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Comparison of Effectiveness between Flipped and Online Learning as Learning Models: A Comparative Analysis in Initial Teacher Training

Comparación de la eficacia entre el aprendizaje invertido y el aprendizaje en línea como modelos de aprendizaje: un análisis comparativo en la formación inicial del profesorado.

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Abstract

This study pursues the objective of comparing students' perceptions between two contemporary teaching methodologies: online learning and the flipped model. It focuses on how these approaches influence the acquisition of key competencies in the educational process. A quasi-experimental methodology with a pretest-intervention-posttest design was implemented in a sample of university students, seeking to comprehensively evaluate the differences in the learning dimensions, the developed competencies and the final grades. The results show an important correlation between the application of online and flipped learning methods with improvements in academic performance. It was evident that the fusion of both approaches promotes a positive effect on educational experiences, self-assessment and the acquisition of knowledge, without one clearly standing out over the other. The study highlights the importance of proper integration of technology in education, highlighting flipped learning as an ideal starting point for beginning students, due to its effectiveness in linking theory and practice, before moving towards online learning that allows more autonomy, it recognizes the limitations of his results due to the small sample used, but finds them promising, recommending future research with larger and more diversified groups to confirm and expand the applicability of these educational methodologies.

Keywords: ICT, educational technology, flipped learning, e-learning, learning environments.

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Comparación de la eficacia entre el aprendizaje invertido y el aprendizaje en línea como modelos de aprendizaje: un análisis comparativo en la formación inicial del profesorado.

Palabras clave: TIC, tecnología educativa, aprendizaje invertido, aprendizaje electrónico, entornos de aprendizaje.

Resumen

Este estudio persigue el objetivo de comparar las percepciones de los estudiantes entre dos metodologías de enseñanza contemporáneas: el aprendizaje en línea y el modelo de aula invertida. Se centra en cómo estos enfoques influyen en la adquisición de competencias clave en el proceso educativo. Se implementó una metodología cuasiexperimental con un diseño pretest-intervención-postest en una muestra de estudiantes universitarios, con el fin de evaluar de manera integral las diferencias en las dimensiones del aprendizaje, las competencias desarrolladas y las calificaciones finales. Los resultados muestran una correlación importante entre la aplicación de los métodos de aprendizaje en línea y de aula invertida y las mejoras en el rendimiento académico. Se evidenció que la fusión de ambos enfoques promueve un efecto positivo en las experiencias educativas, la autoevaluación y la adquisición de conocimientos, sin que uno destaque claramente sobre el otro. El estudio subraya la importancia de una correcta integración de la tecnología en la educación, destacando el aprendizaje invertido como un punto de partida ideal para los estudiantes principiantes, debido a su eficacia para vincular la teoría y la práctica, antes de pasar al aprendizaje en línea que permite una mayor autonomía. Reconoce las limitaciones de sus resultados debido al pequeño tamaño de la muestra utilizada, pero los considera prometedores, recomendando futuras investigaciones con grupos más amplios y diversos para confirmar y ampliar la aplicabilidad de estas metodologías educativas.

Introduction

The COVID-19 pandemic marked a turning point in education, accelerating the adoption of technological and pedagogical tools to sustain teaching and learning [1], This forced transition, from in-person modalities to digital approaches, or more accurately, to pseudo-virtual modalities, questioned the dichotomy between the virtual and the real, establishing virtuality as an extension of human interaction [2], supported by a diverse set of digital devices and platforms [3], [4]. With the resumption of face-to-face activities after confinement, an increase in the digital skills of teachers and students was perceived [5], and among educators a revaluation of their role emerged, strengthening their dedication to teaching [6]. This phenomenon has opened exploration to optimize the use of technology in educational contexts, highlighting the importance of expanding learning beyond the physical space of the classroom, as reflected in the hybrid model [7], which encompasses both virtual learning in its multiple forms such as flipped learning.

Flipped learning, in particular, transforms the management of educational time outside the classroom, allowing students to anticipate their training through educational platforms with accessible material before face-to-face classes [8]. This method favors deepening the topics during face-to-face sessions through feedback and practical activities, thus promoting more active learning. It has been shown that this methodology not only increases student motivation and participation, but also encourages collaboration between peers and with teachers [9]-[11], and contributes to a more effective assimilation of the contents, which is translates into improved educational results and academic performance [12]-[15].

The approach adopted in the teaching-learning process is decisive in the educational experiences of students. The literature shows that approaches based on constructivism facilitate a synergistic interaction between teaching, assessment and the learning environment, positively impacting results [16], [17]. Current research must, therefore, analyze the components of the educational environment that directly impact teaching and learning [18]. Virtual environments, designed for adaptive and stimulating pedagogical practices, offer interactive and collaborative experiences [19], [20], placing the student in a central position and promoting problem-solving and analytical skills [21], [22]. In this framework, it is essential that students develop key competencies to successfully maneuver in hybrid environments and in flipped and online learning modalities [23].

Therefore, techno pedagogical methodologies and models are fundamental in the evolution of education, responding to complex challenges, even in disruptive situations such as those generated by the pandemic [24]. Teaching competencies, particularly digital ones, are vital for the implementation of effective training practices that address student needs and contexts. In turn, students' skills are decisive for success in ubiquitous learning environments. It is, therefore, imperative to develop advanced metacognitive competencies, ranging from time management to critical and creative thinking, to apply theory in practice and promote autonomy in learning.

The present research examines the comparative effects of online learning and the inverted pedagogical model on the perceptions of students of an initial teacher training program in Mathematics at a Colombian university, using a questionnaire to evaluate how these methodologies influence the acquisition of educational competencies.

Materials and methods

Design of the investigation

A quantitative methodology was adopted, implementing a quasi-experimental design, characterized by pretest and posttest evaluations in non-equivalent groups. This configuration was selected due to practical constraints on random assignment and control of variables. Data were analyzed with Student's t test for independent and related samples. The Wilcoxon W test was applied, given the nature of the data distribution and the sample size of approximately 30 participants per group, which limits the effectiveness of parametric methods. The practical effect of the interventions was quantified by calculating the effect size.

Instrument

For data collection, an adapted version of the Teaching and Learning Experiences Questionnaire [27] was used, focusing on two dimensions: "Approaches to learning and studying" and "Teaching and learning experiences". Representative items were selected for an abbreviated version, with the aim of optimizing the administration of the questionnaire without compromising conceptual integrity. The first is subdivided into: deep approach (6 items), superficial approach (4 items), follow-up study (4 items) and organized study (4 items), totaling 18 items. The second includes: organization and structure (8 items), teaching and learning (15 items), student-teacher interaction (7 items) and evaluations and assigned work (10 items), totaling 40 items. In both, responses are rated on a 5-point scale, from "agree" (5) to "disagree" (1). For the present analysis, an abbreviated version of these dimensions was chosen [28].

The content, criterion and construct validity of the questionnaire, as well as its reliability, were confirmed by previous studies, with internal consistency coefficients (Cronbach's alpha) and confirmation of the theoretical model through factor analysis [16], [17], [29]. Its application has been successful in various educational environments [30]-[32].

Interventions implemented

In response to the confinement due to the pandemic, online learning in a pseudo-virtual modality [1], also called emergency remote education [33], [34], was adopted during the second half of 2021. This measure was taken given that the courses were not designed for full virtual implementation. With the reincorporation of in-person attendance, for the first semester of 2022, the flipped classroom modality was implemented. Standardized didactic

sequences were administered for each educational format and, as part of the evaluation process, a questionnaire was applied as an initial test (pretest), in order to establish a baseline for data comparison. After the educational intervention, the questionnaire was administered again as a final test (posttest). In addition, academic performance data was collected, with the final grades assigned by the teacher, to perform a complementary analysis.

Population under study

The research focused on 60 students enrolled in the initial training program for teachers in a Bachelor's degree in Mathematics at a Colombian public university. The distribution of participants into two groups, one of 31 students for online learning and another of 29 for the flipped learning modality, was based on the teaching modality received. The selection was intentional, with the teacher in charge of the groups, playing a dual role as facilitator and researcher in the study. Special attention was paid to the demographic profile, recording 54.9% female participants and an average age of 19 years, to better understand the diversity and characteristics of the sample.

Information processing and analysis

The data were processed with SPSS v25, using descriptive and inferential statistics, including Student's t test and point biserial correlation, the latter to evaluate the relationship between ratings and perceptions through the questionnaire.

Results

The section details a meticulous analysis of data from a study comparing online and flipped learning, using pre- and post-evaluations of the educational intervention and applying statistical analyzes to validate the findings. It includes descriptive statistics and inferences to understand the significant differences between the groups studied, interpreting the results with a balanced approach in their statistical significance and their importance in education.

Descriptive Statistics of Pretest and Posttest

Descriptive statistics such as mean and standard deviation of both pretest and posttest are presented in Table 1 for the comparison of online and flipped learning approaches.

Table I. Descriptive statistics for the study dimensions

		Pretest		Posttest	
Learning focus	Dimensions	Average	Standard deviation	Average	Standard deviation
Online	Approaches to learning and studying	3.11	0.34	3.36	0.35
	Teaching and learning experiences	3.50	0.43	3.62	0.32

	Final course grade	3.18	0.47	3.69	0.49
Invested	Approaches to learning and studying	3.08	0.35	3.50	0.34
	Teaching and learning experiences	3.48	0.42	3.71	0.30
	Final course grade	3.12	0.50	3.43	0.53

In Table I, descriptive statistics show that pretest measurements are similar between groups. This homogeneity is essential for subsequent comparisons, allowing us to conclude that the dimensions evaluated are equivalent in both learning approaches. Especially noteworthy is the 'Teaching and learning experiences' dimension, which receives the highest rating, reflecting a positive perception of the course by students.

Posttest measurements indicate an increase in all dimensions for the online and flipped approaches, with significant improvements compared to the pretest. The final course grade, in particular, shows a greater increase in online learning, suggesting that this approach may be more effective in improving academic performance. In flipped learning, 'Teaching and Learning Experiences' again feature prominently, signaling positive interaction with the learning environment and effective acquisition of knowledge and skills.

Contrary to what was expected, a significant difference is not detected in the pretest-posttest measurements, which could indicate that while there are improvements, they are not statistically significant at a general level. However, the low dispersion of responses, indicated by the consistent standard deviation, suggests congruent and reliable responses within the groups studied.

Comparison of Learning Approaches Using Student's t-statistic

online learning and flipped learning, both for pretest and posttest evaluations. This analysis is carried out using the Student's t statistic for independent samples, with a statistical significance threshold set at $p < 0.05$. Values lower than this threshold indicate statistically significant differences between the groups.

Table II. Student's t for independent samples with pretest and postest

Dimensions	Proof	mean difference	tn1+n2-2	df	d	**rxy**
Approaches to learning and studying	pretest	0.03	ns	31	ns	ns
	posttest	-0.14	-2.64**	29	0.01	0.19
Teaching and learning experiences	pretest	0.02	ns	31	ns	ns
	posttest	-0.09	-3.62**	29	0.01	0.14
Final score	pretest	0.06	ns	31	ns	ns
	posttest	0.26	4.46**	29	-0.02	-0.23

Note: **The correlation is significant at the 0.01 level; ns non-significant correlation

The detailed analysis of Table II reflects a consistency in the pretest results between the online and flipped learning approaches, demonstrating an absence of statistically

significant differences in the means of each dimension evaluated. This homogeneity is essential, as it establishes an equitable baseline from which it is possible to evaluate the differentiated impacts of educational interventions.

In the posttest phase, however, notable differences emerge. Specifically, the final grade in online learning significantly exceeds that of the flipped approach, indicating that, after educational intervention, online learning could have an advantage in improving students' academic performance.

Furthermore, the biserial correlation scores toward a relationship strength of medium-low magnitude on the posttest, with the effect size remaining minimal. Although the differences are statistically significant, this measure of effect size suggests that the magnitude of the relationship between study variables and learning approaches, although present, is modest. This finding implies that while learning approaches have a discernible impact on academic outcomes, the strength of this impact is relatively limited and must be considered in context with other educational and pedagogical factors that may also influence student performance.

Analysis of Related Samples: Pretest vs. Posttest

Table 3 presents an evaluation of intragroup differences, comparing the results obtained in the evaluations before and after the educational intervention for the online and flipped learning approaches. A statistical significance threshold of $p < 0.05$ has been established to determine the relevance of the variations observed between the pretest and posttest measurements. This rigorous demarcation ensures that the reported improvements are not only mathematically robust but also pedagogically significant.

Table III. Student t for related samples between the pretest and the postest of online and flipled learning

Dimensions	Learning focus	mean difference	tn1+n2-2	df	S.D.
Approaches to learning and studying	Online	-0.25	-7,448**	31	0.437
	Invested	-0.42	-11,818**	29	0.459
Teaching and learning experiences	Online	-0.12	-3,563**	31	0.450
	Invested	-0.23	-6,906**	29	0.440
Final score	Online	-0.51	-10,083**	31	0.661
	Invested	-0.31	-5,980**	29	0.680

Note: **. The correlation is significant at the 0.01 level; ns non-significant correlation.

The student's t-test for related samples applied to the online learning data set, involving 31 students, revealed a statistically significant improvement in all study dimensions. This reflects a positive and tangible effect of learning methods on students' academic performance. In particular, the progression in the final course grade stands out, demonstrating the beneficial impact of the applied pedagogical approaches on academic results.

On the other hand, for the flipped learning group, which consists of 29 students, a non-parametric analysis was chosen using the Wilcoxon W test, given the number of subjects less than 30, which is the standard requirement for the implementation of tests. parametric. Although the effect size was not calculated due to the non-parametric nature of the test and the lack of a normal distribution of the data, the results obtained are nonetheless significant.

The findings detailed in Table 3 corroborate that both learning modalities are not only effective, but also contribute to substantial progress in students' understanding and skills. The difference in means indicates a particularly notable improvement in final grade for online learning, suggesting that this approach might be slightly more effective in improving academic performance compared to flipped learning.

Discussion

The relevance of integrating technology in the educational process has been emphasized by the results of recent research, pointing out the transition from a support tool to a fundamental pillar that promotes interaction and student enthusiasm. The pandemic crisis acted as a catalyst in this process, accelerating the digital transformation of education and the adoption of various technological tools.

Advances in technological pedagogical methods, such as online learning and the flipped model, have been enhanced during the pandemic, promoting open and flexible pedagogical practices that have transitioned towards hybrid models in the post-pandemic [7]. This change has highlighted the importance of techno-pedagogical training to strengthen the digital skills of teachers and students, through the use of learning management systems [8], [39].

Research has used pretest and posttest evaluations to compare traditional educational approaches with technological approaches, revealing significant improvements in academic performance, teaching and learning experiences, and in the acquisition of knowledge and skills such as self-assessment [16], [17], [29], [30], [40]. This reinforces the need for an optimal training environment and adequate digital competencies for an effective teaching and learning process in virtual environments [41], [42], [43], [44].

The core of effective learning lies not only in the selection of technology, but in the effectiveness with which techno-pedagogical tools are chosen, designed and implemented in teaching strategies [45]. The combination of methods and techniques and the alignment of teaching with the learning styles of students are crucial for their development and the improvement of educational processes.

The transition to digital has blurred the boundaries between virtual and real interactions, expanding learning beyond classrooms with hybrid models [1], [2], [7]. Flipped learning highlights the importance of prior preparation and more active and collaborative learning,

reflected in educational results [8], [9]-[15].

Pedagogical approaches, especially constructivist ones, significantly influence the quality of educational experiences, requiring a detailed analysis of their impact on educational environments [16], [17], [18]. Virtual environments facilitate interactive experiences, promoting analysis and problem solving and underscoring the importance of advanced competencies for effective autonomy in learning [19]-[23].

Current techno-pedagogical models are key in the evolution of education, facing complex challenges and emphasizing the importance of methodologies adapted to the challenges of modern education [24]. Teachers' digital competencies and students' capacity for autonomous learning are critical to success in ubiquitous learning environments.

Conclusions

This study set out to comparatively examine online learning approaches and flipped learning in terms of their impact on students' academic progress. The results indicated that no significant differences were detected in the overall results between both modalities, however, it was observed that both approaches produce positive results. This phenomenon is attributed to the variations in the specific learning dimensions analyzed, which suggest an enhancement of learning, particularly in the areas associated with metacognitive strategies and academic achievements, reflected in the final grades. These findings imply that the incorporation of digital educational practices can comprehensively benefit the teaching-learning process. It follows, therefore, that both techno-pedagogical approaches offer innovative and viable routes for the development of critical skills and competencies in students.

From a methodological perspective, and taking into account that the study subjects are in the initial stages of their professional training with a prior emphasis on face-to-face education, the initial adoption of flipped learning is recommended. This approach, which is based on a hybrid integration of online and in-person resources, could serve as a precursor to a complete transition to fully virtual teaching methods. Therefore, it is postulated that the complementarity of inverted and online learning is fundamental for educational development, opening wide possibilities for innovation in face-to-face, blended and virtual educational environments.

Given the exploratory and preliminary nature of this pilot study, the results cannot be extrapolated beyond the investigated sample. It is strongly recommended that future research be expanded to include a more diverse sample, encompassing various academic programs and educational levels at different institutions. Despite the limitations, this research provides a referential framework that will lay the foundation for subsequent research, expanding the understanding of the implementation of innovative techno-pedagogical learning methodologies.

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