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Original article

Effectiveness of classroom methodology flipped with artificial intelligence in postgraduate courses

Efectividad de la metodología aula invertida con inteligencia artificial en cursos de posgrado

Eficácia da metodologia de sala de aula invertida com inteligência artificial em cursos de pós-graduação

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ABSTRACT

The postgraduate programs at the Open University for Adults require learning environments that motivate and foster interest in learning through active methodologies, like the flipped classroom. This is an element of the institutional pedagogical model that requires monitoring and recognition in online distance learning. The objective of this article is to describe perceptions of the effectiveness of the flipped classroom methodology with artificial intelligence in online postgraduate courses. It adopts a mixed-methods approach and is a descriptive exploratory study conducted with five groups of online participants. An online instrument, a Likert scale, was used. The effectiveness of the flipped classroom was defined by experiences characterized by motivation, autonomy, responsibility, active participation, and acceptance. This methodology is an innovation in teaching with artificial intelligence tools, compared to traditional classes, by considering the perspectives of being, doing, and ought-to-be of the participants as protagonists of their own learning. The evaluation and

incorporation of the flipped classroom as an active teaching methodology that redefines the roles and responsibilities of the facilitator and participants in online postgraduate courses is imperative.

Keywords: flipped classroom; artificial intelligence tools; virtual classes; postgraduate studies.

RESUMEN

En los programas de posgrado de la Universidad Abierta para Adultos se exigen ambientes de espacios de formación que motiven y propicien el interés por aprender con las metodologías activas, como el aula invertida; este es un elemento del modelo pedagógico institucional que requiere seguimiento y reconocimiento en la enseñanza a distancia virtual. El objetivo del presente artículo es describir las percepciones sobre la efectividad de la metodología aula invertida con inteligencia artificial en los cursos virtuales de posgrado. Asume el enfoque mixto y es un estudio exploratorio descriptivo, a cinco grupos de participantes virtuales. Se aplicó un instrumento en línea, escala Likert. La efectividad de la clase invertida fue definida en experiencias caracterizadas por la motivación, autonomía, responsabilidad, participación activa y aceptación. Esta metodología es una innovación en la enseñanza con herramientas de inteligencia artificial, frente a las clases tradicionales, al considerar las perspectivas del ser, hacer y deber ser de los participantes como protagonistas de su propio aprendizaje. Es imperiosa la valoración e incorporación del aula invertida, como metodología activa de enseñanza que redefina los roles y la figura del facilitador y de los participantes, en los cursos virtuales de posgrado.

Palabras clave: aula invertida; herramientas de inteligencia artificial; clases virtuales; posgrado.

RESUMO

Os programas de pós-graduação da Universidade Aberta para Adultos exigem ambientes de aprendizagem que motivem e fomentem o interesse pelo aprendizado por meio de metodologias ativas, como a sala de aula invertida. Este é um elemento do modelo pedagógico institucional que requer monitoramento e reconhecimento no ensino a distância online. O objetivo deste artigo é descrever as percepções sobre a eficácia da metodologia da sala de aula invertida com inteligência artificial em cursos de pós-graduação online. Adota-se uma abordagem de métodos mistos e trata-se de um estudo exploratório descritivo com cinco grupos de participantes online. Foi utilizado um

instrumento online, uma escala Likert. A eficácia da sala de aula invertida foi definida por experiências caracterizadas por motivação, autonomia, responsabilidade, participação ativa e aceitação. Essa metodologia representa uma inovação no ensino com ferramentas de inteligência artificial, em comparação às aulas tradicionais, ao considerar as perspectivas do ser, do fazer e do dever ser dos participantes como protagonistas de sua própria aprendizagem. O modelo da sala de aula invertida é essencial para avaliação e integração como uma metodologia de ensino ativa que redefine os papéis tanto dos facilitadores quanto dos participantes em cursos de pós-graduação online.

Palavras-chave: sala de aula invertida; ferramentas de inteligência artificial; aulas virtuais; estudos de pós-graduação.

INTRODUCTION

The pedagogical model of the Open University for Adults (OUFA) offers spaces for training, supported by technological means and resources, based on didactics and social aspects; these refer to learning methodologies such as the flipped classroom and the forms of action from the interaction between social actors, and the entrepreneurial, innovative and investigative spirit of the participants and teachers.

In OUFA's virtual distance learning graduate programs, stimulating learning environments are necessary that challenge participants' inquiry and motivation to learn with active methodologies such as the flipped classroom. *Classroom*, which reverses the way course content is taught, is considered a help to students who, for various reasons, cannot attend face-to-face classes.

In the flipped classroom model, according to Rodríguez (2024), "classes left to be lectures by the teacher, and become spaces for the application and execution of new knowledge, meaningful learning and the development of skills or competencies" (p. 57).

The flipped classroom, as an innovative educational approach, transforms the traditional roles of students and teachers. It is an interactive strategy that, with emerging technologies, improves student performance and digital skills. By promoting creativity, self-study, and collaborative learning, it is creating new ways of conceiving the teaching process in virtual and hybrid learning environments (Martínez & Ruiz, 2022).

In this order, Salas *et al.* (2021, p. 34) emphasize that the flipped classroom methodology and the use of technological tools improve teaching conditions because they allow for innovative and creative activities and facilitate knowledge assimilation. The flipped classroom, combined with artificial intelligence (AI) tools, fosters inquiry skills in students, promotes a culture of responsibility through active participation, and improves the social skills so necessary in virtual distance education (Mayorga, 2024).

The flipped classrooms are strengthened by AI and other technological resources. In this regard, Barragán *et al.* (2024) and Gallent *et al.* (2023) emphasize the use of technologies within the framework of ethics.

AI offers a wide variety of tools for teachers to enhance their teaching and facilitate increasingly engaging and accessible multimedia content, which would ultimately motivate participants. The flipped classroom methodology has been studied, and concrete experiences and results have been demonstrated; for example, Jia *et al.* (2023), Salas *et al.* (2021), and Webb and Doman (2020) confirmed that flipped classroom promote higher-order thinking skills and overall student well-being through activities before, during, and after class; they foster creativity, reduce anxiety, and promote digital literacy.

According to Espada *et al.* (2020), the flipped classroom is gaining popularity in universities because it increases inquiry capacity, motivates students, and fosters critical thinking. The flipped classroom, combined with technology and AI, promotes higher-order thinking skills. These levels of thinking contribute to academic performance and achievement in distance learning.

> The flipped classroom methodology…generated a) Promotion of student autonomy, b) Development of critical and self-critical thinking, c) Development of active, meaningful and collaborative learning, d) Creativity on the part of the teacher, e) Greater responsibility, organization and planning of study hours on the part of the students, f) Development of technological skills, both for the student and for the teacher (Rodríguez, 2024, p. 56).

Flipped classroom in higher education have a positive impact on student learning outcomes, but face challenges in adapting to new roles and overcoming resistance from instructors and students, for example, when integrating AI tools into teaching and learning.

In this sense, teachers face the challenge of providing students with active methodologies that produce the necessary knowledge and values to relate to AI in an ethical and efficient manner, in order to promote problem-solving, creativity and design thinking, always from a human-centered approach, with innovative teaching methods (UNESCO, 2024).

This methodology values the personal nature of learning, available resources, context and concrete experiences, the interactive nature of learning, the importance of production and creation, and reflection on learning. These aspects are fundamental in the planning and development of the flipped classroom in virtual classes (Competency-Based Learning-Centered Educational Model, MECCA, 2009).

The theoretical foundation of the flipped classroom methodology is Vygotsky's social constructivism (1981), because it values the social aspect, since the acquisition of new knowledge involves the interaction of existing structures within the learner and new information. Participating with others in the flipped classroom fosters emotional and intellectual support, collaborative work, and self-regulated learning, allowing students to surpass their current level of knowledge and attitudes through interaction with the facilitator, peers, content, and technological tools in virtual distance learning.

The flipped classroom model incorporates Vygotsky's sociocultural theory, emphasizing the collective construction of learning, interaction, and active and participatory autonomy of students within their sociocultural context. This is combined with the dynamics offered by educational technologies and tools such as AI, which are effective in university contexts, particularly in postgraduate programs with clearly defined pedagogical objectives and continuous evaluation, to maximize benefits while minimizing risks.

Furthermore, experiential learning theory suggests that learning is most effective when based on direct experience; in this sense, AI tools can help create simulations or practical scenarios that enrich each learning experience in the virtual flipped classroom. The flipped classroom adopts a competency-based educational approach, characteristic of the OUFA's competency-based educational model (MECCA, 2009), where the objective is to develop specific, relevant, and necessary skills for professional development.

Based on the arguments presented above, this research is important because the integration of the flipped classroom with AI is an innovation that transforms learning roles, schedules, and spaces.

Participants perceive and interpret the value and link between pedagogical theory and teaching practice in virtual environments. The research aims to describe the effectiveness of the flipped classroom with AI tools in online postgraduate courses. To this end, the following research question is posed: What are the participants' perceptions of the effectiveness of the flipped classroom methodology with AI in online distance learning?

MATERIALS AND METHODS

This study considered a mixed approach to understand in depth the meanings given to the situation or object of study, from the perceptions of participants in several virtual distance postgraduate courses. The selected context was the Master's programs in Educational Technology Management and Psycho-pedagogical Intervention offered by the Postgraduate Academic Directorate of OUFA. Participants (160) from five online groups of the Master's programs were randomly selected as key informants based on the following criteria: enrolled in the third trimester of 2024, in the fourth and fifth trimesters of the Master's program, and participating in the online distance learning modality.

The purpose was to describe how participants perceive the effectiveness of flipped classrooms with AI developed in the postgraduate courses: Current Approaches to Learning Theories, Technological Tools at the Service of Learning Processes, Qualitative Research and Workshop I, corresponding to the Master's degree in Psycho-pedagogical Intervention and Educational Technology Management, which are part of the postgraduate studies at OUFA, academic period 4-2024.

The tool best suited to the participants' distance learning modality was Google Forms. A structured form was designed, divided into four sections, using a Likert scale with multiple-choice questions, as well as an open-ended section that participants self-administered at the end of the five courses, where the flipped classroom methodology was implemented. Basic descriptive statistics and the numerical data from the online form were used to complement the qualitative analysis of the information.

Methodologically, it assumes a qualitative analysis and is complemented by a quantitative perspective. The information was subjected to analysis based on three a priori conceptual frameworks: didactic practice, represented in participation and use of AI tools; being, given in the effectiveness of learning and interaction; and the necessary actions of the flipped classroom in postgraduate virtual classes.

The qualitative analysis was developed in three stages: discovery, which involved clarifying the a priori frameworks of reality; axial coding, in which the data were grouped by similarity and differentiation, to discover subcategories and indicators, in the same way the quantitative results were considered added to the qualitative approach; the interpretation of the data, according to the context and the theoretical and empirical contributions.

The results, from a quantitative and complementary perspective, are presented in a first table and graphs with numerical and statistical data on the experience with the flipped classroom; in a second table, the central category of perceptions of the effectiveness of the flipped classroom in virtual postgraduate classes is presented from a qualitative perspective, which is defined in three subcategories, which show the being, the didactic doing and the ought to do.

RESULTS

Data analysis allows for understanding and contextualizing the findings, as it presents a detailed description of the collected data and identifies significant themes and relationships that emerge from the analysis. The discussion interprets these findings, connecting them to other studies and theoretical frameworks, thus providing a deeper understanding of the effectiveness of applying the flipped classroom model in postgraduate courses.

In relation to the findings collected and analyzed, several significant aspects emerged regarding perceptions of the flipped classroom with AI tools for teaching and learning. These dimensions are represented in terms of concepts and absolute frequencies of the responses given by the 160 participants. The results are presented below from a quantitative perspective (Table 1).

Table 1. Quantitative results

Experience with AI in virtual classrooms			
1. Dimension: Perception of the methodology	**1. Responses (%) Participants (160)**	**2. Dimension of effectiveness in learning**	**2. Responses (%) Participants (160)**
General experience	70% = very positive 30% = positive	Autonomy and responsibility	87%=yes, it encourages 13% = yes, in a way
Improved understanding	85% = significantly 13% = moderately 2% there was no change	Active participation	72% = yes, it increases 26% = yes, in a way 2% = decreases
Autonomy	100% = yes, it generates	Time management	98% = is used 2% = does not take advantage
Easy to use AI tools	98% = Yes, it's easy 2% = not easy	Meaningful learning	98% = yes, it generates 2% = does not generate
Satisfaction	63% = very satisfied 33% = satisfied 4% = neutral	This methodology is recommended	98% = Yes, recommends 2% = not recommended

Source: Own elaboration

The quantitative results of the experience with the flipped classroom in postgraduate virtual classes are described below; based on two dimensions: perception of the methodology, effectiveness in learning.

Perception dimension of the flipped classroom methodology

Regarding the perception of the flipped classroom methodology, the following results were observed in the graph of the form, already presented in table 1:

- Overall experience: Regarding this aspect, it can be highlighted that 70% of participants felt it was very positive; followed by 30%, who said that the experience with the flipped classroom methodology in the courses was positive.

- Improves comprehension: Regarding this aspect, 85% of participants indicated that it significantly improves comprehension; 13% said that it moderately improves the understanding of course content, and for 2% there was no improvement.
- Generates autonomy: Regarding this aspect, it was determined that 100% of the participants said that the flipped classroom generated autonomy in training.
- Easy use of AI tools: Regarding this aspect, 98% of participants say that it is easy to use AI tools to develop content in the flipped classroom, and 2% say that it is not easy.
- Satisfaction: Regarding this aspect, 63% are very satisfied, followed by 33% who are satisfied with this flipped classroom methodology, and 4% who are neutral. Figure 1 below illustrates the results described.

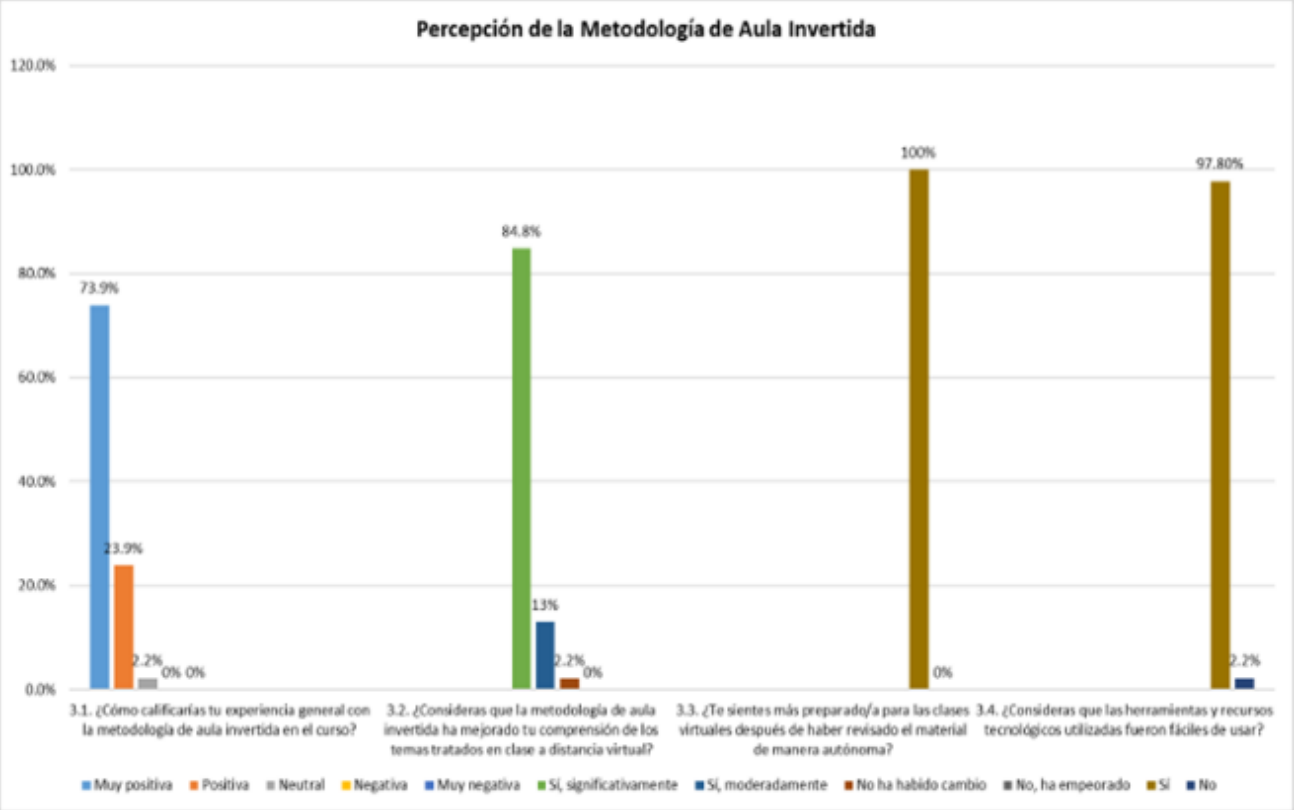

Figure 1. Results of the flipped classroom perception

Dimension of effectiveness in learning

Regarding the effectiveness of the flipped classroom methodology in learning, the following results were observed in graphs 2-3 of the form, represented in: impact on learning satisfaction and recommendations.

- Autonomy and responsibility: Regarding this aspect, 87% of participants say that it does promote autonomy and responsibility, followed by 13% who stated that it does promote it in some way in virtual distance learning.
- Active participation: Regarding this element, 72% of participants stated that active participation does increase, 26% said that participation in virtual classes increases to some extent, and 2% said that it decreases.
- Time management: In this aspect, 98% of participants stated that time is used more efficiently in flipped classroom activities, and 2% do not use time efficiently.
- Meaningful learning: In this sense, 98% of the participants stated that the flipped classroom methodology in postgraduate courses does generate meaningful learning, and 2% do not.
- Regarding the recommendation of this methodology, 98% of participants do recommend it, while 2% do not. The following two graphs illustrate the results described (Figures 2 and 3).

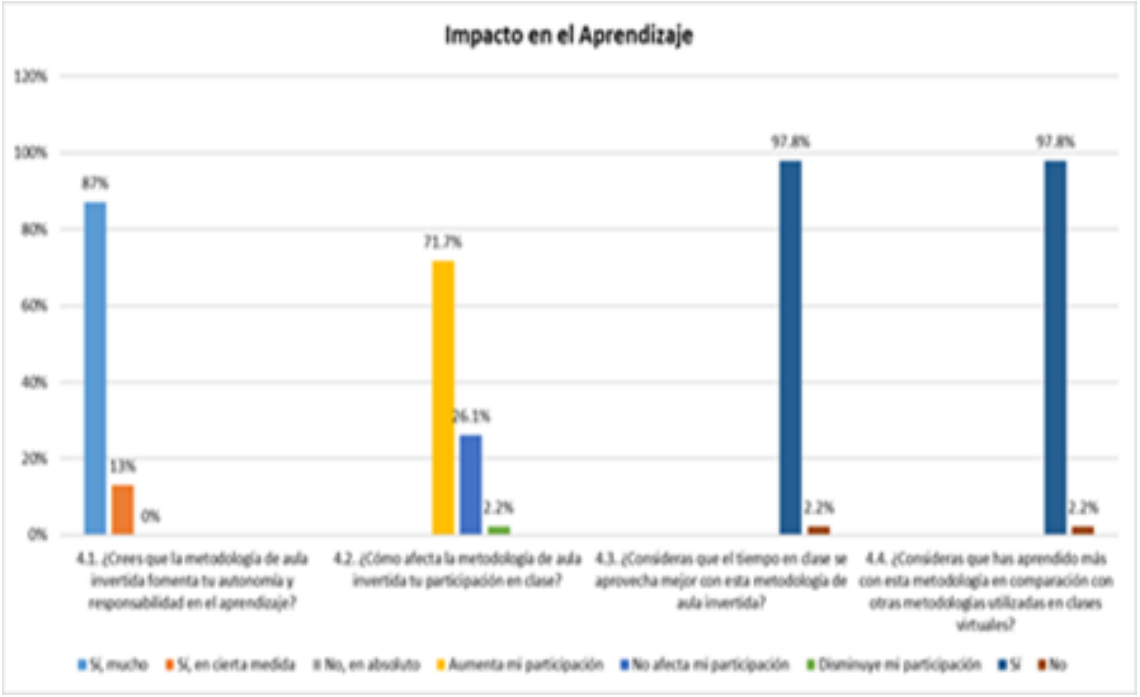

Figure 2. Impact on learning

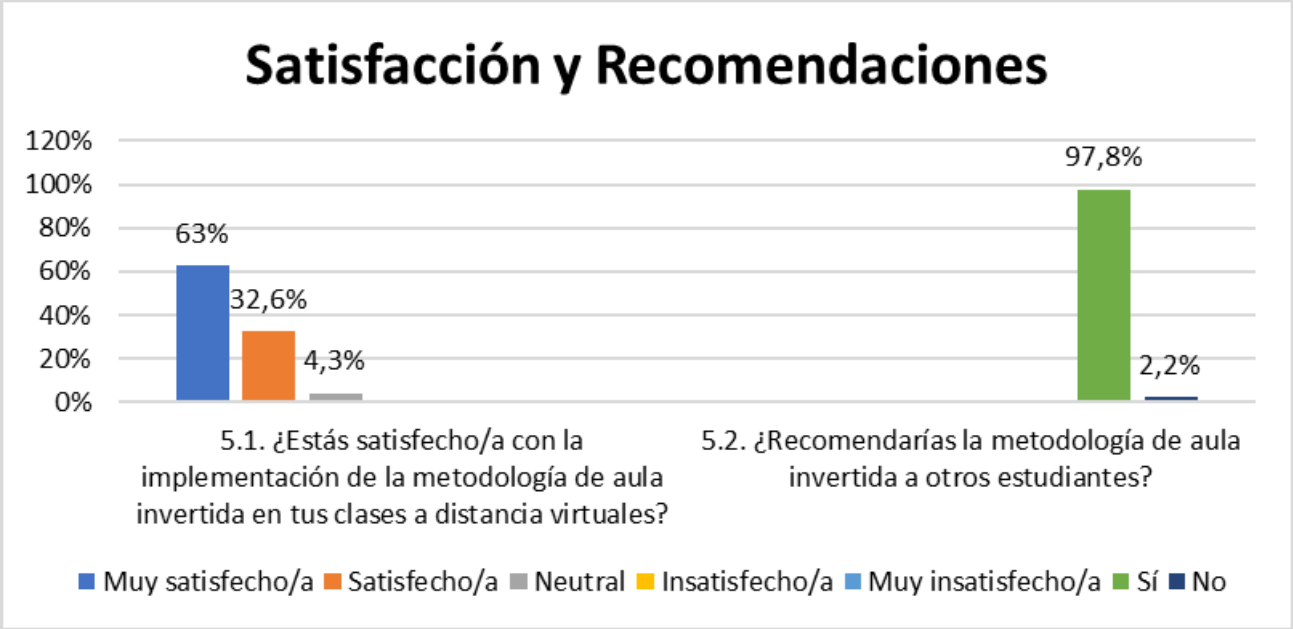

Figure 3. Satisfaction and recommendations

Qualitative discussion and analysis require coding. Coding is a fundamental process for organizing and analyzing unstructured data from the online survey administered to participants.

Open axial coding facilitated the formation of categories and subcategories and the establishment of relationships between them. The central category, perceptions about the effectiveness of the flipped classroom methodology, was ultimately defined in three subcategories: being effective, doing didactics, and what should be done, which are represented in key concepts about the participants' experiences (Table 2).

Table 2. Qualitative results

Perceptions of the effectiveness of the flipped classroom in virtual postgraduate classes		
Category	**Subcategories**	**Key concepts**
Perceptions of the effectiveness of the flipped classroom in virtual postgraduate classes	Being effective	Generates participation Develops the potential in the participants It promotes concentration and attention They exercise autonomy Active, collaborative and meaningful learning I appreciate and enjoy every experience.
	The didactic practice	It's dynamic, it's a very positive method Integrates AI and interactive activities into the material It provides materials in various formats to cater to different learning styles. It allows you to address doubts and clarify concepts It ensures that they truly understand the content and engage with it. Make better use of your time
	The duty to do	That diverse resources and more AI tools are always used Implement this methodology in all master's degree courses Induction of participants in the methodology Teachers who teach online classes should be trained in this methodology.

Source: Own elaboration

DISCUSSION

The flipped classroom methodology in postgraduate virtual classes yielded significant results from both quantitative and qualitative perspectives. It presented and confirmed the perceived effectiveness, the actual practices, and the needs to be addressed within the central category of perceptions, regarding whether the flipped classroom is truly effective. Along these lines, Campos's research (2021) showed a notable correlation with the indicators found concerning perceptions and the impact of the flipped classroom methodology.

These indicators are described below:

Perception of learning: Students participating in flipped classrooms reported a positive perception of their learning level. For example, 96% of students in an argumentation course and 100% in written communication stated that they had learned a lot.

Satisfaction and motivation: Overall satisfaction with the subject matter and interest in the content are key indicators. Students tend to show greater interest and satisfaction with the flipped classroom, which translates into increased motivation to participate actively.

Academic performance: A comparison between groups using the flipped classroom model and those following traditional methods has revealed significant improvements in academic performance. For example, the experimental group (flipped classroom) increased its high level of participation.

Autonomy and self-efficacy: The flipped classroom fosters learner independence by empowering them to manage their own learning, which is associated with greater self-efficacy and responsibility. This translates into better preparation for classes, as students review materials before attending.

Interaction and collaboration: the methodology promotes a collaborative learning environment where students interact more with each other and with the teacher, which is fundamental to developing social and cooperative work skills.

Along similar lines of indicators on the effectiveness of the flipped classroom, Ruoti Cops and Duarte Sánchez (2022, p. 1) demonstrated in their study that "the deep learning approach, with active participation, in the flipped classroom method, although it requires a greater investment of time and

dedication from various actors, is highly satisfactory in the performance of postgraduate students." Similarly, regarding student satisfaction with the flipped classroom methodology:

> ... through the change they themselves recognize when they express feeling more autonomous, more responsible, and more identified with their academic and personal work. Definitely, the application of the flipped classroom methodology makes a significant contribution to active learning, which in turn enhances the authenticity and protagonism of the student, in contrast to the routine and limitations of traditional learning (Rodríguez, 2024, p. 57).

The flipped classroom is a flexible and effective strategy for online learning, especially at the postgraduate level. Sánchez *et al.* (2019) determined that this methodology offers advantages in the educational process for university students, such as optimized class time, greater use of AI tools, a greater willingness to work in teams, the ability to argue and communicate ideas and proposals, and increased motivation. The effective implementation of the flipped classroom can transform the dynamics of the virtual classroom, fostering the development of participants' competencies. These results align with the indicators that define what is, what is, and what should be; for example, the formal implementation of this flipped classroom methodology in all master's degree courses.

The flipped classroom model transforms common teaching practices because it requires prior preparation by participants, with resources provided by the facilitator and AI (virtual tutoring, content generators, research article search engines, interactive multimedia). The teacher provides continuous guidance and fosters collaboration and active participation. Along these lines, a study revealed that the collaborative learning approach significantly improved the writing skills of Indonesian university students compared to standard classroom instruction (Kheryadi *et al.*, 2024).

The flipped classroom, in combination with artificial intelligence, improves the quality of teaching, learning and student motivation, highlighting their increasingly active and participatory role in the teaching-learning process, since it allows adapting the content and learning activities to individual preferences and working at their own pace; given the previous collaborative work carried out by the students and the direction and motivation of the teacher (Díaz & Andrés, 2024).

The analysis and discussion of the information confirmed that the incorporation of the flipped classroom in postgraduate courses represents an innovation in online distance learning, because the data revealed the effectiveness of this teaching methodology. In conclusion, the flipped classroom,

compared to traditional teaching methods in OUFA's online postgraduate courses, facilitates the consolidation of competencies within the participant's profile. Novel and valuable elements emerged that link theory and practice from three frameworks of knowledge:

- The flipped classroom model: The flipped classroom is part of active learning methodologies that foster autonomous learning oriented toward competency development. Participants perceived the flipped classroom as an innovative pedagogical tool for transforming teaching practices and constructing meaningful, self-regulated learning, based on socio-emotional, affective, constructivist, and holistic approaches with AI (Integrated Learning). One aspect of the flipped classroom's effectiveness is its acceptance by participants, as they achieved positive academic performance and achievement.
- The flipped classroom model involves the teacher facilitating, promoting, guiding, and directing content, strategies, resources, and digital tools, adhering to principles of integrity and ethics. These actions translate into engaging and guiding participants in independent work outside of class, fostering responsibility, autonomy, and effective time management. This optimizes cognitive processes by enabling students to recall, understand, apply, analyze, evaluate, and create concepts using AI tools in virtual contexts. These facilitator efforts confirm the transformation and innovation of online distance learning. Rico and Ponce (2022, p. 95) highlighted "the importance of relational and affective being in the actions of the teacher concerned with the construction of shared meanings, influenced by sociocultural and technological contexts."
- The flipped classroom's duty: that teachers receive timely training on the what, how, why, with what, and with whom the flipped classroom can be formally implemented in different postgraduate courses, taking into account that teaching methodologies, technologies, and AI are constantly evolving according to the context, in order to respond to the styles, paces, and knowledge of the participants in their professional development. The Report Horizon 2024 emphasized that students demand access to learning anytime, anywhere; this implies the inclusion of AI tools when personalizing the teaching-learning experience with active methodologies such as the flipped classroom in postgraduate courses.

It is important to note that these knowledge frameworks bridge the gap between the theory and practice of the flipped classroom methodology, which is based on four pillars: flexible environments, a learning culture, intentional content and professional educators. These aspects confirm the effectiveness of the flipped classroom with AI because it facilitates the learning process and the

development of competencies for participants and postgraduate teachers, in response to the challenges of virtual distance education, as outlined by UNESCO (2024).

The relationships between the four pillars require teachers to promote active and participatory student learning and the development of the skills necessary to integrate into a society that demands creative and self-actualizing individuals. Therefore, the use of active methodologies such as the flipped classroom with Information and Communication Technologies (ICT) and AI is confirmed and strengthened, from an innovative approach that fosters a collaborative environment for knowledge construction.

It is imperative that, in the practical context of the flipped classroom, prior skills are acquired by both teachers and students in AI, including basic literacy, digital coding skills, and media and information literacy; as well as critical and creative thinking, teamwork, communication, socio-emotional skills, and AI ethics competencies, according to UNESCO's 8th Framework for Action in Education and Research (2023).

It is essential to outline, in the short and medium term, lines of work to make this active methodology sustainable, which requires facilitating teachers to become aware, in accordance with the regulations of the university, of the advances in educational technology, AI tools and the demands of the participants for being the protagonist actors in their own training with active methodologies, as required by the pedagogical model of the Open University for Adults, OUFA.

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Conflict of interest

Authors declare no conflict of interests.

Authors' contribution

The authors participated in the design and writing of the article, in the search and analysis of the information contained in the consulted bibliography.