field of FC were retrieved. In this context, first of all, the number of articles (n = 2959) in the field of FC from past to

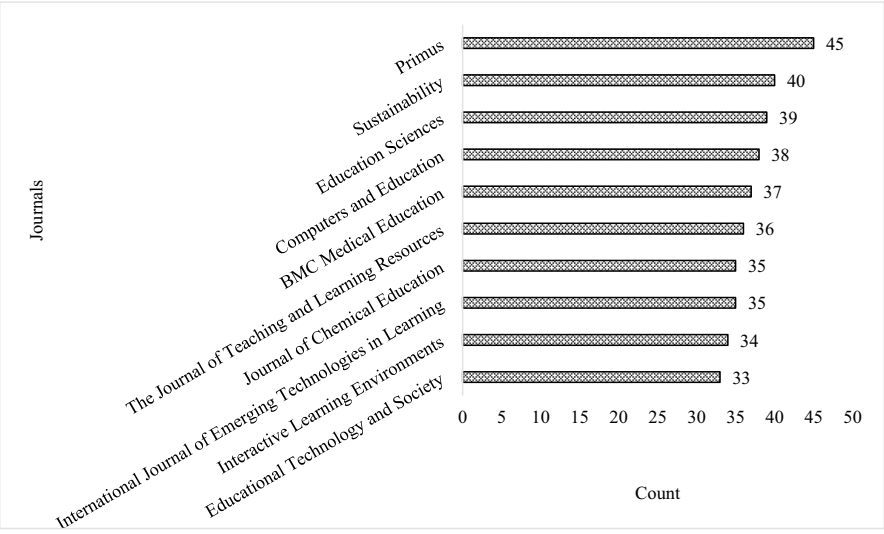



**Fig. 3** Top ten prominent journal and number of publication

**Table 1** Top ten authors who have the highest number of publication and their number of publication

| Authors | n |
|---|---|
| Hwang, G.J. | 20 |
| Hew, K.F. | 18 |
| Lo, C.K. | 16 |
| Jeong, J.S. | 15 |
| González-Gómez, D. | 14 |
| López-Belmonte, J. | 14 |
| Belmonte, J.L. | 10 |
| Zainuddin, Z. | 10 |
| Gopalan, C. | 9 |
| McLaughlin, J.E. | 9 |

**Table 2** Top ten prominent subject area and number of publication

| Subject area | n |
|---|---|
| Social Sciences | 2128 |
| Computer Science | 555 |
| Medicine | 407 |
| Engineering | 400 |
| Arts and Humanities | 228 |
| Mathematics | 157 |
| Nursing | 157 |
| Psychology | 152 |
| Business, Management and Accounting | 137 |
| Health Professions | 101 |

present according to years (RQ1) and the slope graph that emerged accordingly are given in Fig. 2.

As seen in Fig. 2, the number of publications increases linearly in the field where 5 articles were published in 2012. Especially the increase in 2015 draws attention and creates a break. Findings on journals, authors and subject areas (RQ2) that stand out in the articles in the field of FC are given in Fig. 3; Tables 1 and 2, respectively.

According to Fig. 3, the journals with the highest number of publication are journals in different fields of educational technologies and sciences. The top three journals with the highest number of publications are Primus (n = 45), Sustainability (n = 40) and Education Sciences (n = 39), respectively. In addition, journals on health sciences and chemistry education draw attention. The first prominent author in this field is Hwang, G.J. (National Taiwan University of Science and Technology), with 20 articles, as seen in Table 1. He is followed by Hew, K.F., with 18 articles, and Lo, C.K. (from The University of Hong Kong) with 16 articles. In terms of the subject areas of the publications it is seen that the first field is Social Sciences (n = 2128), which also includes educational sciences. When the top ten prominent

**Table 3** Top ten prominent affiliation and number of publication

| Affiliation | n |
|---|---|
| Universidad de Granada | 38 |
| The University of Hong Kong | 35 |
| National Taiwan University of Science and Technology | 27 |
| The University of North Carolina | 25 |
| Universidad de Extremadura | 23 |
| Harvard Medical School | 22 |
| The Education University of Hong Kong | 19 |
| Monash University | 19 |
| Universidad Politécnica de Madrid | 19 |
| National Taiwan Normal University | 18 |

**Table 4** Top ten countries with the highest number of publication, their publication numbers and rates

| Country | n | f |
|---|---|---|
| United States | 870 | 29.40% |
| China | 251 | 8.48% |
| Spain | 233 | 7.87% |
| Taiwan | 177 | 5.98% |
| Australia | 142 | 4.80% |
| United Kingdom | 124 | 4.19% |
| South Korea | 119 | 4.02% |
| Turkey | 105 | 3.55% |
| Malaysia | 93 | 3.14% |
| India | 80 | 2.70% |
| Total | 2194 | 74.15% |

fields are examined, it is possible to say that there are publications on FC in different disciplines (Computer science, medicine, engineering, business etc.). The findings on prominent affiliation and country (RQ3) in the articles in the field of FC are given in Tables 3 and 4, respectively.

As seen in Table 3, in terms of the affiliation origins of the publications the first three places are shared by "Universidad de Granada", "The University of Hong Kong" and "National Taiwan University of Science and Technology". In terms of the country origins of the publications, as in Table 4, "United States", "China" and "Spain" share the first three ranks. The ratio of the publications originating from the top 10 countries to the total publications was 74.15%.

### 3.2 Findings of topic modeling analysis

Findings on prominent topics (RQ4) and trends (RQ5) in articles in the field of FC are given in this section. As a result of the LDA-based topic modeling analysis, 16

**Table 5** Discovered topics, terms that make up the topics, the number of articles assigned to the topics, volume rates and accelerations

| Topic name | Topic terms | n | Rate | $Acc_T$ |
|---|---|---|---|---|
| Performance and perception | performance, assessment, perception, active, exam, higher, pharmacy, undergraduate, examination, material, grade, final, activity, university, significant | 839 | 28.35% | 20.67 |
| Nursing education | nursing, effect, achievement, efficacy, self, satisfaction, strategy, motivation, significant, regulated, directed, design, regulation, skill, undergraduate | 417 | 14.09% | 12.04 |
| Effectiveness and motivation | learner, teacher, effectiveness, effect, motivation\| perception, questionnaire, significant, instructional, training, impact, digital, environment, online, performance | 405 | 13.69% | 11.10 |
| Thinking skills | thinking, skill, critical, learner, ability, technology, design, activity, performance, teacher, content, reading, college, development, mobile | 277 | 9.36% | 6.90 |
| Programming learning | programming, performance, computer, experience, load, cognitive, program, design, trauma, lab, assessment, blended, pas, effort, handoff | 226 | 7.64% | 7.00 |
| Active learning strategies | technology, active, information, strategy, learning, implementation, innovation, training, student, work, development, teacher, practice, pedagogical, virtual | 190 | 6.42% | 6.23 |
| English foreign language | english, language, writing, efl, learner, foreign, instruction, skill, speaking, technology, college, teacher, university, activity, effect | 119 | 4.02% | 3.43 |
| Simulation based learning | simulation, development, mobile, neurology, skill, material, feedback, ultrasound, analytics, social, radiation, knowledge, learner, small, activity | 100 | 3.38% | 2.71 |
| Mathematics education | mathematics, technology, calculus, blended, informa, trading, limited, design, student, university, instructional, video, published, publication, effect | 94 | 3.18% | 1.65 |
| Medical education | medical, curriculum, health, clinical, knowledge, patient, skill, care, student, medicine, resident, training, program, practice, confidence | 85 | 2.87% | 2.03 |
| Information literacy | online, information, literacy, mooc, technology, library, service, practice, instruction, open, professional, reality, reform, project, training | 57 | 1.93% | 0.73 |
| Engineering education | engagement, activity, engineering, online, university, active, learning, blended, content, higher, experience, strategy, faculty, evaluation, implementation | 43 | 1.45% | 0.57 |
| Achievement and attitude | university, achievement, attitude, effect, higher, perception, gamification, technology, significant, motivation, teacher, skill, positive, design, questionnaire | 38 | 1.28% | 1.04 |
| Experiences | experience, activity, design, knowledge, environment, peer, technology, practice, challenge, instruction, material, university, team, support, active | 37 | 1.25% | 0.80 |

**Table 5** (continued)

| Topic name | Topic terms | n | Rate | $Acc_T$ |
|---|---|---|---|---|
| Professional skills | skill, profession, evidence, competency, faculty, module, technology, instruction, university, program, assessment, smart, team, practice, industry | 22 | 0.74% | 0.18 |
| Chemistry education | video, online, chemistry, content, chemical, material, watching, instructor, undergraduate, introductory, collaborative, society, experience, design, concept | 10 | 0.34% | -0.09 |

$Acc_T$: Total Acceleration

topics were discovered. The proportion of each topic was calculated based on the number of articles assigned to each topic. The topics are given in Table 5 in order of volume. In addition, the first 15 terms that make up each topic are listed in order according to the density of creating that topic.

Table 5 shows that the most studied (the number of publications with the highest number of publications is called the volume throughout the text) and the three fastest accelerating topics in the FC field are "Performance and perception" (n = 839; f = 28.35%; Acc = 20.67), "Nursing education" (n = 417; f = 14.09%; Acc = 12.04), and "Effectiveness and motivation" (n = 405; f = 13.69% and Acc = 11.10). While calculating the acceleration (Acc), the slope formula was used and the slope value of the data in a range was taken into account as acceleration. The fact that this acceleration value is negative or positive is accepted as an indicator of a decrease or increase in the number of publications on that topic. The time period was divided into certain periods in order to determine the distribution of the discovered topics by years, and the trend of each topic within itself and according to other topics. Since the data set is ten years old (2012–2021), five two-year periods were created. In Table 6, the number of publications of the topic in the periods and the slope values of each topic in the periods are given. With the help of the data in Table 6, the volume (number of articles) and slope graphs for each topic in periods were created. In Fig. 4, the number of articles of the first three topic- period graph is given in order according to the slope.

**Table 6** Distribution of the number of articles on the topics according to two-year periods and their acceleration values

| | Periods | | | | | Total | $Acc_P$ |
|---|---|---|---|---|---|---|---|
| | 2012–2013 | 2014–2015 | 2016–2017 | 2018–2019 | 2020–2021 | | |
| | n | | | | | | |
| Performance and perception | 8 | 80 | 175 | 236 | 340 | 839 | 82 |
| Nursing education | 2 | 25 | 68 | 129 | 193 | 417 | 48.6 |
| Effectiveness and motivation | 5 | 29 | 71 | 120 | 180 | 405 | 44.1 |
| Thinking skills | 6 | 19 | 58 | 88 | 106 | 277 | 26.9 |
| Programming learning | 2 | 14 | 37 | 74 | 99 | 226 | 25.4 |
| Active learning strategies | 2 | 8 | 31 | 57 | 92 | 190 | 22.9 |
| English foreign language | 2 | 7 | 23 | 35 | 52 | 119 | 12.8 |
| Simulation based learning | 0 | 10 | 17 | 31 | 42 | 100 | 10.5 |
| Mathematics education | 1 | 16 | 19 | 28 | 30 | 94 | 7 |
| Medical education | 1 | 8 | 21 | 22 | 33 | 85 | 7.8 |
| Information literacy | 2 | 13 | 12 | 15 | 15 | 57 | 2.8 |
| Engineering education | 1 | 10 | 8 | 10 | 14 | 43 | 2.6 |
| Achievement and attitude | 0 | 2 | 5 | 14 | 17 | 38 | 4.6 |
| Experiences | 1 | 2 | 9 | 12 | 13 | 37 | 3.4 |
| Professional skills | 1 | 4 | 6 | 4 | 7 | 22 | 1.2 |
| Chemistry education | 0 | 3 | 1 | 2 | 4 | 10 | 0.7 |
| Total | 34 | 250 | 561 | 877 | 1237 | 2959 | |

$Acc_P$ = Acceleration in Periods

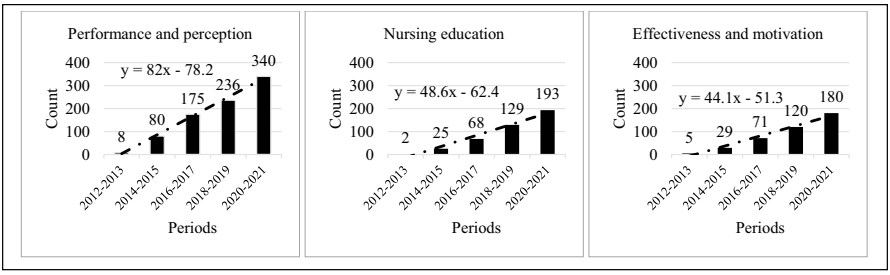



**Fig. 4** Volume and slope graphs of the top three topics with the highest volume

As seen in Fig. 4, the first three topics whose volumes increase the fastest over time are respectively "Performance and perception" (AccP = 82), "Nursing education" (AccP = 48.6), and "Effectiveness and motivation" (AccP = 44.1). This shows that these three topics are both the most voluminous topics and the topics that increase the number of publications withing themselves the fastest in time. Volume-period graphs of all topics are given in Appendix 1 in order of acceleration.

With the help of Table 6, the percentages of the number of publications on each topic in each period were calculated. The slope value was determined with these percentages. With the help of these data, the ratio of the number of publications on each topic in the periods has been revealed. In this way, the acceleration of each topic in itself was obtained from the percentages. While this process is being done, the operations on Table 6 are made on a row basis. For example, the number of publications on the topic "Performance and perception" in the periods is 8, 80, 175, 236 and 349, respectively. Accordingly, the percentages of the publications on this topic in the periods are obtained as 0.95%, 9.54%, 20.86%, 28.13%, 40.52%, respectively. In other words, while 0.95% of the publications on this topic were made in the first period, 40.52% were made in the last period. The acceleration of the percentages of this topic in periods (AccPP = Percentage acceleration in periods) was calculated as 9.77. In Fig. 5, the percentices of the first three topics in order of acceleration and slope graphs are given.

As can be seen in Fig. 5, the first three subjects whose number of publications increased proportionally over time were respectively "Achievement and attitute"

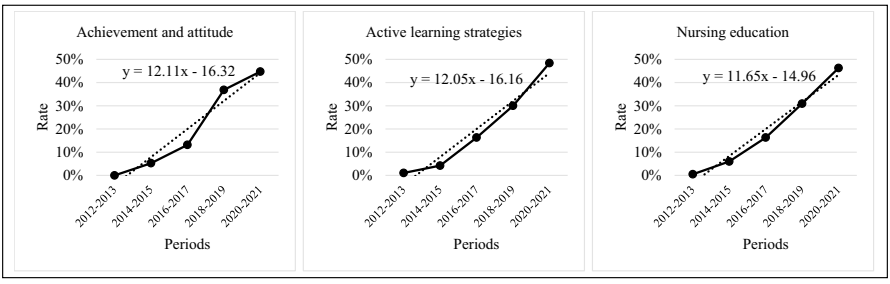



**Fig. 5** Volume ratio graphs of the top three topics with the highest percentage increase in the number of publications in periods

(AccPP = 12.11), "Active learning strategies" (AccPP = 12.05) and "Nursing education" (AccPP = 11.65). When Fig. 5; Table 6 are interpreted together, it can be seen that the top three topics with the most volume are "Performance and perception", "Nursing education" and "Effectiveness and motivation", while the top three topics with the fastest increase in percentage over time are "Achievement and attitute", "Active learning strategies" and "Nursing education". In other words, the top three topics with the highest slope, the ratio of the publications on that topic within itself is increasing as time goes by. In Fig. 6, the percentige slope (AccPP) values of all topics in the periods are given in order.

As can be seen in Fig. 6, the publication rates of all topics in periods are gradually increasing. However, the top three topics that accelerated the most within themselves - although the slope values are close to each other - are "Achievement and attitute", "Active learning strategies" and "Nursing education", respectively, and they are followed by "Programming learning". The last three topics with the slowest rate of increase are "Engineering education", "Professional skills" and "Information literacy", respectively.

In addition to the percentages of the topics over time within themselves, the percentages compared to other topics in each period were also obtained from the data in Table 6. Considering the number of publications of the relevant topic in each period, the percentage rate was calculated compared to other topics. A slope value (AccPTP = Percent acceleration relative to other topics in periods) was determined again with these percentages. With the support of these data, the percentage weight of each topic was calculated compared to other topics in the relevant period. While this process is being done, column-based operations are performed on Table 6. For example, in the first period, a total of 34 publications were made, 8 of which (23.53%) were on "Performance and perception". The number of publications of this topic in other

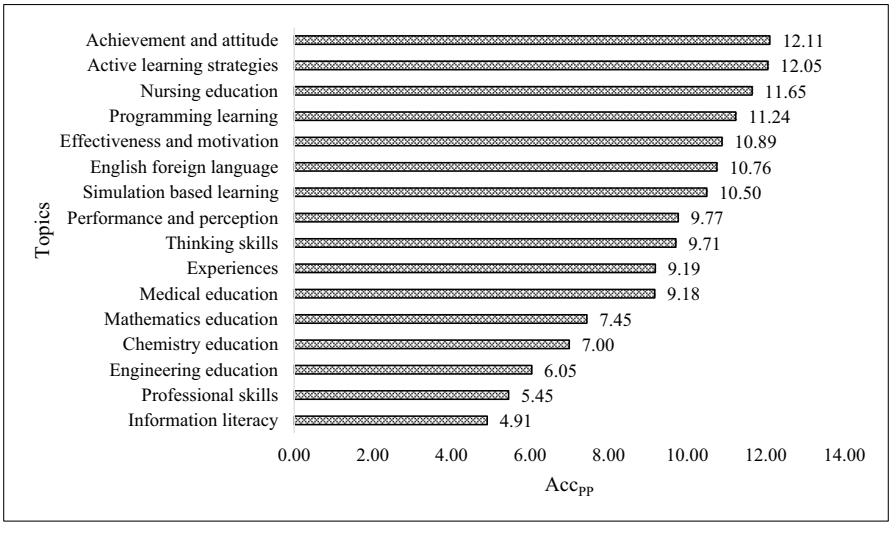



**Fig. 6** Slope values of all topics' publication rates in periods

periods and the number of publications in that period are in pairs (80;250), (175;561), (236;877) and (340;1237), respectively. Therefore, the percentage weight of the "Performance and perception" topic in each period compared to the other topics was calculated 23.53%; 32.00%; 31.19%; 26.91%; 27.49% respectively. In summary, while the percentage weight of this topic was 23.53 (23.53% of all publications on this topic) in the first period, it was 27.49 in the last period. This calculation was made for all topics and the percentage rate of each topic in the relevant period was calculated compared to other topics. Based on these ratios, an acceleration value (AccPTP) was calculated for each topic. In Fig. 7a and b, the ratio and slope graphs of the top three topics, which increase and decrease their weight over time, are given respectively.

As can be seen in Fig. 7, the top three topics that increase their weight in percentage among other topics over time are respectively "Nursing education" (AccPTP = 2.41), "Programming learning" (AccPTP = 0.71) and "Active learning strategies" (AccPTP = 0.64). However, the top three topics, whose percentage weight decreased over time compared to other topics, were "Engineering education" (AccPTP = -0.65), "Information literacy" (AccPTP = -1.28) and "Thinking skills" (AccPTP= -1.57). Considering the slope values of all topics, the evaluation of the weights in the periods is given in Fig. 8.

As can be seen in Fig. 8, among all the studied topics while the percentage of seven topics increased over time, the weight of nine topics gradually decreased. Nursing education, which is the topic with the most increased weight among other topics, is also in the second rank among the most voluminous topics. The most voluminous topic, "Performance and perception", was the second to last topic with increasing weight compared to other topics.

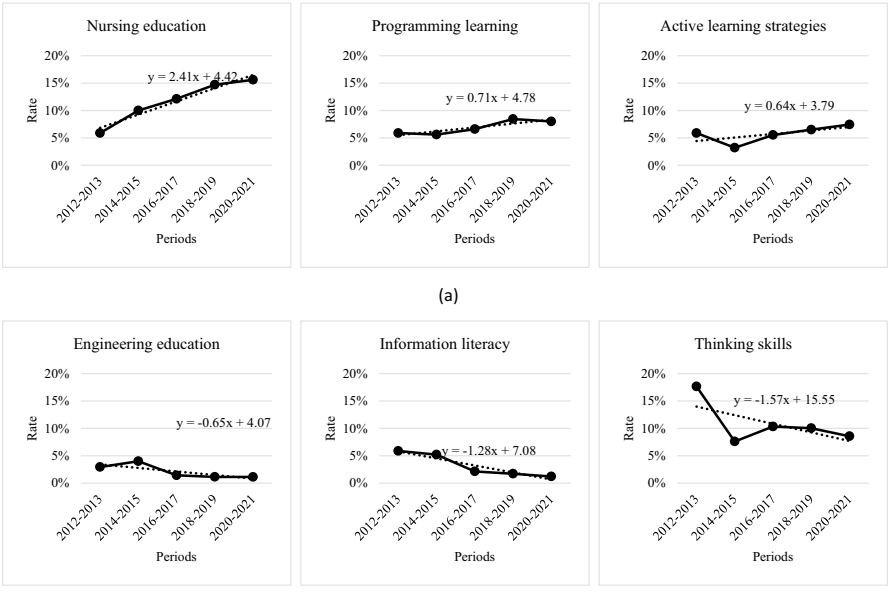



**Fig. 7** The top three topics that increased (**a**) and decreased (**b**) the percentage rate compared to other topics in periods

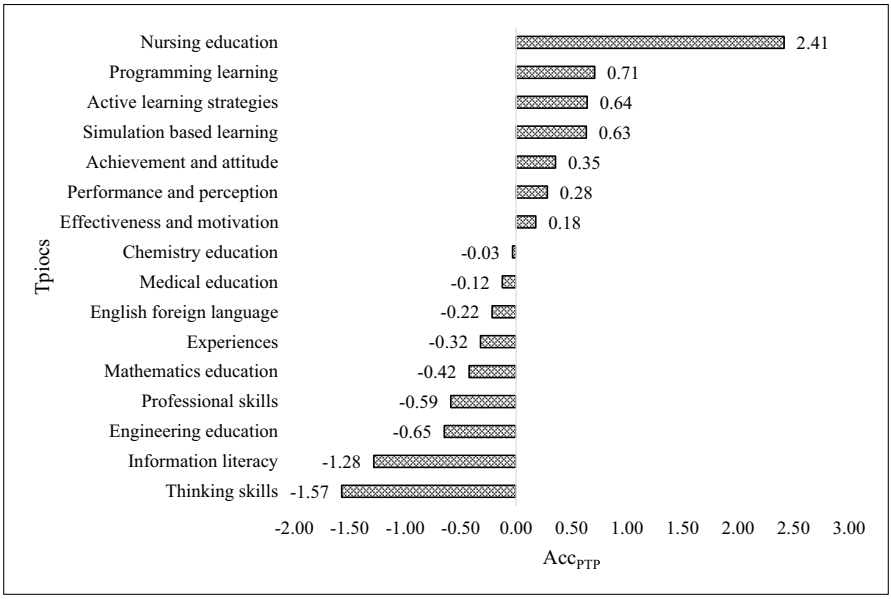



**Fig. 8** Change in weights of all topics over time compared to other topics

Finally, the prominence time of the prominent topics among the other topics were examined on the periods. In this way, the periods in which the first seven topics with positive momentum value became prominent were described. For this reason, the percentages in each period were listed among these topics and the first three were taken. "Performance and perception", "Effectiveness and motivation" and "Thinking skills" topics constitute the first three ranks in the first period. The topic "Thinking skills" is not shown in the schedule as it has a decreasing weight. Starting from the first period, this process was iteratively examined in all periods. Accordingly, the chart shown in Fig. 9 was created.

As can be seen in Fig. 9, the prominence times of seven topics, whose weight is gradually increasing compared to other topics, differ from each other. As a matter of fact, the first two topics that have continued since 2012 till our day were determined as "Performance and perception" and "Effectiveness and motivation". Since 2014, "Nursing education", "Programming learning" and "Simulation based learning" topics have started to become prominent. While the topic of "Active learning strategies" gained momentum since 2016, the topic of "Achievement and attitute" has become prominent since 2018.

## 4 Discussion and conclusions

In this section, the results obtained from the study are discussed in accordance with the research questions and a future perspective is presented in the light of these. The chapter is organized under two headings. The first title addresses the first three research questions; the second title was created for the 4th and 5th research questions.

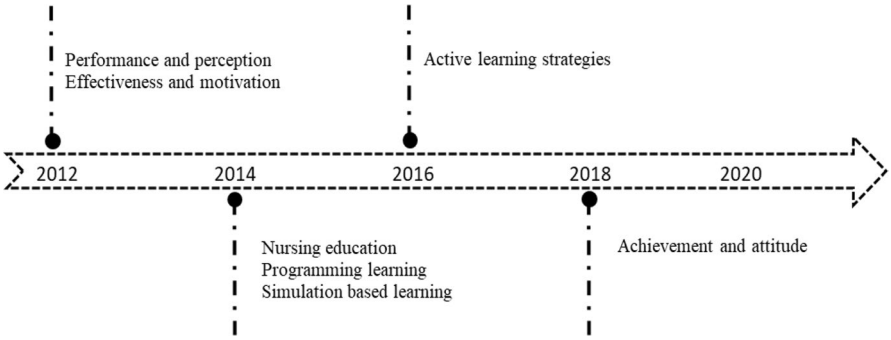



**Fig. 9** Timeline of prominence of prominent topics compared to other topics

### 4.1 Reflections from the descriptive analysis

In order to answer the first three research questions (RQ1, RQ2 and RQ3), the total number of articles by years, the prominent journals, authors and subject areas in the articles and the publication trend in the field of FC in the context of publication by institution and country were examined. The results of the study showed that (in the context of RQ1), the number of articles in 2021 reached 634 in the field where there were 5 articles in 2012. In this context, Parslow (2012) successfully predicted the threshold of the quantum leap of flipped madness in the second decade of the millennium in his study. In addition, the "flipped classroom" in the academic field was first discussed in a Horizon Report in 2012 and was introduced as a promising model that could open the door to new approaches in education (Johnson et al., 2012). In this context, the results of the study confirm these. In terms of the year of initiation of the studies in the field of FC and the distribution of publications by years it is possible to say that the FC approach will attract more and more attention in the following years by an increasing number of practitioners, researchers and scientists. This prediction is based on the rapid increase in technology-based education, which is seen as a savior especially in difficult times when face-to-face physical meetings and education cannot be held or applied. The best example of this is the current COVID-19 pandemic, which is promoting and promoting emergency distance learning globally (Kushairi & Ahmi, 2021). It is known that there is a general increase in FC-related publications during the Covid-19 period (Elkhatat & Al-Muhtaseb, 2021; Haqiyah et al., 2021; Pozo-Sánchez et al., 2021).

In terms of the prominent author, journal and subject areas in the articles published in the field of FC (in the context of RQ2) it is seen that the author with the most publications in this field is Hwang, G.J. (n=20), journal with the highest number of publication is Primus (n=45), and the most prominent subject area is Social Sciences (n=2128). Hwang, G.J. (n=20) is followed by Hew, K.F. with 18 publications and Lo, C.K. with 16 publications. When the journals in which the articles are published are examined, it is seen that journals with the highest number of publications are journals in different fields of educational technologies and sciences. In addition, it was seen that the journals in the field of health sciences and chemistry education were among the top ten journals. Although the number of articles published in the journals is different, it can be said that most of the

journals in the studies in the literature (Julia et al., 2020; Kushairi & Ahmi, 2021) are in the top ten journals in our study. In addition, the fact that medical and chemical education journals have become prominent in this study, as in the literature (Kushairi & Ahmi, 2021; Yang et al., 2017) can be related to the state of being interdisciplinary, which will become more meaningful when the subject area distribution is examined. Indeed, when the top ten subject areas were examined, it was seen that the first area was "Social Sciences" (n=2128), which also includes educational sciences. The fact that the field of educational sciences is under social sciences has highlighted this field (Kushairi & Ahmi, 2021). It was observed that this area was followed by the "Computer Science" (n=555) and "Medicine" (n=407) areas, respectively. Apart from these, there are different disciplines such as "Engineering", "Nursing", "Psychology" in the top ten. Although the ranking in the studies in the literature changes, the distribution of the subject area obtained in the study is very close to the study of Kushairi & Ahmi (2021). Indeed, the first four subject areas are the same, and the subject areas in 3rd and 4th rows have changed places. the "Engineering" and "Medicine" fields, which shared the 3rd and 4th places in the other study, changed palces with each other in our study. The subject areas of the publications in this field are generally similar, which supports the emphasis that the field has the opportunity to be applied on an interdisciplinary platform (Julia et al., 2020; Kushairi & Ahmi, 2021; Yang et al., 2017).

In terms of the affiliation and country origins of the articles published in the field of FC, (in the context of RQ3) the top three institutions with the most publications were Universidad de Granada (n=38; origin:Spain); The University of Hong Kong n=35; origin: Hong Kong) and National Taiwan University of Science and Technology (n=27; origin: Taiwan). When the origins of the articles were examined, it was seen that the most publications were from the United States (n=870; f=29.40%). It is followed by China (n=251; f=8.48%) and Spain (n=233; f=7.87%), respectively. Almost one-third of the articles originated in the United States. Although the results are in parallel with the prominent institutions and countries in the studies in the literature (the first two countries are in the same rank) ) (Çakır et al., 2020; Kushairi & Ahmi, 2021; Yang et al., 2017), in our study it has been observed that publications originating from countries such as "Spain", "United Kingdom" have increased. Indeed, unlike the current studies, the institution with the highest number of publication (Universidad de Granada) originated in Spain. While Yang et al., (2017) and Çakır et al., (2020) state that the institutions and countries in the top ten are mostly of western origin, the results of our study are parallel with the results of Kushairi & Ahmi (2021) and showed that FC applications tends to increase in developing Asian countries especially such as Taiwanese, Turkey, Malesia and India. This situation can be interpreted as an indicator of the importance that developing countries attach to educational technologies (Kushairi & Ahmi, 2021).

### 4.2 Reflections from the topic modeling analysis

The results of the topic modeling analysis (in the context of RQ4) showed that the articles in the field of FC were grouped under 16 main topics. Among these topics, the three most voluminous – having the highest number of publication/the most studied – are respectively "Performance and perception" (n=839; f=28.35%), Nursing education (n=417;

f=14.09%) and Effectiveness and motivation (n=409; f=13.69%). The number of publications on these three topics constitutes more than half of the total number of publications (56.13%). "Programming learning", "Active learning strategies" and "English foreign language" follow these topics in terms of volume. The least voluminous topics are respectively "Experiences", "Professional skills" and "Chemistry education". FC has evolved into useful learning at his own pace for all types of students or mastery learning paradigm known since the age of constructivist theory (Kushairi & Ahmi, 2021). From this perspective, the FC approach suggests the student-centered strategy which has been promoted by leading scholars for along time. In this regard, it is not surprising that the effects of FC-based learning environments on students' learning performance, perceptions, motivations and the effectiveness of these environments are among the most studied topics. It is possible to mention many studies on these topics in the literature (Blair et al., 2016; Thai et al., 2017; Touchton, 2015). In addition to performance and perception, topics such as "Achievement and attitude", "Experiences", "Professional skills" have emerged as FC-based learning environments create an active learning environment and therefore the effects of these environments on learning experiences are examined from different aspects withing these topics. In this regard, it can be accepted as an indication that the FC approach is frequently applied and evaluated from different dimensions.

When the topics obtained from the topic modeling analysis are examined, it is seen that topics such as field teaching also draws attention. As a matter of fact, "Nursing education" (the second highest voluminous topic), "Programming learning", "English foreign language", "Mathematics education", "Medical education", "Engineering education" and "Chemistry education" are the topics emerged in this direction. The increasing complexity of the nursing and healthcare environments in recent years (Barbour & Schuessler, 2019; Njie-Carr et al., 2017) has brought along significant changes and transformations in the medical field, especially in nursing education. With this change, innovative learning strategies have been implemented and FC has been widely used for this. Many studies in the literature have emphasized that the FC approach effectively supports learning in the field of nursing and health and increases the quality of learning (Özbay & Çınar, 2021; Youhasan et al., 2021).

The fact that the FC approach, which forces students to learn basic medical information and create skills and abilities beyond remembering information, is regarded as a promising modality in medical education (Barbour & Schuessler, 2019) may have highlighted the studies in this field. "Programming learning" is among the most voluminous area-based topics. Difficulties in programming learning (Ruiz de Miras et al., 2022) have triggered student-centered learning approaches and many studies have been implemented in this direction (Ruiz de Miras et al., 2022; Taşpolat et al., 2021). The belief that the positive results of the FC approach help to overcome the difficulties in programming learning may have led to intense studies in this area. In addition, the positive aspects of the FC approach and its frequent use in the field of education have triggered the frequent implementation of studies in different fields.

Finally, in order to determine the trends in FC studies (in the context of RQ5), the acceleration of the topics over time and according to other topics was examined. The first three topics, whose intensity of study increased the most over time, are "Achievement and attitute", "Active learning strategies" and "Nursing education", respectively.

The last three topics with the slowest rate of increase are "Engineering education", "Professional skills" and "Information literacy", respectively. Nursing education is one of the three most voluminous topics in terms of volume. In other words, "Nursing education" is common among the top three most voluminous topics and the top three topics that increase the intensity of study the most over time. On the other hand, in terms of the trends of the topics over time, the first three topics that increased their weight in percentage among other topics over time are "Nursing education", "Programming learning" and "Active learning strategies", respectively. The topics of "Nursing education" and "Active learning strategies" are also among the topics whose intensity of study increases over time. The fact that nursing education is an important criterion for the quality of the health system (Kim et al., 2019) has encouraged researchers in this field to implement innovative studies (Youhasan et al., 2021). The importance given to "nursing education" may have triggered this topic to be one of the most accelerated topics. Similarly, the difficulties and troubles experienced in programming learning (Özyurt & Özyurt, 2018; Ruiz de Miras et al., 2022) may have highlighted the implementations in this field. Enabling student-centered learning environments in FC studies flourishes by the student's taking responsibility for learning. FC constructivism is an important approach that encourages active learning (Shapran & Shapran, 2019; Stöhr & Adawi, 2018). In this context, as aresult of the increase in FC studies in recent years the topic of "Active learning strategies" may have become prominent. The first three topics, whose percentage weight decreased over time compared to other topics, were obtained as "Engineering education", "Information literacy" and "Thinking skills".

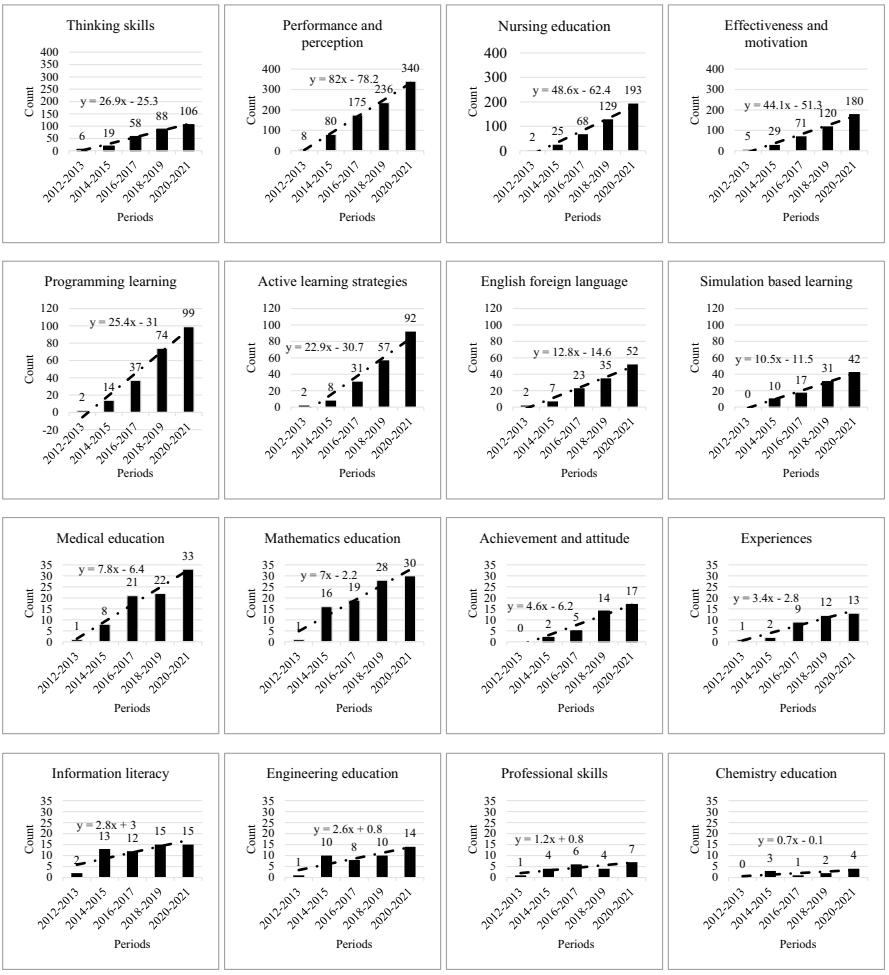
There are a total of 7 topics, which increased in intensity over time (showing positive momentum) compared to other topics. According to the timeline divided into two-year periods, it has been observed that the topics of "Performance and perception" and "Effectiveness and motivation" have been studied since 2012. This situation can be interpreted as the evaluation of the effects of the first studies in the field of FC on learning outcomes. Since 2014, "Nursing education", "Programming learning" and "Simulation based learning" topics have started to become prominent. While the topic of "Active learning strategies" gained momentum since 2016, the topic of "Achievement and attitute" has become prominent since 2018.

## 5 Limitations and future works

With this study, it is aimed to examine the research interests and trends of the articles in the field of FC from the past to the present (until the end of 2021). The most innovative aspect of the study is that it is the most comprehensive study based on topic modeling-based semantic analysis. However, it is also possible to mention some limitations of the study. First, the dataset is limited to peer-reviewed articles in the Scopus database. Databases other than scopus and all document types can be included in the corpus by scanning more comprehensive databases. In addition, the widely used - accepted in the literature - LDA algorithm was used for the topic modeling analysis. In future studies, comparative studies can be carried out with different algorithms. Another important issue is the necessity of repeating such studies throughout FC or its sub-topics (especially the most

voluminous or the fastest accelerating issues) in certain time periods. In this way, it can be seen how the situation in the current study continues in the future and how the increasing/decreasing trends in the topics have changed. In this way, trend changes in the field will be followed in a healthy way.

# Appendix 1. Volume and slope graphs of each topic in two-year periods



**Data availability** The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

## Declarations

**Ethical approval** Not required for this study.

**Informed consent** None.

**Conflict of interest** None.

## References


Abeysekera, L., & Dawson, P. (2015). Motivation and cognitive load in the flipped classroom: definition, rationale and a call for research. *Higher Education Research and Development, 34*(1), 1–14. https://doi.org/10.1080/07294360.2014.934336

Adams Becker, S., Cummins, M., Davis, A., Freeman, A., Giesinger, H., & Ananthanarayanan, V. (2017). *NMC Horizon Report: 2017 Higher Education Edition*. Austin: The New Media Consortium.

Adarkwah, M. A. (2021). I'm not against online teaching, but what about us?: ICT in Ghana post Covid-19. *Education and Information Technologies, 26*(2), 1665–1685. https://doi.org/10.1007/s10639-020-10331-z

Aggarwal, C. C., & Zhai, C. X. (2013). Mining text data. In *Mining Text Data* (Vol. 9781461432). https://doi.org/10.1007/978-1-4614-3223-4

Akçayır, G., & Akçayır, M. (2018). The flipped classroom: A review of its advantages and challenges. *Computers and Education, 126*, 334–345. https://doi.org/10.1016/j.compedu.2018.07.021

Al-Shabibi, T. S., & Al-Ayasra, M. A. K. (2019). Effectiveness of the flipped classroom strategy in learning outcomes (bibliometric study). *International Journal of Learning Teaching and Educational Research, 18*(3), 96–127. https://doi.org/10.26803/ijlter.18.3.6

Al Mamun, M. A., Azad, M. A. K., Al Mamun, M. A., & Boyle, M. (2021). Review of flipped learning in engineering education: Scientific mapping and research horizon. *Education and Information Technologies*. https://doi.org/10.1007/s10639-021-10630-z

Alvarez, K. S. (2021). Using virtual simulations in online laboratory instruction and active learning exercises as a response to instructional challenges during COVID-19. *Journal of Microbiology & Biology Education*, *22*(1). https://doi.org/10.1128/jmbe.v22i1.2503

Baepler, P., Walker, J. D., & Driessen, M. (2014). It's not about seat time: Blending, flipping, and efficiency in active learning classrooms. *Computers and Education, 78*, 227–236. https://doi.org/10.1016/j.compedu.2014.06.006

Barbour, C., & Schuessler, J. B. (2019). A preliminary framework to guide implementation of The Flipped Classroom Method in nursing education. In *Nurse Education in Practice* (Vol. 34, pp. 36–42). https://doi.org/10.1016/j.nepr.2018.11.001

Bergmann, J., & Sams, A. (2012). Before you flip, consider this. *Phi Delta Kappan, 94*(2), 25. https://doi.org/10.1177/003172171209400206

Blair, E., Maharaj, C., & Primus, S. (2016). Performance and perception in the flipped classroom. *Education and Information Technologies, 21*(6), 1465–1482. https://doi.org/10.1007/s10639-015-9393-5

Blei, D. M., & Lafferty, J. D. (2007). Correction: A correlated topic model of Science. *The Annals of Applied Statistics*, *1*(2). https://doi.org/10.1214/07-aoas136

Blei, D. M., Ng, A. Y., & Jordan, M. I. (2003). Latent Dirichlet allocation. *Journal of Machine Learning Research*. https://doi.org/10.1016/b978-0-12-411519-4.00006-9

Bolat, Y. (2016). The flipped classes and educatıon ınformatıon network (EIN) < p > Ters yüz edilmiş sınıflar ve eğitim bilişim ağı (EBA). *Journal of Human Sciences, 13*(2), 3373. https://doi.org/10.14687/jhs.v13i2.3952

Bristol, T. J. (2014). Flipping the Classroom 1. *Teaching and Learning in Nursing, 9*(1), 43–46.

Butt, A. (2014). Student views on the use of a flipped classroom approach: Evidence from Australia. *Business Education & Accreditation, 6*(1), 33–43.

Çakır, R., Sayın, V., & Bektaş, S. (2020). Bibliometric analysis of studies conducted between 2015–2019 on the flipped classroom model. *International Journal of Research in Education and Science, 7*(1), 163. https://doi.org/10.46328/ijres.1126

Chen, Y., Wang, Y., Kinshuk, & Chen, N. S. (2014). Is FLIP enough? or should we use the FLIPPED model instead? *Computers and Education, 79*, 16–27. https://doi.org/10.1016/j.compedu.2014.07.004

D'Souza, M. J., & Rodrigues, P. (2015). Investigating the effectiveness of the flipped classroom in an introductory programming course. *New Educational Review, 40*(2), 129–139. https://doi.org/10.15804/tner.2015.40.2.11

Davies, R. S., Dean, D. L., & Ball, N. (2013). Flipping the classroom and instructional technology integration in a college-level information systems spreadsheet course. *Educational Technology Research and Development, 61*(4), 563–580. https://doi.org/10.1007/s11423-013-9305-6

De Mauro, A., Greco, M., Grimaldi, M., & Ritala, P. (2018). Human resources for Big Data professions: A systematic classification of job roles and required skill sets. *Information Processing and Management, 54*(5), 807–817. https://doi.org/10.1016/j.ipm.2017.05.004

Elkhatat, A. M., & Al-Muhtaseb, S. A. (2021). Hybrid online-flipped learning pedagogy for teaching laboratory courses to mitigate the pandemic COVID-19 confinement and enable effective sustainable delivery: investigation of attaining course learning outcome. *SN Social Sciences*, *1*(5). https://doi.org/10.1007/s43545-021-00117-6

Filiz, O., & Kurt, A. A. (2015). Flipped learning: Misunderstandings and the truth. *Eğitim Bilimleri Araştırmaları Dergisi, 5*(1), 215–229. https://doi.org/10.12973/jesr.2015.51.13

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences of the United States of America, 111*(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111

Gaughan, J. E. (2014). The flipped classroom in world history. *History Teacher, 47*(2), 221–244. http://search.ebscohost.com/login.aspx?direct=true&db=tfh&AN=94677349&lang=es&site=ehost-live. Accessed 23 May 2022.

Gurcan, F., & Cagiltay, N. E. (2019). Big data software engineering: analysis of knowledge domains and skill sets using LDA-Based Topic Modeling. *IEEE Access: Practical Innovations, Open Solutions, 7*, 82541–82552. https://doi.org/10.1109/ACCESS.2019.2924075

Gurcan, F., Ozyurt, O., & Cagiltay, N. E. (2021). Investigation of emerging trends in the e-learning field using latent dirichlet allocation. *International Review of Research in Open and Distance Learning, 22*(2), 1–18. https://doi.org/10.19173/irrodl.v22i2.5358

Haqiyah, A., Lubis, J., Tangkudung, J., Muhamad, M., Kusumawati, M., Lanos, M. E., & Riyadi, D. N. (2021). Flipped classroom model integrated with the online learning platform and video biomechanic analysis to enhance learning outcome of Pencak silat during the Covid-19 pandemic. *Turkish Journal of Computer and Mathematics Education, 12*(11), 1489–1494.

Hindle, A., Ernst, N. A., Godfrey, M. W., & Mylopoulos, J. (2013). Automated topic naming. *Empirical Software Engineering, 18*(6), 1125–1155.

Hu, Y., Boyd-Graber, J., Satinoff, B., & Smith, A. (2014). Interactive topic modeling. *Machine Learning, 95*(3), 423–469. https://doi.org/10.1007/s10994-013-5413-0

Hwang, G. J., Lai, C. L., & Wang, S. Y. (2015). Seamless flipped learning: a mobile technology-enhanced flipped classroom with effective learning strategies. *Journal of Computers in Education, 2*(4), 449–473. https://doi.org/10.1007/s40692-015-0043-0

Jacot, M. T., Noren, J., & Berge, Z. L. (2014). The flipped classroom in training and development: fad or the future? *Performance Improvement, 53*(9), 23–28. https://doi.org/10.1002/pfi.21438

Johnson, L., Adams, S., & Cummins, M. (2012). *NMC Horizon Report: 2012 K–12 Edition*. New Media Consortium. https://files.eric.ed.gov/fulltext/ED532397.pdf. Accessed 14 May 2022.

Julia, J., Dolifah, D., Afrianti, N., Isrokatun, I., Soomro, K. A., Erhamwilda, E., Supriyadi, T., & Ningrum, D. (2020). Flipped classroom educational model (2010–2019): A bibliometric study. *European Journal of Educational Research, 9*(4), 1377–1392. https://doi.org/10.12973/eu-jer.9.4.1377

Kaisara, G., & Bwalya, K. J. (2020). Investigating the E-Learning Challenges Faced by Students during Covid-19 in Namibia. *International Journal of Higher Education, 10*(1), 308. https://doi.org/10.5430/ijhe.v10n1p308

Kang, J., Kim, S., & Roh, S. (2019). A topic modeling analysis for online news article comments on nurses' workplace bullying. *Journal of Korean Academy of Nursing, 49*(6), 736–747. https://doi.org/10.4040/jkan.2019.49.6.736

Karabatak, S., & Polat, H. (2020). The effects of the flipped classroom model designed according to the ARCS motivation strategies on the students' motivation and academic achievement levels. *Education and Information Technologies, 25*(3), 1475–1495. https://doi.org/10.1007/s10639-019-09985-1

Kardaş, F., & Yeşilyaprak, B. (2015). A current approach to education: flipped learning model. *Ankara Üniversitesi Eğitim Bilimleri Fakültesi Dergisi, 48*(2), 103–122.

Kim, Y. M., Yoon, Y. S., Hong, H. C., & Min, A. (2019). Effects of a patient safety course using a flipped classroom approach among undergraduate nursing students: A quasi-experimental study. *Nurse Education Today*. https://doi.org/10.1016/j.nedt.2019.05.033

Kocabatmaz, H. (2016). The ideas of pre-service teachers regarding the "FilipPed Classroom Model". *Journal of Research in Education and Teaching, 5*(4), 14–24.

Kong, S. C. (2014). Developing information literacy and critical thinking skills through domain knowledge learning in digital classrooms: An experience of practicing flipped classroom strategy. *Computers and Education, 78*, 160–173. https://doi.org/10.1016/j.compedu.2014.05.009

Kushairi, N., & Ahmi, A. (2021). Flipped classroom in the second decade of the Millenia: a Bibliometrics analysis with Lotka's law. *Education and Information Technologies, 26*(4), 4401–4431. https://doi.org/10.1007/s10639-021-10457-8

Latorre-Cosculluela, C., Suárez, C., Quiroga, S., Sobradiel-Sierra, N., Lozano-Blasco, R., & Rodríguez-Martínez, A. (2021). Flipped Classroom model before and during COVID-19: using technology to develop 21st century skills. *Interactive Technology and Smart Education*. https://doi.org/10.1108/ITSE-08-2020-0137

Lee, Y. Y., & Martin, K. I. (2020). The flipped classroom in ESL teacher education: An example from CALL. *Education and Information Technologies, 25*(4), 2605–2633. https://doi.org/10.1007/s10639-019-10082-6

Li, C., Feng, S., Zeng, Q., Ni, W., Zhao, H., & Duan, H. (2019). Mining dynamics of research topics based on the combined LDA and WordNet. *IEEE Access: Practical Innovations, Open Solutions, 7*, 6386–6399. https://doi.org/10.1109/ACCESS.2018.2887314

Mimno, D., Wallach, H. M., Talley, E., Leenders, M., & McCallum, A. (2011). Optimizing semantic coherence in topic models. *EMNLP 2011 - Conference on Empirical Methods in Natural Language Processing, Proceedings of the Conference*, 262–272

Mok, H. N. (2014). Teaching tip: The flipped classroom. *Journal of Information Systems Education, 25*(1), 7–11.

Musib, M. K. (2014). Student perceptions of the impact of using the flipped classroom approach for an introductory-level multidisciplinary module. *Centre for Development of Teaching Learning (CDTL Brief), 17*(July), 15–20.

Nerantzi, C. (2020). The use of peer instruction and flipped learning to support flexible blended learning during and after the COVID-19 pandemic. *International Journal of Management and Applied Research, 7*(2), 184–195. https://doi.org/10.18646/2056.72.20-013

Ng, W. (2015). Technology integration and the flipped classroom. *New digital technology in education.* Cham: Springer. https://doi.org/10.1007/978-3-319-05822-1_7

Njie-Carr, V. P. S., Ludeman, E., Lee, M. C., Dordunoo, D., Trocky, N. M., & Jenkins, L. S. (2017). An integrative review of flipped classroom teaching models in nursing education. In *Journal of Professional Nursing* (Vol. 33, Issue 2, pp. 133–144). https://doi.org/10.1016/j.profnurs.2016.07.001

Özbay, Ö, & Çınar, S. (2021). Effectiveness of flipped classroom teaching models in nursing education: A systematic review. *Nurse Education Today, 102*, 104922. https://doi.org/10.1016/j.nedt.2021.104922

Özyurt, H., & Özyurt, Ö. (2018). Analyzing the effects of adapted flipped classroom approach on computer programming success, attitude toward programming, and programming self-efficacy. *Computer Applications in Engineering Education, 26*(6), 2036–2046. https://doi.org/10.1002/cae.21973

Özyurt, Ö, & Özyurt, H. (2017). Programlama ve algoritma öğretiminin ters yüz sinif yaklasimi ile zenginlestirilmesine yönelik nitel bir çalisma. *Pegem Egitim ve Ogretim Dergisi, 7*(2), 189–210. https://doi.org/10.14527/pegegog.2017.007

Özyurt, Ö., & Ayaz, A. (2022). Twenty-five years of education and information technologies: Insights from a topic modeling based bibliometric analysis. *Education and Information Technologies*, 1–30. https://doi.org/10.1007/s10639-022-11071-y

Parslow, G. R. (2012). Commentary: The Khan academy and the day-night flipped classroom. In *Biochemistry and Molecular Biology Education* (Vol. 40, Issue 5, pp. 337–338). https://doi.org/10.1002/bmb.20642

Paudel, P. (2020). Online education: benefits, challenges and strategies during and after COVID-19 in higher education. *International Journal on Studies in Education, 3*(2), 70–85. https://doi.org/10.46328/ijonse.32

Pozo-Sánchez, S., López-Belmonte, J., Fuentes-Cabrera, A., & López-Núñez, J. A. (2021). Twitch as a techno-pedagogical resource to complement the flipped learning methodology in a time of academic uncertainty. *Sustainability (Switzerland)*, *13*(9). https://doi.org/10.3390/su13094901

Pyatt, K., & Sims, R. (2012). Virtual and physical experimentation in inquiry-based science labs: attitudes, performance and access. *Journal of Science Education and Technology, 21*(1), 133–147. https://doi.org/10.1007/s10956-011-9291-6

Rizun, M., & Strzelecki, A. (2020). Students' acceptance of the covid-19 impact on shifting higher education to distance learning in Poland. *International Journal of Environmental Research and Public Health, 17*(18), 1–19. https://doi.org/10.3390/ijerph17186468

Ruiz de Miras, J., Balsas-Almagro, J. R., & García-Fernández, ÁL. (2022). Using flipped classroom and peer instruction methodologies to improve introductory computer programming courses. *Computer Applications in Engineering Education, 30*(1), 133–145. https://doi.org/10.1002/cae.22447

Scopus. (2022a). *Content Coverage*. https://www.elsevier.com/solutions/scopus/how-scopus-works/content?dgcid=RN_AGCM_Sourced_300005030. Accessed 2 Jun 2022.

Scopus. (2022b). https://blog.scopus.com//about. Accessed 2 Jun 2022.

Sever, G. (2014). The application of flipped learning model on individual violin lessons. *Journal of Qualitative Research in Education, 2*(2), 27–41. https://doi.org/10.14689/issn.2148-2624.1.3s2m

Shapran, O., & Shapran, O. (2019). Features of using «Flipped Learning» technology in higher education institutions. *Professional Education: Methodology Theory and Technologies, 9*, 226–243. https://doi.org/10.31470/2415-3729-2019-9-226-243

Singhal, R., Kumar, A., Singh, H., Fuller, S., & Gill, S. S. (2020). Digital device-based active learning approach using virtual community classroom during the COVID-19 pandemic. *Computer Applications in Engineering Education*. https://doi.org/10.1002/cae.22355

Sointu, E. T., Valtonen, T., Hirsto, L., Kankaanpää, J., Saarelainen, M., Mäkitalo, K., Smits, A., & Manninen, J. (2019). Teachers as users of ICT from the student perspective in higher education flipped classroom classes. *Seminar net, 15*(1), 1–15. https://doi.org/10.7577/seminar.3402

Stöhr, C., & Adawi, T. (2018). Flipped classroom research: From "black box" to "white box" evaluation. In *Education Sciences* (Vol.8, Issue 1). https://doi.org/10.3390/educsci8010022

Taşpolat, A., Özdamli, F., & Soykan, E. (2021). Programming language training with the flipped classroom model. *SAGE Open*, *11*(2). https://doi.org/10.1177/21582440211021403

Thai, N. T. T., De Wever, B., & Valcke, M. (2017). The impact of a flipped classroom design on learning performance in higher education: Looking for the best "blend" of lectures and guiding questions with feedback. *Computers and Education, 107*, 113–126. https://doi.org/10.1016/j.compedu.2017.01.003

Touchton, M. (2015). Flipping the classroom and student performance in advanced statistics: evidence from a quasi-experiment. *Journal of Political Science Education, 11*(1), 28–44. https://doi.org/10.1080/15512169.2014.985105

Turan, Z., & Akdag-Cimen, B. (2020). Flipped classroom in English language teaching: a systematic review. *Computer Assisted Language Learning*. https://doi.org/10.1080/09588221.2019.1584117

Turan, Z., & Goktas, Y. (2015). A new approach in higher education: the students' views on flipped classroom method. *Journal of Higher Education and Science, 5*(2), 156. https://doi.org/10.5961/jhes.2015.118

Vivek, C. M., & Ramkumar, P. (2021). Evaluation of course outcome attainment of engineering course with traditional, blended and flipped classroom approaches. *Education and Information Technologies, 26*(2), 2225–2231. https://doi.org/10.1007/s10639-020-10353-7

Yang, L., Sun, T., & Liu, Y. (2017). A bibliometric investigation of flipped classroom research during 2000–2015. *International Journal of Emerging Technologies in Learning, 12*(6), 178–186. https://doi.org/10.3991/ijet.v12i06.7095

Yang, X. L., Lo, D., Xia, X., Wan, Z. Y., & Sun, J. L. (2016). What security questions do developers ask? A large-scale study of stack overflow posts. *Journal of Computer Science and Technology, 31*(5), 910–924. https://doi.org/10.1007/s11390-016-1672-0

Yen, T. F., & TF. (2020). The performance of online teaching for flipped classroom based on COVID-19 Aspect. *Asian Journal of Education and Social Studies*, 57–64. https://doi.org/10.9734/ajess/2020/v8i330229

Youhasan, P., Chen, Y., Lyndon, M., & Henning, M. A. (2021). Exploring the pedagogical design features of the flipped classroom in undergraduate nursing education: a systematic review. *BMC Nursing*, *20*(1). https://doi.org/10.1186/s12912-021-00555-w

Yung, R., & Khoo-Lattimore, C. (2019). New realities: a systematic literature review on virtual reality and augmented reality in tourism research. In *Current Issues in Tourism* (Vol. 22, Issue 17, pp. 2056–2081). https://doi.org/10.1080/13683500.2017.1417359

Zainuddin, Z., & Halili, S. H. (2016). Flipped classroom research and trends from different fields of study. *International Review of Research in Open and Distance Learning, 17*(3), 313–340. https://doi.org/10.19173/irrodl.v17i3.2274

Zheng, X. L., Kim, H. S., Lai, W. H., & Hwang, G. J. (2020). Cognitive regulations in ICT-supported flipped classroom interactions: An activity theory perspective. *British Journal of Educational Technology, 51*(1), 103–130.

**Publisher's note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Springer Nature or its licensor holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.