SYSTEMATIC REVIEW: FLIPPED CLASSROOMS IN THE PERFORMANCE OF UNDERGRADUATE SCIENCE STUDENTS

REVISIÓN SISTEMÁTICA: FLIPPED CLASSROOM EN EL RENDIMIENTO DE UNIVERSITARIOS DE CIENCIAS

ABSTRACT

The sciences are a complex and especially demanding area of study for undergraduate students, particularly in the earlier years, which are a critical period of adaptation to a new educational stage. The use of new teaching models is encouraged to improve their learning, such as flipped classroom (FC), which pursues more meaningful and effective learning that encourages an active role for students.

The aim of this study is to perform a systematic review to evaluate the effectiveness of the FC model in learning in the field of experimental and health sciences in higher education during the 2014–2021 period, specifically in students' performance, determining the influence of students' motivation and self-regulation during the process. The phases and quality standards for systematic reviews were complied with in the search for and compilation of the articles analysed.

Science students generally view FC as satisfactory. The results show increased motivation and self-regulation and, by extension, a general positive impact on academic performance as benefits. Furthermore, motivation and self-regulation are regarded as key requirements for good performance in an FC environment in the sciences.

However, to achieve good results, FC must be applied in such a way that students are able to reflect on their own learning process.

RESUMEN

El ámbito de las ciencias se caracteriza por ser un estudio complejo especialmente demandante para los estudiantes universitarios, y más en los primeros años, que suponen un periodo crítico de adaptación a la nueva etapa educativa. Para mejorar su aprendizaje se fomenta el uso de nuevos modelos, como el flipped classroom (FC), que persigue un aprendizaje más significativo y eficaz que fomente el papel activo de los estudiantes.

El objetivo de este estudio es realizar una revisión sistemática para evaluar la eficacia del FC en el aprendizaje en el ámbito de las Ciencias Experimentales y de la Salud, en la etapa de educación superior, entre 2014-2021, concretamente en el rendimiento de los

estudiantes, determinando la influencia de la motivación y la autorregulación del alumnado durante el desarrollo del método. Para la búsqueda y recopilación de los artículos analizados se han cumplido con las fases y estándares de calidad de las revisiones sistemáticas.
De modo general, el FC se percibe de un modo satisfactorio por los alumnos del ámbito de ciencias. Los resultados evidencian como beneficios el aumento de la motivación, autorregulación y, por extensión, el impacto positivo generalizado sobre el rendimiento académico. Por otro lado, la motivación y la autorregulación son consideradas requisitos clave para el buen desempeño dentro del entorno del FC en el ámbito de las ciencias.
Sin embargo, para lograr buenos resultados el uso del FC debe ser aplicado de forma que los estudiantes sean capaces de reflexionar sobre su propio proceso de aprendizaje.

KEYWORDS:

Flipped classroom; systematic review; academic performance; motivation; self-regulation.

PALABRAS CLAVE

Clase invertida; revisión sistemática; rendimiento académico; motivación, autorregulación.

INTRODUCTION

In the teaching–learning process in the experimental sciences it is necessary for students to play an active role (Allchin & Zemplén, 2020; Pujol, 2007). They must think for themselves to formulate questions, make predictions, verify through experiments, and draw conclusions (Allchin, 2013) and they must also reflect and be autonomous, through effective learning (Pozo & Monereo, 1999).

This type of active learning is based on a series of theoretical constructs that are linked to one another, such as learning strategies, self-regulation, metacognition, and motivation (García, 2012). Indeed, self-regulated learning is one of the variables that best predicts academic performance (Hernández & Camargo, 2017; Hoyle, 2013; Lennon, 2010), and so has become one of the cornerstones of educational praxis. It is centred on the strengths that students use as a systematic learning method, directing their thoughts,

feelings, and behaviour towards study and making it possible for them to adapt to the different scenarios presented to them (Zimmerman, 2001; 2013). There is a meaningful relationship between the cognitive and the emotional, since when students are connected to the task and are motivated to engage with the concepts being studied, even when these are scientific and complex, they will feel satisfied and be able to assimilate them more effectively, thus giving good results (Hendrie & Bastacini, 2020).

Furthermore, the capacity for self-regulation also has an influence on the effort students make to tackle activities they do not find interesting and to maintain their attention, and so is involved in achieving academic goals (Broc, 2011). In science study programmes, problem-based learning (Han et al., 2015; Savery, 2019) and working on case studies (Creswell, 2017; Noor, 2008) are methodologies used to promote meaningful learning, as well as critical thinking (Yadav et al, 2007). In this process, cooperative work helps students improve their metacognitive skills and with them their capacity to tackle problems (Guillen, 2017).

It is important to consider how new technologies (ICT) are making it possible for new teaching models to appear that encourage an active role for students, including flipped classroom (FC) (Aznar & Romero, 2018). Effective integration of technology with educational processes can facilitate deeper learning (Flores et al., 2016) through contextualisation in the real world, thus contributing to educational improvement in terms of innovation and quality.

FC is a student-centred pedagogical model, which sets out to achieve more meaningful, active, and effective learning by inverting traditional roles in the classroom, as students review the content before the in-person class (Bergmann & Sams, 2012). Delozier & Rhodes (2017) and Long et al. (2016) explained that flipped classroom is the practice whereby learning materials, which are usually taught in class in conventional methods in the form of lectures, are assigned to students to study outside the classroom and class time is used for a variety of other learning activities regarding the assigned learning materials.

So, although there is no single model (Tucker 2012), in FC, it is essential to provide students with access to enriched content (video, audio, and/or documentary) ahead of class, so that the delivery of information moves out of the classroom, with time in class being used to work on more complex learning, through more reflexive, practical, and collaborative tasks and/or activities guided by the teacher (Tourón & Santiago, 2015),

something that demands a higher cognitive and metacognitive level and greater autonomy.

The key points for successful implementation of FC (Delozier & Rhodes, 2017; Hamdan et al, 2013; Rotellar & Cain, 2016) include: 1) having flexible environments (different ways to access and learn content); 2) using class time to work on the previously selected concepts in more depth and create more enriching learning opportunities; 3) ad hoc design of materials with relevant and meaningful content to maximise learning; 4) teachers who have a set of specific competences (Moreno-Guerrero, 2021), to promote students' activity, and to be able to identify and provide guidance on the subject covered and evaluate the learning process. With the aim of boosting the consolidation of concepts and knowledge, it is common practice to combine FC with normal collaborative learning as well as with other types such as problem-based or project-based learning, case studies, debates, and others depending on the subject matter being covered, always bolstered by the use of digital tools.

A range of benefits are associated with implementation of FC, among which are students' positive views of the experience as they report feeling more motivated and active, and their preference for it over traditional teaching methodologies (Gilboy et al., 2015; Long et al., 2016; Salcines-Talledo et al., 2018). It improves their perception that time is being used effectively both inside and outside the classroom, and they especially value the continuous availability of study material, which enables them to control the pace of their learning and react to their learning needs (Flores et al., 2016; Jeong et al., 2016). From the perspective of the teachers, it is apparent that implementing this model favours dynamic lessons and intrinsic motivation, improves understanding of concepts, and that the learning is significant and lasting. It has been shown that students develop skills characteristic of self-regulation and autonomy (Rivero-Guerra, 2018; Zheng & Zhang, 2020; Zheng et al., 2020), they display greater engagement and responsibility towards tasks and participate in collaborative work (Gilboy et al., 2015), and they participate in collaborative work (Strayer, 2012). Another benefit is that it facilitates teaching that is more personalised to the students, taking into account the different paces of learning present in the classroom, although experience of FC suggests that teachers need to devote more effort to the design, sequencing, and progress of content, and that there is a need to consider variety in motivation and prior knowledge (Jovanovic et al., 2017).

Comentado [TP1]: Este fragmento se repite. ¿Sería mejor poner algo como <se muestra participativo en los trabajos de índole colaborativo (Gilboy et al., 2015; Strayer, 2012).>?

Comentado [AUTOR2R1]: Sí puede ponerse así. Era una errata.

These advantages explain why implementation of FC has grown notably, in particular in higher education (Moraros et al., 2015; Sánchez-Cruzado et al., 2019). It is posited that university students understand what they are learning, why they are learning, and what they are learning for, developing their capacity to reason and their critical thinking (Smith et al., 2018), which are so vital in the scientific sphere.

Many studies have highlighted better learning outcomes particularly in the sciences, stressing that FC is especially useful for overcoming difficulties related to interdisciplinary concepts (González-Gómez et al., 2016; Jeong et al., 2016; Newman et al., 2014). Nonetheless, the literature in this field includes various studies in the experimental sciences and health sciences in which the effectiveness of FC was weak or was not clearly demonstrated (Evans et al., 2018; Jensen et al., 2015), especially in the first year of university. Consequently, it is necessary to consider in more depth the relationship between self-regulation and learning outcomes among science students who study in an FC environment.

Some authors observe that many students who enter university are not fully proficient at directing and controlling their own learning, do not yet possess fully developed higher-level thinking skills, and do not command a wide range of self-regulation strategies (Velde et al, 2021; Zheng & Zhang, 2020). This is a critical period where the student must adapt to a new system of education and where some existing shortcomings emerge that could affect their future academic success. The experimental sciences (that perform experiments to explain or find phenomena) and health sciences in particular are characterised by being complex, dynamic, and intensive fields of study, in which interdisciplinary concepts must be applied to analyse and solve practical real-world problems. Therefore, taking into account the different observations about FC, there is a need to establish how it influences the academic performance of university students in the experimental sciences and health sciences, or in other words, to evaluate the efficacy of FC when learning experimental sciences in higher education, determining its relationship with the process of the students own self-regulation and motivation.

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Comentado [AUTOR4R3]: ¿Cuál es la falta de ortografía? Esta traducción la vemos bien.

METHODOLOGY

Review process

In carrying out this research we followed a series of standard stages for systematic reviews (Sánchez-Meca, 2010; Siddaway et al, 2019): setting an explicit and defined

question; completing a broad and systematic search for primary studies; and establishing an explicit and replicable process for extracting and codifying data and appropriate procedures for analysing and interpreting results. The quality standards from the PRISMA declaration for systematic reviews were taken into account (Liberati et al., 2009).

The central question of this work is: how does implementing FC affect the academic performance, motivation, and self-regulation of university students in the experimental sciences and health sciences? To answer this question, we performed a content analysis of journal articles relating to empirical studies that use FC in the field of education. The systematic literature review used the ERIC, Scopus, and Web of Science (WOS) databases. These were chosen on the basis of the Journal Citation Report (JCR) and Scientific Jpornal Ratings (SJR) impact factors, as well as the indexing of academic articles from peer-reviewed journals following a rigorous process for inclusion.

The terms used in the search were in English, first using the expression "flipped classroom" and then using the descriptors "motivation, self-regulation, and performance" in the field of higher education to limit the results. The search equation was finally established: ("flipped classroom" OR "flipped learning" OR "flipped education") AND (motivation OR self-regulation OR "self regulated" OR "self regulation" OR "academic achievement") AND (universit* OR "higher education").

Comentado [TP5]: ¿Faltan comillas aquí?

Comentado [AUTOR6R5]: No faltan comillas, porque es una única palabra.

Comentado [TP7]: ¿Comillas?

Comentado [AUTOR8R7]: Está bien como lo hemos puesto.

Determining the sample

The publications analysed were selected according to the following inclusion criteria:

a. Publications from between 2014 and 2021.

b. Journal articles.

c. Research done in the field of university education (courses or studies in university degrees).

d. Studies carried out in the area of the experimental sciences (Physics, Chemistry, Biology, Geology, Environment Science) and health sciences.

The exclusion criteria were:

a. Works not published in English.

b. Studies not published in peer reviewed journal (Conference proceedings, theses, books, book chapters, and other types of publication).

c. Theoretical studies or reviews.

d. Master's and doctoral studies (theses).

e. Studies relating to mathematics, economics, statistics, engineering, or computing were excluded, as well as mixed ones that included these subjects or topics.

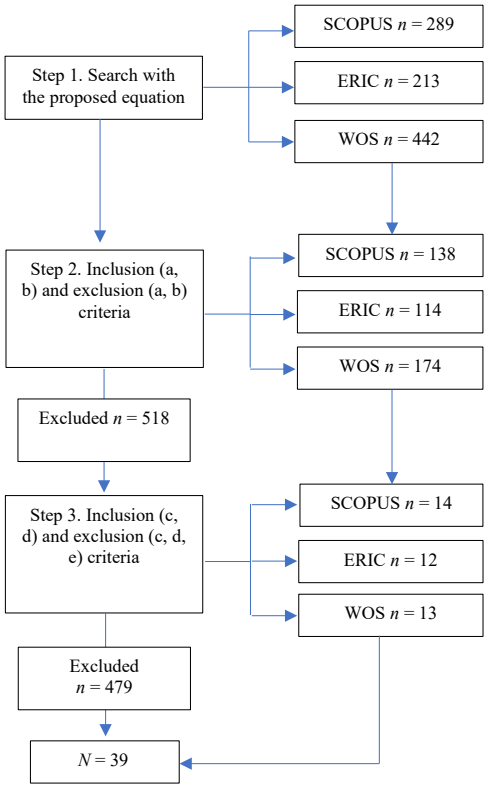

Figure 1. Selection process flow chart Source: own elaboration.

Accordingly, when we entered the keywords, we found 289 documents through Scopus, 213 through ERIC, and 442 on WOS. We first eliminated duplicates, and then applied the inclusion and exclusion criteria, finally selecting 39 articles. The flow chart in Figure 1 shows the process we followed to establish the definitive sample of articles reviewed ($N = 39$).

RESULTS

Table 1 summarises the articles analysed in this review.

Table 1. Characteristics of the studies analysed

Authors	Subject/Degree	Year	-Instructional Model

			nd	FC	FC vs. traditional	Other
Weaver & Sturtevant (2015)	General chemistry (Chemistry)	1			x	
Casasola et al. (2017)	Chemistry	1 & 2			x (first year)	Traditional (second year)
Crimmins & Midkiff (2017)	Organic Chemistry	-			x	
Saunders et al. (2017)	Nursing	1		x		
Thai et al. (2017)	Course on invertebrates	2		x		Blended Learning (BL), Traditional and E-Learning (EL)
White et al. (2017)	Pharmacy	-		x (in-person vs. distance)		
Cho & Kim (2018)	Nursing	-		x (theoretical vs. practical)		
Hoepner & Hemmerich (2018)	Neuroanatomy	4 & 1		x		FC + sandwich focus and traditional control
Kim et al. (2018)	Environment (dentistry)	2		x		
Ma et al. (2018)	Immunology (medicine)	2			x	
Sezer & Abay (2018)	Good practices (medicine)	1			x	
Fatima et al. (2019)	Respiratory and cardiovascular module (medicine)	1		x		
He et al. (2019)	General chemistry	1			x	
Jeong et al. (2019)	Environmental sciences	-		x		
Kühl et al. (2019)	Biochemistry (medicine)			x		Collaborative
Lee & Choi (2019)	Sciences (dentistry)	1 & 2		x		
Sherr et al. (2019)	Human anatomy and physiology	-	x			
Wang & Chu (2019)	Inorganic chemistry	1			x	
Bawaneh & Moumene (2020)	Medicine	-			x	
Bingen et al. (2020)	Nursing	1		x		
Dunkle & Yantz (2020)	Hydrogeology course (geology and biology)	2, 3 & 4			x	
Gómez et al. (2020)	Physiology and human anatomy course I & II	2		x		

Gu & Sok (2020)	Nursing	2			x	
Halasa et al. (2020)	Science (nursing)				x	
Jdaitawi (2020)	General science course	-			x	
Jeong et al. (2020)	Science course, primary education students	2		x		
Jiménez-Rodríguez et al. (2020)	Nursing	2		x		
Sudarmika et al. (2020)	Nursing	-			x	
Thai et al. (2020)	Human and animal physiology	3		x		Blended Learning (BL), traditional and E-Learning (EL)
Zheng & Zhang (2020)	Medicine	1 & 2		x		
Zheng et al. (2020)	Medicine	1 & 2		x		
Zhu et al. (2020)	Ophthalmology	-			x	
Dong et al. (2021)	Nursing	3			x	
Gu & Sok (2021)	Nursing	2		x		
Lo et al. (2021)	Organic Chemistry	-		x		Multicomponent blended learning vs. traditional learning
Naibert et al. (2021)	General chemistry	-		x (in 3 institutions simultaneously)		
Pence et al. (2021)	Physiopathology (nursing)	-		x		
Velde et al. (2021)	Health Sciences	1			x (expert laboratories vs. traditional)	
Zheng et al. (2021)	Medicine	1 & 2		x		

(nd: no data) Source: own elaboration.

Performance

Of the 39 articles analysed, 32 analyse the impact of FC on students' academic performance. Of these, 26 measure it in an objective and quantifiable manner through some type of grade or score that the students obtain (marks from exams, tests, or formative assessments), depending on the sample, subject, context, method, data collection instrument, and time of the study. The other 6 (Gómez et al., 2020; Pence et

al., 2021; Saunders et al., 2017; Sudarmika et al., 2020; Velde et al., 2021; Zheng et al., 2020) use surveys, interviews, or students' self evaluations of their level of academic performance.

Of the 26 articles that include grades, it is only in the study by He et al. (2019) that FC students perform worse than the control group in the final exam, contrasting with their earlier study (He et al., 2016). However, their results improve with a second year of FC. Most of the works that compare FC with traditional learning found higher scores in the FC learning group than in the control group (Bawaneh & Moumene, 2020; Crimmins & Midkiff, 2017; Dong et al., 2021; Fatima et al., 2019; Gu & Sok, 2020; Hasala et al., 2020; Lo et al., 2021; Ma et al., 2018; Sezer & Abay, 2018; Wang & Zhu, 2019; Weaver & Sturtevant, 2015; Zhu et al., 2020). In the study by Dunkle and Yantz (2020) there were apparently no significant differences between the marks from traditional and flipped classrooms. Test scores with FC were a reasonably precise indicator of students' general performance on the course (with the lowest-performing students benefiting most from flipped teaching).

Comentado [TP9]: Entiendo que <curso> aquí no se refiere al año escolar (students' general performance for the year").

Comentado [AUTOR10R9]: Eso es, no se refiere al año escolar, sino al ámbito académico.

Similarly, the other works analysed found a generalised improvement in students' performance:

- The students on the FC chemistry course obtained higher grades in chemistry in the following year compared with students taught using a traditional methodology (Casasola et al., 2017).
- With the same feedback and guidance from the teacher, the students in an FC environment achieved better academic results (Thai et al., 2017).
- White et al. (2017) noted better performance in exams in questions that involved innovative scenarios among students who engaged fully with FC.
- The final marks of students taught using traditional pedagogy were considerably lower than the final marks with FC, although the FC students did express some displeasure at having to take more responsibility for their own learning (Hoepner & Hemmerich, 2018).
- Kim et al. (2018) found an increase in performance in the formative tests and final exam for students with the divergent learning style.
- The results of Thai et al. (2017) suggest that students in an FC setting do better than students in a digital learning environment.
- Positive impact on students in an FC setting at the end of the attributed to relentless nudging via text messages (Sherr et al., 2019).

- The students' marks reflected higher levels of performance, especially when working with videos (Lee & Choi, 2019).
- Jeong et al. (2020) carried out assessments at different moments on a STEM course, and compared the overall mark with the earlier performance on a scale of 0 to 10, increasing performance by more than half a point.
- Zheng & Zhang (2020) indicated that a period of transition was necessary from traditional learning to FC where learning between peers and seeking help could significantly improve the academic performance of the students.
- Gu & Sok (2021) noted that the academic performance of students who were taught using a flipped learning simulation practice was relatively higher than the average.
- FC improves understanding and the students' level of comfort with different chemistry concepts at the end of the year (Naibert et al., 2021).
- Zheng et al. (2021) note that the marks in the exam at the end of the semester increased as the students' self-conviction in their capacity to achieve academic goals increased.

Motivation

A total of 26 articles consider the question of motivation. It is a study variable in 21 of them while 5 refer to a concept called engagement as a directly related variable (Fatima, et al., 2019; Jdaitawi, 2020; Jeon et al., 2019; Lo et al., 2021; White et al., 2017). Engagement can be defined as a positive mental state relating to work and characterised by vigour (high levels of energy and mental resistance), dedication (high engagement with work) and absorption (high state of concentration and immersion) (Schaufeli et al., 2002).

Of the 21 articles that study motivation as a variable, 12 explicitly mention this variable, measuring motivation through the opinion of the teacher and through surveys of students' perceptions following the implementation of FC (Jiménez-Rodríguez et al., 2020; Thai et al., 2017) and through validated questionnaires (Bawaneh & Moumene, 2020; Cho & Kim, 2019; Gómez et al., 2020; Jeong et al., 2020; Kühl et al., 2019; Ma et al., 2018; Pence et al., 2021; Thai et al., 2020; Wang & Zhu, 2019; Zheng et al., 2021). The other 9 articles that implicitly analyse students' motivation (they do not mention this term as such, but instead satisfaction), measure it through satisfaction surveys that are sent to students at the end of the academic year (Casasola et al., 2017; Dong et al., 2021; Gu & Sok, 2020; Gu & Sok, 2021; He et al., 2019; Saunders et al., 2017; Sezer & Abay, 2018; Velde et al., 2021; Weaver & Sturtevant, 2015).

Comentado [TP11]: ¿Esto se refiere a la FC o al periodo de transición?

Comentado [AUTOR12R11]: Se refiere al período de transición.

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Comentado [AUTOR14R13]: https://www.mdpi.com/1660-4601/18/11/5970

Comentado [TP15]: - La fecha de este artículo es (2020) en la lista de referencias. Creo que debe ser 2020 aquí también. - El doi de "The effectiveness of the flipped classroom on students' learning achievement and learning motivation" no funciona.

Comentado [AUTOR16R15]: Este artículo tiene bien el año. Pero no es el que comentas con el doi, sino que es: Zheng, B., Chang, C., Lin, C.H., & Zhang, Y. (2021). Self-efficacy, academic motivation, and self-regulation: How do they predict academic achievement for medical students? *Medical Science Educator*, 31, 125-130. https://doi.org/10.1007/s40670-020-01143-4 .El doi, del otro artículo que no funciona lo hemos modificado

Comentado [TP17]: Este artículo es de pago así que la traducción es mía. Recomiendo consultar la fuente original.

Comentado [AUTOR18R17]: No es una cita textual, así que vamos a quitar las comillas y la página.

Of the 5 articles that consider motivation indirectly, 2 study engagement through students' perceived satisfaction (Fatima et al., 2019; White et al., 2017). In this case, it has been observed that as engagement increases, there is an increase in the number of students who prepare for the class in advance and who attend it in-person, which in turn correlates positively with students' success in resolving novel scenarios in exams. Furthermore, Jeong et al. (2019) study engagement and motivation and Jdaitawi (2020) analyses positive emotions towards the FC model, relating it to engagement and motivation, finding an interrelation.

Of the 26 articles selected, 23 reported a significant increase in students' perceived motivation/satisfaction. In contrast, Casasola et al. (2017) did not find significant differences between the FC model and the traditional model, although they did find that students attendance in class was better, perhaps because classes that incorporate active learning methods, like the FC teaching , have been shown to be beneficial. Pence et al. (2021) even observed a reduction in motivation between the pre-test and post-test, although, in this case, the FC model was not compared with a traditional lecture-based classroom teaching. Similarly, Velde et al. (2021) found that with an FC model, students felt that they had less autonomy and were less competent than in the traditional classes, something that led them to report a lower level of satisfaction. In all cases, active work by students during classes is referred to, with problem solving and carrying out case studies mentioned as activities done.

Self-regulation

Of the 39 articles selected, in 13 self-regulated learning is determined a with a qualitative research approach during the teaching–learning process. For data collection, they principally use self-reports, structured observation and interviews with students, standardized test about self-efficacy and self-regulated learning strategies, and analysis of documents created by the teacher (such as teaching diaries) or created by the student (such as activities and pieces of work, recordings of debates, etc.).

In all of them, the self-regulatory capacity of students is considered to be a key requirement for good performance in an FC environment, as during the different stages of implementation of the method, the teacher will design opportunities for students to take responsibility for their own learning. The selected research works centre on two lines; on the one hand they consider the positive effect on students' performance in the FC learning environment of applying self-regulation strategies (Gu & Sok, 2021; Sherr et al., 2019; Thai et al., 2017; Thai et al., 2020; Zheng & Zhang, 2020; Zheng et al., 2021),

and on the other hand, identifying the strategies students use during FC (Gu & Sok, 2020; Lee & Choi, 2019; Naibert et al, 2021; Zheng et al., 2020; Zhu et al., 2020).

All of the authors agree that command of these strategies is essential, as students who have a higher level of self-regulation can use material and/or didactic resources more independently and effectively. Only one study found a reduction in self-efficacy, owing to the authors recognising that students have many restrictions on their autonomy (Cho & Kim, 2019).

DISCUSSION AND CONCLUSIONS

Use of FC is growing in popularity, partly thanks its great versatility, something apparent in the diversity of contexts and variety of forms of application contained in the selected articles. Despite this, there is uniformity in the results obtained. From the data collected, a generalised increase in the marks of students in an FC setting is apparent in almost all of the studies. In the exceptions found, some time is needed to become habituated to learning with the new teaching focus, as the students improve their performance through the use of a systematic learning method that enables them to adapt to different educational contexts (Zimmerman, 2001). Consequently, an improvement is confirmed in the academic performance of students who follow FC (Casasola, 2017; Lee & Choi, 2019; Sherr et al., 2019; White et al., 2017) compared with those who follow a traditional lecture-based classroom teaching in experimental science and health science field.

Furthermore, the results verify others relating to the benefits of FC, in line with what is stated by various authors (Aguilera et al., 2017; Alebrahim & Ku, 2020; Rivero-Guerra, 2018; Romero-García et al., 2021; Valero et al., 2019; Zheng et al., 2020), such as increased motivation, self-regulation, and team work and, by extension, improved academic performance compared with the traditional teaching methodology.

With regards to motivation, FC in general is perceived as satisfactory by the students (Kim et al., 2018; White et al, 2017), which correlates with greater dedication and preparation of work before class (Bingen et al., 2020). Fundamentally, it is apparent that students increase their study time in FC but without increasing appreciably the total workload (Bawaneh & Moumene, 2020; He et al., 2019). This is why various studies agree on the importance of emphasising work prior to the class so that students understand its importance and are more motivated (Lee & Choi, 2019; Pence et al., 2021).

Furthermore, by dedicating face-to-face teaching time to promoting higher-order learning, FC can improve the learning outcomes achieved (Saunders et al., 2017).

In relation to self-regulation, in agreement with Wang (2019) the self-regulated learning data can be used as a source to complement the motivation data to predict learning behaviours and achievement in the FC model. Integrating FC in to the learning process has a significant effect on improving students' self-regulation (Thai et al, 2017; Zheng et al., 2021). This positive effect is attributed to interaction with the teacher and other classmates, which plays a decisive role in boosting skills with respect to organising materials, sequencing study, assimilating concepts, and clear expression during team work. Students' self-regulating capacity is regarded as a key requirement for good performance throughout all of the pedagogical sequence of the FC model. It has been confirmed that FC is more effective for highly regulated, highly motivated, and academically well prepared students (He et al., 2016). It has also been found that students who do not have self-regulation or have a low level of it often find it hard to understand concepts or content in the pre-class stage, something that will inevitably lead to less effective results, less participation, and less interest in the subsequent activities during the class.

University students should be capable of taking decisions that control the selection and use of strategies and their involvement in study: planning and organising which strategies to use in each situation, controlling the execution of the process, and evaluation to detect flaws. In fact, it turns out that when students are trained, they display more use of strategies, optimise their actions, improve their academic performance and take more responsibility regarding their academic tasks (Sáiz & Valdivieso-León, 2020). However, FC does not in itself improve academic performance. Instead, performance genuinely improves when students are guided with self-regulation tools (Butzler, 2016; Gu & Sok, 2021; Velde et al., 2021). Dunkle and Yantz (2020) note that in addition to the importance of good design and planning of FC, regular communication with students is also needed, and there is the possibility that FC specifically adapts to the context of the needs of the students, their teachers, and universities (Velde et al., 2021).

In this work we collated studies on FC in the field of the experimental sciences and health sciences: in all of them, the flipped model is presented as an effective active learning methods with the objective of fostering students' analytic focus for solving problems and encouraging them to learn about autonomous interpretation of information.

To cite Jdaitawi (2020), if FC is implemented with good instructional design results in the development of positive synergies with the construction and quality of the learning and with fostering the development of competencies (critical thinking, communication, and problem solving skills), which is fundamental in the field of study on which this work focusses.

As limitations of the study, we should note that the search was performed in the WoS, ERIC, and Scopus databases, leaving out other scientific literature that is not indexed in these databases, as well as other types of publication, such as book chapters and conference proceedings. In addition, looking to the future, it would be of interest to consider team work and collaborative work alongside motivation and self-regulation in reviewing the benefits associated with FC for improving engagement, satisfaction, and academic performance of higher-education students.

Consent Statement: "Not applicable".

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