





Evaluation of contextual variables in the implementation of the Flipped Classroom methodology in secondary education

Evaluación de variables contextuales en la implementación de la metodología Flipped Classroom en educación secundaria



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ABSTRACT

This study focuses on the Flipped Classroom (FC) methodology in secondary education, evaluating its impact in relation to different contextual variables of the educational system. The hypotheses explore whether variables such as the type of educational institution, the teacher's area of expertise, their experience and training, age, the classroom layout and the academic semester within the school year, impact the adoption of the FC. For this purpose, information was collected by means of a questionnaire that contemplated aspects of students, educational institutions and teachers, in addition to observing the use of FC in classrooms. The questionnaire contains predominantly closed questions with the idea of encouraging a quantitative study methodology. After analyzing the results, statistically significant differences were found in the use of FC between private and subsidized centers versus public ones. The age of the teacher also proved to be an influential factor, with greater adoption of FC among teachers under 40 years of age. The teaching specialty of knowledge was also a significant factor, with greater use of FC in the areas of English Language and Professional Training compared to others such as Mathematics, Spanish Language and Literature or Biology. These results indicate that the implementation of FC is uneven, influenced by the type of school, the age of the teachers and their specialization. Our research underlines the need to provide adequate resources and continuous training, especially in public schools, to foster the equitable adoption of innovative educational methodologies such as FC.

Keywords: open education; active methodologies; flipped classroom; quantitative research.

RESUMEN

El presente estudio se centra en la metodología Flipped Classroom (FC) en la educación secundaria, evaluando su impacto en relación con distintas variables contextuales del sistema educativo. Las hipótesis abordan si el tipo de centro educativo, especialidad docente, experiencia y formación del profesorado, su edad, la disposición de las aulas y la relación del uso de FC con el semestre académico, influyen en la adopción de FC. Para ello, se recopiló información mediante un cuestionario que contemplaba aspectos de los estudiantes, los centros de prácticas y los docentes, además de observar el uso de FC en el aula. El cuestionario contiene predominantemente preguntas cerradas con la idea de fomentar una metodología de estudio cuantitativa. Tras el análisis de resultados, se encontraron diferencias estadísticamente significativas en el uso de FC entre centros privados y concertados frente a los públicos. La edad del docente también resultó ser un factor influyente, con una mayor adopción de FC entre docentes menores de 40 años. La especialidad docente también supuso un factor significativo, dándose un mayor empleo de FC en las áreas de Inglés y Formación Profesional en comparación con otras como Matemáticas, Lengua y Literatura o Biología. Estos resultados indican que la implementación de FC tiene un carácter desigual, influenciada por la tipología del centro educativo, la edad del profesorado y la especialización. Esto subraya la necesidad de proporcionar recursos adecuados y formación continua, especialmente en centros públicos, para fomentar la adopción equitativa de metodologías educativas innovadoras como el FC.

Palabras clave: educación abierta; metodologías activas; flipped classroom; investigación cuantitativa.

INTRODUCTION

In recent years, and through the emergence of new technologies and their application in education, new methodological currents have emerged that facilitate learning in an active and participatory way (Cárdenas et al., 2023). Thanks to these possibilities, students have come to play a leading role in their own teaching-learning process, leading to the emergence of more open and flexible educational environments (Berenguer, 2016).

One of the emerging methodologies that has the student as the main axis has been the so-called "Flipped Classroom", hereinafter "FC" and is defined as one in which students carry out a process of research and study on specific content outside the educational center, which is subsequently worked on practically in the classroom by solving problems, resolving doubts or carrying out practical work (Pozuelo, 2020).

This methodology, applicable to all curricular areas of the different educational levels (Blasco et al., 2016), allows students to adopt their own learning pace and enables teachers to individualize the teaching process by devoting a greater amount of time to the students who require it most, taking into account their interests and needs (Mohanty & Parida, 2016; Aguilera-Ruiz et al., 2017), thus facilitating the personalization of teaching (La Marca, 2020). Furthermore, according to studies by González-Fernández and Carrillo (2016) the use of FC in combination with other methodologies, such as cooperative learning, are highly recommended. It is important to keep in mind that the application of FC is accompanied by a series of teaching skills that are unavoidable to ensure correct implementation, such as the creation of audiovisual content, activity design and technological skills (Yeh, 2022).

According to some studies, the application of the FC methodology has a positive impact that influences, at the psycho-educational level, several emotional and cognitive variables (Sánchez-Soto & García Martín, 2023). In terms of emotional variables, we find aspects such as motivation, participation, collaboration or satisfaction of the individual, and in terms of cognitive variables, performance, creativity and the individual's capacity for critical thinking or autonomy are identified.

In contrast, other researchers have not identified statistically significant differences between the use of new active methodologies versus traditional ones in terms of aspects such as degree of satisfaction or self-assessment of knowledge by students (Kim, 2018; Morgan et al., 2015), identifying the possibility that the modifying variables are the types of technologies used, the amount of time available to students or school organization.

Regarding the students' perception of the use of CF in the classroom, some studies, such as those of Pozuelo (2020), show that positive bonds are created between students and teachers, considering it an effective and useful factor. These results are in line with other authors who point out the need to increase, in this type of methodology, the levels of co-responsibility and commitment in both students and teachers (Del Arco Bravo et al., 2019). Along the same lines, Espada et al. (2020), highlight a better use of time, a positive assessment of the flexibility provided by the use of this methodology, a greater involvement and enjoyment with the training process and a better adaptability to the learning needs of students.

The successful use of FC depends on a minimum degree of teaching digital competence that allows its correct development, which is affected by factors such as age, gender, degree of experience or continuous training (Çebi & Reisoglu, 2020). This

fact possibly explains the disparity in the results of different scientific studies that reach conflicting conclusions regarding the real effectiveness of this methodology (Galindo-Domínguez & Benzanilla, 2019). However, and in line with research related to the analysis of teachers' digital knowledge, although digital equipment and infrastructures are not currently a problem (Gómez, 2016), a low level of teachers' digital competencies has been identified, with only 19 % of teachers having a high level of digital competencies (Raposo et al., 2020; Andía-Celaya et al., 2020).

In the context described, we have sought to analyze the influence of factors related to the teachers themselves, as well as structural and organizational factors of the center, these being the object of analysis of the present research. The results obtained after the collection and processing of data, the statistical-descriptive analyses and the study of the results obtained from students who have completed a period of compulsory internships in educational institutions during the master's degree in Teacher Training in Secondary Education at the Distance University of Madrid (UDIMA) are presented below.

In this sense, different variables have been taken into account, such as the area or specialty of knowledge in which the methodology is used, the type of institution, the age and years of experience of the teachers who have tutored the internships, the pedagogical training of the teachers and the types of spaces and resources used.

OBJECTIVES AND HYPOTHESIS

The general objective of this research is to analyze the influence of different contextual variables on the use of the FC methodology in compulsory secondary education. In order to evaluate the impact of the FC methodology in secondary education classrooms, several hypotheses have been formulated that consider contextual variables within the educational system in relation to this methodology.

- H1: The type of educational center (public, private, subsidized) does not significantly affect the frequency of use of FC.
- H2: The expertise in specific subject areas of secondary school teachers does not have a significant impact on the adoption of FC.
- H3: The years of teaching experience do not significantly determine the use of FC.
- H4: The pedagogical training of teachers does not significantly impact the adoption of FC.
- H5: The age of the teachers is not determinant in the adoption of FC.
- H6: The layout of the classrooms does not significantly affect the use of FC.
- H7: The use of FC does not vary significantly between the semesters of the 20/21 to 22/23 academic years.

We will delve into the study of each hypothesis, focusing on key aspects for future discussions. Details about the concepts employed to measure "the use of the methodology", including the evaluation scale, will be provided later.

METHODOLOGY

The importance of establishing a clear definition of FC, following Pozuelo (2020), is emphasized as a crucial step so that respondents can properly identify this educational methodology. The observation of three essential elements is highlighted:

the provision of audiovisual material by teachers for its use outside the classroom, the promotion of research and self-exploration by students through this material, and the dedication of class time to active participation activities, such as debates and clarification of doubts, after reviewing the audiovisual content.

This investigation has been conducted within a context of contemplation on the 180-hour training activities performed by Master's students in Teacher Education. Throughout their internships, these students shadow a currently practicing teacher, gaining insights into the educational dynamics of their assigned schools. They are required to maintain a detailed journal documenting: the activities they engage in; key information about both the educational institution and the supervising teacher; along with their reflections on teaching methodologies, time and space management, resources, and assessment practices observed. In addition, they are asked to complete a specially designed questionnaire for this study, which gathers data on the students' personal backgrounds (including their specific master's program, gender, age, and prior education) and details about the internship site (like its type, operating hours, geographic location, and socioeconomic context). The survey also probes into characteristics of the mentor teacher, including their age, educational background, and teaching competencies. Moreover, it seeks to gather data on the implementation of the FC approach within the classroom setting. The questionnaire primarily consists of closed questions with single-choice answers, allowing students to select from a list of provided options.

To design the questionnaire, the study dimensions were initially identified to establish key indicators, following the approach of Ruiz (2014). This formed the basis for creating clear and straightforward questions, avoiding negative phrases and judgments towards respondents, in line with Palou's recommendations (2011). Afterward, a group of multidisciplinary education experts reviewed the draft of the questionnaire, conducting an analysis according to procedures suggested by Palou (2011). This panel recommended changes to enhance the tool, ensuring that the questions aligned with the constructivist paradigm, praised by Marsh and Dunkin (1997) for its effectiveness towards the coherence and alignment of the questionnaire's objectives. Finally, the revised questionnaire was tested with teachers not involved in its creation, who assessed its relevance and suitability, allowing for further refinement of the tool before its final application.

Regarding construct validity, various techniques were employed. Bartlett's test of sphericity was applied, yielding significant results ($X^2(15) = 1056,366$; $p = <,001$), and the Kaiser-Meyer-Olkin (KMO) index reached a value of ,717, indicating an adequate correlation matrix according to Kaiser (1970). Additionally, a principal component analysis revealed a cumulative variance of 0,570 for the FC methodology, confirming the questionnaire's suitability to assess this factor. Internal consistency was verified through Cronbach's alpha coefficient, recording a value of 0,739 for the FC methodology, which demonstrates a satisfactory correlation among the items. Regarding reliability, in addition to Cronbach's alpha, it is noted that students complete a logbook during their internships. In this logbook, they record details and reflections on the FC, contributing to consistency between direct observations and questionnaire responses, ensuring reflective assessment.

The study's sample includes 1,139 Master of Education students from various specialties, who undertook internships from September 2020 to June 2023, providing data from 2,114 classrooms. This represents a significant sample compared to the estimated 130,000 classrooms in secondary, high school, and professional training in

Spain, offering national representativeness with a margin of error less than 3 %. Most data come from Andalusia, Catalonia, and Madrid. The gender distribution of the students is 58.82 % women and 41.18% men, with 77.35 % between 25 and 40 years old, 16.07 % over 40, and 6.58 % under 25 years old.

Once the data were collected, the following phases were followed for analysis:

1. Response consolidation: The study variable had five levels of gradual implementation based on the applicability of the methodology, which were coded as follows:
 - Value 1: I have not seen FC being part of the methodologies used (0 %).
 - Value 2: I have seen some use of videos and online materials but not meeting some of the FC characteristics (0 %).
 - Value 3: I have seen FC used on an occasional basis (<25 %).
 - Value 4: I have seen FC used in a significant number of sessions (>25 % and <75 %).
 - Value 5: I have seen FC used in the majority of sessions (>75 %).
2. Quantitative analysis: Descriptive statistics, such as contingency tables, were used to evaluate the implementation of the methodology based on the responses.
3. Non-parametric mean comparison: To identify significant differences between groups, we used non-parametric tests, specifically Kruskal-Wallis and Mann-Whitney tests. The appropriateness of these tests was based on the Kolmogorov-Smirnov test, which showed results less than 0.05, confirming the non-normal distribution of the data (Berger & Zhou, 2014).

RESULTS

The results are organized based on the percentage of time that teachers dedicate to the FC methodology in the classroom according to the coding Value 1 - 5. These results are segmented based on different independent variables according to the response options. These variables are:

- Subject areas or specialties: Biology and Geology, Physical Education, Professional Oriented Training, Geography and History, Spanish Language and Literature, English Language and Mathematics.
- Type of educational center: public, private, or subsidized.
- Teacher's age: less than 25 years, between 25 and 40 years (inclusive), more than 40 years.
- Years of teaching experience: Between 1 and 5 years (inclusive); between 6 and 10 years (inclusive); and more than 10 years.
- Teacher's pedagogical training: Teacher Training Certificate (former CAP in Spain), Master in Teacher Training, None, Other.
- Organization and types of educational spaces: Open Classroom, variable structure classroom, subject-specific classroom, classroom building, Other.
- Semester of methodology observation: Coded by indicating first or second semester (1S, 2S) followed by an underscore with the corresponding academic year (20_21, 21_22, 22_23).

In Tables 1 - 7, the information collected in our study is summarized. A review of the tables reveals significant differences in the adoption of the FC methodology based on various criteria, as outlined below.

Table 1
Usage of the FC methodology by knowledge specialty

Specialty	FC (Coded Variable) - Case counts (%)					Total
	1	2	3	4	5	
Biology and Geology	108 (47,0%)	56 (24,3%)	42 (18,3%)	14 (6,1%)	10 (4,3%)	230 (100%)
Physical Education	49 (32,5%)	30 (19,9%)	37 (24,5%)	26 (17,2%)	9 (6,0%)	151 (100%)
Professional Training	11 (23,9%)	12 (26,1%)	7 (15,2%)	9 (19,6%)	7 (15,2%)	46 (100%)
Geography and History	128 (35,1%)	66 (18,1%)	81 (22,2%)	60 (16,4%)	30 (8,2%)	365 (100%)
English Language	168 (36,8%)	91 (19,9%)	104 (22,8%)	68 (14,9%)	26 (5,7%)	457 (100%)
Spanish Language and Literature	102 (54,3%)	24 (12,8%)	30 (16,0%)	20 (10,6%)	12 (6,4%)	188 (100%)
Mathematics	382 (56,4%)	125 (18,5%)	93 (13,7%)	57 (8,4%)	20 (3,0%)	677 (100%)
Total	948 (44,8%)	404 (19,1%)	394 (18,6%)	254 (12,0%)	114 (5,4%)	2114 (100%)

Analyzing the specialty of knowledge (see Table 1), the use of FC constitutes more than 25 % of the sessions (sum of the percentages in values 4 and 5) and is less in Mathematics (11.4 %), Spanish Language and Literature (17 %), and Biology and Geology (10.4 %). The methodology is used more in Physical Education (23.2 %), English (20.6 %), Geography and History (24.6 %), and Professional Oriented Training (34.8 %).

Table 2
Use of the FC methodology based on the type of educational institution

Type of institution	FC (Coded Variable) - Case counts (%)					Total
	1	2	3	4	5	
Subsidized	502 (43,6%)	216 (18,8%)	212 (18,4%)	153 (13,3%)	68 (5,9%)	1151 (100%)
Private	128 (43,5%)	56 (19,0%)	53 (18,0%)	36 (12,2%)	21 (7,1%)	294 (100%)
Public	318 (47,5%)	132 (19,7%)	129 (19,3%)	65 (9,7%)	25 (3,7%)	669 (100%)
Total	948 (44,8%)	404 (19,1%)	394 (18,6%)	254 (12,0%)	114 (5,4%)	2114 (100%)

Regarding the use of the FC methodology based on the type of educational institution (see Table 2), it is used less in public centers (13.4%) compared to private (19.3%) and subsidized (19.2%) centers.

Table 3
Use of the FC methodology based on the teacher's age

Age (years)	FC (Coded Variable) - Case counts (%)					Total
	1	2	3	4	5	
Less than 25	4 (28,6%)	4 (28,6%)	2 (14,3%)	4 (28,6%)	0 (0,0%)	14 (100%)
Between 25 and 40	237 (39,6%)	110 (18,4%)	125 (20,9%)	84 (14,0%)	42 (7,0%)	598 (100%)
More than 40	707 (47,1%)	290 (19,3%)	267 (17,8%)	166 (11,1%)	72 (4,8%)	1502 (100%)
Total	948 (44,8%)	404 (19,1%)	394 (18,6%)	254 (12,0%)	114 (5,4%)	2114 (100%)

Regarding teacher age (see Table 3), teachers over 40 years old show less use of FC (15.9 %), while those between 25 and 40 years old apply it more (21 %).

Table 4*Use of the FC methodology based on the teacher's years of experience*

Experience (years)	FC (Coded Variable) - Case counts (%)					Total
	1	2	3	4	5	
Between 1 and 5	194 (45,0%)	97 (22,5%)	79 (18,3%)	41 (9,5%)	20 (4,6%)	431 (100%)
Between 6 and 10	153 (41,0%)	67 (18,0%)	72 (19,3%)	60 (16,1%)	21 (5,6%)	373 (100%)
More than 10	601 (45,9%)	240 (18,3%)	243 (18,5%)	153 (11,7%)	73 (5,6%)	1310 (100%)
Total	948 (44,8%)	404 (19,1%)	394 (18,6%)	254 (12,0%)	114 (5,4%)	2114 (100%)

Based on the teacher's years of experience (see Table 4), the use of FC is higher in teachers with 6 to 10 years of experience (sum of values 4 and 5 at 21.7 %) compared to teachers with 1 to 5 years of experience (14.1 %) and those with more than 10 years (17.3 %).

Table 5*Use of the FC methodology based on teacher's pedagogical training*

Pedagogical training	FC (Coded Variable) - Case counts (%)					Total
	1	2	3	4	5	
Teacher Training Certificate (former CAP in Spain)	668 (45,3%)	278 (18,9%)	281 (19,1%)	175 (11,9%)	72 (4,9%)	1474 (100%)
Master in Teacher Training	201 (40,9%)	102 (20,8%)	94 (19,1%)	62 (12,6%)	32 (6,5%)	491(100%)
None	26 (63,4%)	5 (12,2%)	3 (7,3%)	4 (9,8%)	3 (7,3%)	41 (100%)
Other	53 (49,1%)	19 (17,6%)	16 (14,8%)	13 (12,0%)	7 (6,5%)	108 (100%)
Total	948 (44,8%)	404 (19,1%)	394 (18,6%)	254 (12,0%)	114 5,4%)	2114 (100%)

After analyzing teacher training and its relationship with the FC methodology (see Table 5), it is observed that the percentage of FC use is similar between teachers with CAP pedagogical training (sum of values 4 and 5 at 16.8%) and those with a Master's in Secondary Education Teacher Training (19.1%), although it is slightly higher in the latter case.

Table 6*Use of the FC methodology according to the organization of classroom spaces*

Type of classroom spaces	FC (Coded Variable) - Case counts (%)					Total
	1	2	3	4	5	
Open Classroom	19 (30,2%)	15 (23,8%)	19 (30,2%)	5 (7,9%)	5 (7,9%)	63 (100%)
Variable Structure Classroom	55 (26,8%)	25 (12,2%)	54 (26,3%)	46 (22,4%)	25 (12,2%)	205 (100%)
Subject-Specific Classroom	67 (42,1%)	28 (17,6%)	27 (17,0%)	28 (17,6%)	9 (5,7%)	159 (100%)
Classical rows layout	800 (48,2%)	325 (19,6%)	291 (17,5%)	170 (10,2%)	75 (4,5%)	1661 (100%)
Other	7 (26,9%)	11 (42,3%)	3 (11,5%)	5 (19,2%)	0 (0,0%)	26 (100%)
Total	948 (44,8%)	404 (19,1%)	394 (18,6%)	254 (12,0%)	114 (5,4%)	2114 (100%)

Regarding the physical teaching space (see Table 6), the use of FC is higher in classrooms with variable structure (34.6%), whereas in traditional classrooms with classical rows layout, the usage rate is approximately 15%.

Table 7*Evolution of the usage percentage of FC per classroom sessions over the semesters*

SEMESTER	FC (Coded Variable)					Total
	1	2	3	4	5	
1S_20_21	77 (43,5%)	30 (16,9%)	33 (18,6%)	22 (12,4%)	15 (8,5%)	177
2S_20_21	166 (42,9%)	59 (15,2%)	77 (19,9%)	58(15,0%)	27(7,0%)	387
1S_21_22	158 (38,7%)	97 (23,8%)	81 (19,9%)	46 (11,3%)	26 (6,4%)	408 (100%)
2S_21_22	199 (44,4%)	88 (19,6%)	85 (19,0%)	57 (12,7%)	19 (4,2%)	448 (100%)
1S_22_23	185 (58,5%)	53 (16,8%)	36 (11,4%)	28 (8,9%)	14 (4,4%)	316 (100%)
2S_22_23	163 (43,1%)	77 (20,4%)	82 (21,7%)	43 (11,4%)	13 (3,4%)	378 (100%)
Total	948 (44,8%)	404 (19,1%)	394 (18,6%)	254(12,0%)	114 (5,4%)	2114 (100%)

Finally, according to the analyses of progress over time by Semesters (see Table 7), it is observed that the sum of values 4 and 5 over the semesters remains without significant variations, except in the first semester of the 2022/23 academic year, where a noticeable decrease in the use of FC is observed.

This data collected indicates that, although the use of the FC methodology varies more significantly depending on the teaching specialty, type of center, characteristics of the teachers, and physical teaching space. In general, its implementation is still limited compared to traditional methodologies since the majority of implementation levels are located in the coded values 1 and 2.

Statistically Significant Differences in the Implementation of FC According to Educational Variables

To analyze statistical differences between different groups defined by specific variables in relation to the use of FC, the Kruskal-Wallis test was employed. This statistical technique is used to determine if there are significant differences between three or more independent groups, without assuming a normal distribution of the data. For example, if we investigate the use of the FC methodology by type of institution, the groups would be: "public institution," "private institution," and "subsidized institution." In this scenario, each category represents a distinct group that we analyze to determine if there are significant differences when compared to the other two groups.

After applying the Kruskal-Wallis test to the variables in question, results have been obtained that allow us to perform hypothesis testing, comparing the data associated with each group. According to the findings, it has been determined that there are statistically significant differences in the use of FC in relation to the following variables: type of educational center (p-value: 0.041), area of knowledge (p-value < 0.001), teacher's age (p-value: 0.004), type of physical space (p-value < 0.001), and academic semester (p-value: 0.004). This indicates that the use of the FC methodology varies significantly depending on these variables. Moreover, a more detailed analysis of the results of the Kruskal-Wallis test will be presented in the Hypothesis Testing section.

Likewise, we employ the Mann-Whitney U test to examine variations in the application of FC. This test serves as a post-hoc analysis following the Kruskal-Wallis test, aiming to pinpoint the specific pairs of specialties among which significant differences exist in the utilization of FC. In the results, we identify two groups, labeled Sample 1 and Sample 2, representing different categories within the variables.

Table 8
Use of FC with respect to the specialty of knowledge

		Sample 2						
		Mathematics	Spanish Language and Literature	Biology and Geology	English Language	Geography and History	Physical Education	Prof. Training
Sample 1	Mathematics							
	Spanish Language and Literature	0,138						
	Biology and Geology	0,077	0,9					
	English Language	<,001	<,001	<,001				
	Geography and History	<,001	<,001	<,001	0,284			
	Physical Education	<,001	<,001	<,001	0,306	0,829		
	Prof. Training	<,001	<,001	<,001	0,047	0,139	0,211	

Note: P-values obtained after applying the Mann-Whitney U test. The significance level is < .050.

For the analysis of differences within each variable, we consider the data from the Mann-Whitney U tests presented in Tables 8-12 along with the descriptive values provided in Tables 1-7. Specifically, Table 8 shows the p-values resulting from comparing the use of FC among different specialties of knowledge. In this context, a significance level less than 0.050 indicates that the differences between groups are statistically significant. Therefore, we highlight that:

- Mathematics, Spanish Language & Literature, and Biology & Geology specialties show significantly lower use of FC compared to English Language, Physical Education, Geography and History, and Professional Oriented Training.
- The English Language specialty shows significantly lower use of FC compared to Professional Oriented Training.

These results indicate specific patterns in the adoption of the FC methodology among different educational specialties. In particular, they suggest limitations in the use of FC in traditionally more rigid areas, such as Mathematics and Spanish Language & Literature, compared to specialties that may offer more flexibility, such as English Language or Professional Oriented Training.

Table 9
Use of FC with respect to the type of institution

		Sample 2		
		Public	Subsidized	Private
Sample 1	Public			
	Subsidized	0,015		
	Private	0,078	0,945	

Note: P-values obtained after applying the Mann-Whitney U test. The significance level is < .050.

Following the previous reasoning, regarding the use of FC according to the type of institution (see Table 9), a lower usage is found in public centers, having shown statistically significant results, compared to subsidized centers (p-value: 0.015).

Table 10
Use of FC with respect to the teachers' ages

		Sample 2		
		Less than 25 years	Between 25 and 40 years	More than 40 years
Sample 1	Less than 25 years			
	Between 25 and 40 years	0,566		
	More than 40 years	0,21	<,001	

Note: P-values obtained after applying the Mann-Whitney U test. The significance level is < .050.

Regarding the use of FC, we conclude that there is lower usage among teachers over 40 years old compared to teachers aged between 25 and 40 years old (p-value <0.001).

Table 11
Use of FC with respect to the organization of classroom spaces

		Sample 2				
		Classical rows layout	Subject-Specific Classroom	Other	Open Classroom	Variable Structure Classroom
Sample 1	Classical rows layout					
	Subject-Specific Classroom	0,033				
	Other	0,208	0,734			
	Open Classroom	0,012	0,327	0,751		
	Variable Structure Classroom	<,001	<,001	0,107	0,07	

Note: P-values obtained after applying the Mann-Whitney U test. The significance level is < .050.

The results of the statistical tests indicate significant differences in the use of the FC methodology depending on the type of classroom space (see Table 11). Specifically, significant differences were found between:

- The use of FC in classical rows layout classrooms is lower compared to the organization in subject-specific classrooms, open classrooms, and classrooms with variable structure.
- The use of FC is higher in classrooms with variable structures compared to classical rows layout classrooms and subject-specific classrooms.

These findings suggest that the physical environment in which teaching is delivered significantly influences the implementation of the FC methodology.

Table 12
Use of FC with respect to the academic semester

		Sample 2					
		1S_20-21	2S_20-21	1S_21-22	2S_21-22	1S_22-23	2S_22-23
Sample 1	1S_20-21						
	2S_20-21	0,789					
	1S_21-22	0,852	0,916				
	2S_21-22	0,422	0,168	0,198			
	1S_22-23	<0,001	<0,001	<0,001	<0,001		
	2S_22-23	0,463	0,208	0,242	0,948	<0,001	

Note: P-values obtained after applying the Mann-Whitney U test. The significance level is < .050.

Similarly, significant differences are observed in the use of FC during the first semester of the 2022-23 academic year compared to the rest of the observed semesters (see Table 12).

HYPOTHESIS TESTING

After applying statistical tests to test hypotheses, the results obtained allow us to make significant comparisons between the data associated with each hypothesis (H1-H7):

- H1. Type of educational institution and use of FC: The Kruskal-Wallis test revealed that the type of institution (public, private, or subsidized) is a statistically significant factor in the frequency of FC use, with a significance value of 0,041. This leads us to reject the null hypothesis, suggesting that the type of institution influences how FC methodology is adopted.
- H2. The specialty of knowledge in secondary education and adoption of FC: Using the Kruskal-Wallis test, it was found that the specialty of knowledge (biology-geology, physical education, geography-history, English language, Spanish language-literature, mathematics, and professional-oriented training) is a statistically significant factor in the adoption of FC, with a significance value less than 0,001. This indicates a need to reject the null hypothesis, showing that the specialty area significantly affects the implementation of FC.

- H3. Years of teaching experience and use of FC: The significance found in the Kruskal-Wallis test was 0,608, which indicates that the number of years of teaching experience does not significantly affect the use of FC, retaining hence the null hypothesis.
- H4. Type of pedagogical training of teachers and adoption of FC: With a significance value of 0,513 in the Kruskal-Wallis test, it is concluded that the type of pedagogical training received by teachers is not a determining factor in the adoption of FC, thus retaining the null hypothesis.
- H5. Age of teachers and adoption of FC: The test yielded a significance value of 0,004, indicating that the age of teachers is indeed a statistically significant factor in the adoption of FC. This leads us to reject the null hypothesis, indicating that age does influence the implementation of this methodology.
- H6. The spatial arrangement of classrooms and use of FC: The analysis using the Kruskal-Wallis test showed a significance value of less than 0,001, revealing that the spatial arrangement of classrooms is a statistically significant factor in the use of FC. Therefore, the null hypothesis is rejected, suggesting that the physical classroom environment influences the application of FC.
- H7. Relationship between the academic semester and the use of FC: With a significance value of 0,004 in the Kruskal-Wallis test, it is determined that the use of FC is significantly related to the academic semester, leading us to reject the null hypothesis. This indicates that the timing (by semesters) within an academic year affects the implementation of FC.

These results provide information about the factors influencing the adoption and practical implementation of the FC methodology, highlighting the importance of the type of educational institution (public, private, or subsidized), the area of knowledge, the age of teachers, and the spatial arrangement of classrooms, while years of experience and the type of pedagogical training of teachers were not identified as significant determining factors.

DISCUSSION AND CONCLUSIONS

Discussion

The results of this research on the use of the FC methodology concerning the type of educational institution show statistical differences between subsidized centers compared to public ones, without finding these differences between private and subsidized centers. These data are consistent with other studies that have also analyzed the use of this methodology based on the type of institution (Pozo et al., 2021). Among the reasons, the lack of technical-pedagogical resources and the teachers' lack of knowledge are identified as the main contributors to not using FC in classrooms. In this context, studies by Tucker (2012) have revealed a strong association between the utilization of this methodology and the resource availability within educational establishments. They noted that public institutions typically possess fewer technological resources in comparison to private ones (López-Aguado, 2020), and their students often have limited access to electronic and virtual tools as well as less familial support, resulting in lower cultural and human capital (Cabrera, 2020). Therefore, it is plausible to suggest that the observed discrepancy in usage may stem from underlying social and economic factors.

Another factor that, in line with our analyses, influences the application of FC in classrooms is the age of the teacher, where differences have been found among professionals over 40 years old compared to other younger age groups. This finding is consistent with other studies such as that of Vega et al. (2021), where age has been identified as a decisive factor in determining the digital competence of teachers across all its dimensions, with higher competencies found in the age groups between 31 and 40 years old. This fact, combined with the relationship between the degree of use of active methodologies and the level of teachers' digital competence (López et al., 2019; Hao & Lee, 2016), as defined by Andía-Celaya et al. (2020) as "highly improvable," could explain the lack of implementation of the FC model in classrooms by teacher groups over 40 years old. In this sense, teachers must be able to integrate new technologies into pedagogical models, even if they have very superficial knowledge about their use (Mollo-Torrico et al., 2023). Continuous training must play an essential role in ensuring the ongoing development of educational professionals (Torres & Álvarez, 2019) who facilitate the integration of active methodologies in the classroom.

It is worth noting that teaching experience has not proven to be a decisive factor, which might seem contradictory but aligns with Tello and Cascales (2015). The influx of mid-career professionals into teaching in recent years could explain this, as experience does not always correlate with age uniformly. However, attributing this difference solely to that factor would be speculative, warranting further research for clarification.

On the other hand, after analyzing the results concerning the semester variable, it is worth noting that the data appear to be fairly stable over time, with no significant differences found. The only exception is in the first semester of 2022-23, where a lower usage of FC is detected. It is possible that the initial effort to adapt to the new Spanish curricular legislation in secondary education (LOMLOE) could be behind this decline, but this hypothesis cannot be confirmed based on the data collected in this study.

Our study examines the use of FC after the pandemic, which began in early 2020. The shifts in educational paradigm during the lockdown situation have been well-documented in educational research, detecting changes in the utilization and management of resources (López et al., 2021), the onset of unforeseen virtual education (Estévez-Méndez & Moraleda, 2022), and an increase in emotional strain due to higher teaching workload and consequently increased stress during this period (Bravo-Villa et al., 2022). However, adaptations in the use of employed methodologies and the discovery of new available possibilities (Gómez-Hurtado et al., 2020; Purizaca-Gallo & Jolay-Benites, 2022) forced all teachers to face a technological challenge for which they were not prepared (Bonilla, 2020), but which allowed the creation of an alternative learning system particularly linked to student self-management and self-regulation (Muñoz & Lluch, 2020). In this sense, the stability detected in the use of FC can be interpreted as a sign of consolidation of this methodology in the educational institutions that continued to use it after returning to face-to-face instruction, demonstrating the partial consolidation of the learning made during the lockdown period.

It is also worth noting the significance of the specialty of knowledge when implementing the FC methodology, with two distinct groups observed: mathematics, Spanish language and literature, and biology and geology showing lower usage compared to physical education, geography, and history, English language, or professionally oriented training with higher usage. The reasons for this difference cannot be speculated on in this study, but further investigation into this topic is

necessary to explore potential epistemological or academic social prestige reasons that may shed light on this disparity.

We have uncovered significant findings concerning the classification of classroom spaces and the use of FC methodology. Nonetheless, similar to the examination of the specialty of knowledge variable, it is prudent to approach these findings with caution due to the absence of supporting evidence in the scientific literature to corroborate the results obtained in this study.

Conclusions

In line with the findings presented here and in accordance with the analyzed scientific evidence, it can be affirmed that the FC methodology is applied unevenly depending on the age of the teacher, with its use predominantly among age groups under 40. Concerning the type of educational institution, a higher usage is observed in private and subsidized schools, which seems to stem from differences in training and available resources. The post-pandemic usage has remained fairly constant across different semesters analyzed, although there are fluctuations in its sporadic use in classrooms, the reasons for which are not clear but may be due to circumstantial factors. The variables of specialty of knowledge and classroom spatial typology have also shown significance, although further research is needed to confirm these differences and investigate their causes. It should also be noted that variables such as years of experience or pedagogical training of the teacher do not present significant differences when adopting the FC methodology.

The results obtained in this study will enable the educational community to understand the importance of key factors such as ongoing training associated with the age of the teacher, the development of digital competencies, or the relevance of having the necessary resources to implement the FC methodology in classrooms.

Limitations and Future Directions

One of the primary limitations of our study is the temporal scope of the sample used. We couldn't compare the results obtained with pre-pandemic data or reliable data on FC usage during the pandemic. Longitudinal studies over time are needed to identify potential trend changes.

Looking ahead, it is imperative to consider several directions in which research could be expanded to enrich and validate our conclusions. A promising line of inquiry would be to further explore those variables that have proven to be significant but lack comparative studies in the scientific literature. An example of this could be the detailed study of variations found in different specialties of knowledge or the examination of the impact of different types of classroom spaces. Additionally, the incorporation of additional variables, such as the gender of participants or a broader and more representative geographical distribution of the sample, could provide a deeper understanding of the use and peculiarities of the FC methodology analyzed in this study.

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