

Original article



Didactic conception of the inverted classroom in the teaching-learning process of Mathematics in upper secondary education in Ecuador

Concepción didáctica del aula invertida en el proceso de enseñanza-aprendizaje de matemática en educación media superior en Ecuador

Concepção didática da sala de aula invertida no processo de ensino-aprendizagem da matemática no ensino médio superior no Equador

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ABSTRACT

This research aims to design a didactic concept based on the flipped classroom pedagogical strategy applicable to the teaching-learning process of mathematics at the upper secondary level, specifically in tenth grade at the Miguel de Santiago Educational Institution in Ecuador. The methodology employed is qualitative, descriptive-documentary, based on the critical review of scientific literature and official documents. The results indicate that the flipped classroom can significantly improve

academic performance, encourage active student participation, and promote autonomous and collaborative learning. The proposal is developed within a socio-constructivist framework, in accordance with current curricular guidelines in Ecuador.

Keywords: flipped classroom; mathematics teaching; upper secondary education; socio-constructivist method; Ecuador.

RESUMEN

La presente investigación tiene como objetivo diseñar una concepción didáctica basada en la estrategia pedagógica del aula invertida, aplicable al proceso de enseñanza-aprendizaje de las matemáticas en el nivel de educación media superior, específicamente en décimo grado de la Institución Educativa Miguel de Santiago en Ecuador. La metodología empleada es cualitativa, de tipo descriptivo-documental, fundamentada en la revisión crítica de literatura científica y documentos oficiales. Los resultados indican que el aula invertida puede mejorar significativamente el rendimiento académico, fomentar la participación activa del estudiante y promover aprendizajes autónomos y colaborativos. La propuesta se desarrolla dentro de un marco socioconstructivista, acorde con los lineamientos curriculares vigentes en Ecuador.

Palabras clave: aula invertida; enseñanza de las matemáticas; educación media superior; método socioconstructivista; Ecuador.

RESUMO

O objetivo desta pesquisa é elaborar um conceito didático baseado na estratégia pedagógica da sala de aula invertida, aplicável ao processo de ensino e aprendizagem de matemática no ensino médio, especificamente no décimo ano, na Instituição Educacional Miguel de Santiago, no Equador. A metodologia empregada é qualitativa, descritivo-documental, e baseia-se em uma revisão crítica da literatura científica e de documentos oficiais. Os resultados indicam que a sala de aula invertida pode melhorar significativamente o desempenho acadêmico, incentivar a participação ativa dos alunos e promover a aprendizagem autônoma e colaborativa. A proposta é desenvolvida dentro de uma estrutura socioconstrutivista, em consonância com as diretrizes curriculares vigentes no Equador.

Palavras-chave: sala de aula invertida; ensino de matemática; ensino médio; método socioconstrutivista; Equador.

INTRODUCTION

In today's educational context, one of the major challenges is transforming traditional teaching practices to make them more dynamic, interactive, and student-centered. In this regard, the flipped classroom model offers a valuable opportunity, it emerges as an innovative strategy that breaks with the passive transmission of knowledge, giving prominence to the student in their formative process (Bergmann & Sams, 2012).

In today's world, with technological advancements, mathematics is often perceived as a routine, rote, and boring subject that fails to leverage students' potential (Hsieh & Maritz, 2023). Therefore, efforts are underway to modify teaching and learning methodologies to promote student motivation and support in solving problems both individually and in groups. The 21st-century education system has been progressively implementing Information and Communication Technologies (ICTs). Their integration brings about changes in how knowledge is transformed, acquired, and transmitted. The advantages they offer foster the development of skills geared toward more critical, independent, and creative thinking, facilitating the social, economic, and cultural development of students (Sierra *et al.*, 2016).

In the field of mathematics, the flipped classroom and digital tools have improved academic performance, motivation, participation, learning, critical thinking, autonomy, confidence, attitude, communication among participants, and responsibility (Sen, 2022).

During the organization of school activities under the flipped classroom model, the instructor relies on consulting digital resources from home to facilitate interaction in the classroom (Chuts *et al.*, 2024; Sen, 2022). In fact, consulting multimedia resources from home promotes comprehension and analysis during both face-to-face and distance learning sessions (Kangaslampi *et al.*, 2024).

The flipped classroom allows for improved educational conditions, because this pedagogical approach promotes student-centered learning (Keskin, 2023; Makruf *et al.*, 2021; Sen, 2022; Weinhandl *et al.*, 2020).

Following Qi *et al.* (2024), in the traditional classroom, knowledge is transferred by the teacher to the student as a lecture, and the information provided remains at a basic level (knowledge), according to Bloom's Taxonomy. This does not allow for the development of transversal skills that students are expected to acquire. Ecuadorian education has been subject to various changes in teaching practices for more than ten years, as the educational system has shown a willingness to incorporate pedagogical innovations in accordance with the times (Barrera *et al.*, 2017). Keskin (2023) mentions that a methodology centered on student activity and participation will be promoted, fostering critical and rational thinking, individual and cooperative work in the classroom, research and reading, as well as diverse forms of expression.

In Ecuador, upper secondary education faces significant challenges in terms of educational quality, especially in areas such as mathematics, where high rates of failure and student demotivation persist (Kangaslampi *et al.*, 2024). The Miguel de Santiago Educational Institution, located in Quito, reflects this problem, which necessitates a rethinking of traditional pedagogical practices and the adoption of more participatory and personalized educational models.

Under this paradigm, several documents were studied, such as those presented by Sandobal *et al.* (2021), Cedeño & Viguera (2020), and Guevara *et al.* (2024), which concur and discuss the flipped classroom as a novel methodology that complements the traditional model, giving it a modern twist due to the integration of ICT and emerging active methodologies. The work of Guerrero *et al.* (2018), Madrid *et al.* (2018), Coto (2021), and Chero *et al.* (2025) is also mentioned, as they have implemented the flipped classroom for teaching and learning mathematics, revealing its positive impact on learning outcomes and high student performance. The learning difficulties in mathematics among Ecuadorian students are highly concerning, as they present low grades, lack creative problem-solving skills, and perform exercises by rote or systematically without proper reasoning.

The flipped classroom is an alternative, student-centered strategy that allows students to complete at home what is typically done in the classroom, providing knowledge acquisition and efficiently addressing student needs by fostering collaborative work environments and interaction between teachers and students (Salas *et al.*, 2025). According to González and Huerta (2019), the flipped classroom is characterized by a flexible setting with direct and natural access for participants.

The teacher, as a guide for students in the classroom, fosters the analysis and communication of knowledge to resolve doubts, enabling students to learn and understand the content meaningfully.

According to Gaviria *et al.* (2019), the flipped classroom is a strategy that allows for a relationship between face-to-face and virtual learning during the educational process. This approach allows students to access information in real time without the teacher's physical presence, thus empowering students to take on a fundamental role in the learning process and increasing their responsibility, involvement, and commitment.

In a certain way, Barcia and Rodríguez (2025) argue that the flipped classroom is a strategy that makes a case for a favorable progress of the traditional learning process, insofar as it reverses the arrangement of classes, harmonizing face-to-face learning and *online training*.

flipped classroom model It is based primarily on the principles of social constructivism, particularly the contributions of Vygotsky (1978), who emphasized the importance of the social environment in the knowledge construction process. Furthermore, the model is linked to the theory of cognitive scaffolding, which describes how the teacher facilitates learning through structured guidance of the student.

As Bergmann and Sams (2012) explain, the classroom It is not merely a technological tool, but a pedagogical strategy that breaks with the passive transmission of knowledge, placing the student at the center of the learning process. This implies a reorganization of both school time and the role of the teacher, who becomes a facilitator and guide of learning.

The existing problems, mentioned above, when teaching and learning Mathematics, allow us to formulate the following question as a problem: how can the use of the flipped classroom improve the teaching-learning process of mathematics in upper secondary education in Ecuador: case of the Miguel de Santiago Educational Institution, in tenth grade students?

This work aims to design a didactic conception based on the flipped classroom model, applicable to the teaching-learning process of mathematics at the upper secondary education level of the Miguel de Santiago Educational Institution in Ecuador, in tenth grade students.

To this end, recent scientific literature on the subject is reviewed, the local context is analyzed, and a viable and relevant teaching strategy is designed.

MATERIALS AND METHODS

Methodological design

The research was conducted using a qualitative, descriptive-documentary approach. This type of methodology allows for the exploration, description, and analysis of educational phenomena based on primary and secondary documentary sources, without manipulating variables or directly experimenting with human subjects (Hernández *et al.*, 2018).

Sources of information

Systematic searches were conducted in indexed databases such as Scielo, Redalyc, Dialnet and Google Scholar, prioritizing articles published in Spanish and with peer review between 2019 and 2024. Official documents from the Ministry of Education of Ecuador, institutional reports from the Miguel de Santiago Educational Institution and specialized books on pedagogy and educational technology were also consulted.

Selection criteria

The selected documents met the following criteria:

1. To be relevant to the topic of the flipped classroom in mathematics teaching.
2. Be published in indexed journals or academic books.
3. Include complete bibliographic references according to APA seventh edition standards.
4. To offer educational proposals applicable to contexts similar to Ecuador's.

Data analysis

The analysis was carried out using synthesis and triangulation techniques of sources, identifying trends, coincidences and contrasts in relation to the effectiveness of the flipped classroom model, its benefits and limitations in diverse educational environments.

RESULTS

Institutional diagnosis

Tenth-grade students exhibit significant difficulties in basic mathematical concepts, according to interviews conducted with 110 students. The sample consisted of Group 1, with 60 students, and Group 2, with 50 students, as shown in table 1, representing 65% of the total sample. These difficulties include operations with fractions, solving linear equations, and elementary geometry (Internal Academic Report, 2024) (Appendix 1). These deficiencies negatively impact overall performance and lead to demotivation among the students.

Table 1. Number of students interviewed to detect problems in the subject of mathematics in tenth grade

Tenth grade groups	Number of students	Problems detected
Group 1	60	Lack of knowledge in: <ul style="list-style-type: none">- Operations with fractions.- Solving linear equations and elementary geometry.
Group 2	50	
Total	110	

Source: Own elaboration

Furthermore, it was observed that most classes are conducted using an expository approach, with little interaction between students and teacher, which limits the ability to deepen conceptual understanding and the practical application of the content. To address this, a didactic proposal is presented, as shown below.

Teaching proposal

The proposed didactic approach is structured in three fundamental moments:

a) Preparation phase outside the classroom (pre-class)

- Students access multimedia resources (explanatory videos, interactive tutorials, simulations) previously selected or developed by the teacher.
- They carry out introductory activities such as questionnaires or concept maps to assess their prior understanding.

b) Development phase in the classroom (during the class)

- Space intended for group discussion, collaborative problem solving and feedback.
- Application of techniques such as project-based learning and cooperative learning.
- Use of educational software (GeoGebra, Khan Academy, Desmos) to reinforce abstract concepts.

c) Consolidation phase (post-class)

- Formative assessment through additional exercises, virtual forums, or oral presentations.
- Individualized support for students with greater difficulties.

This teaching sequence seeks to generate a continuous learning cycle, fostering autonomy and critical thinking, essential elements for the integral development of the student, as shown in figure 1.

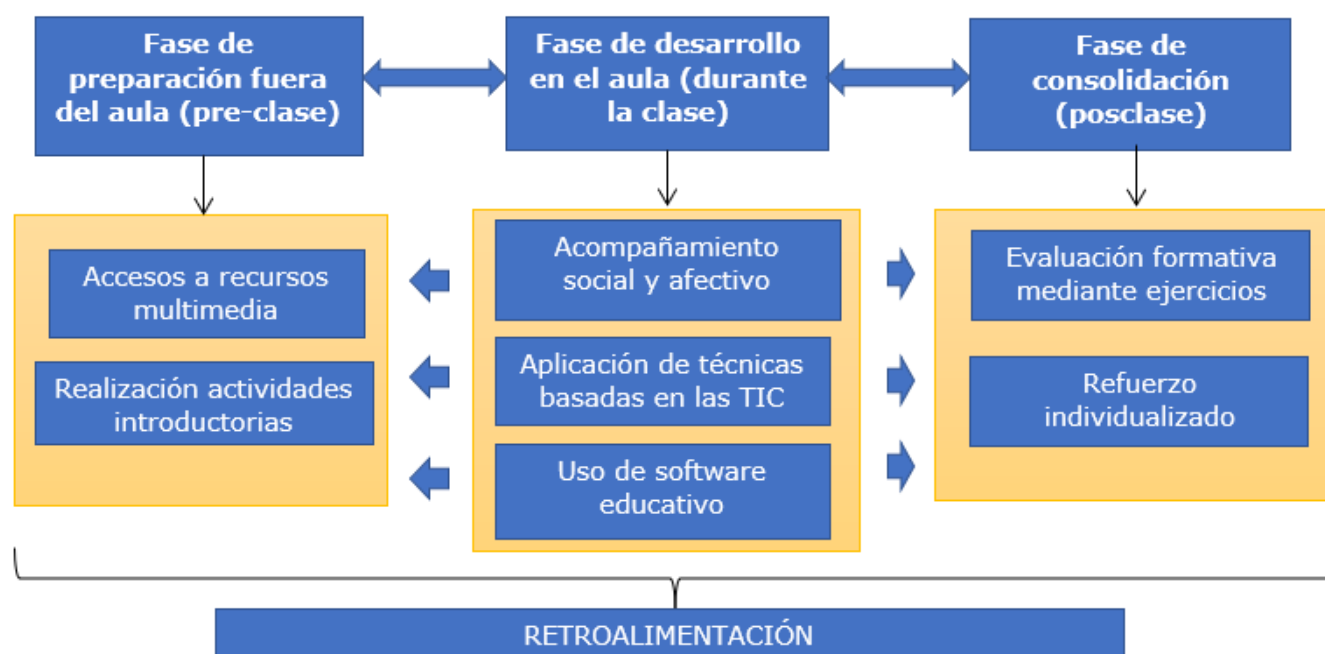


Figure 1. Didactic conception model for the use of the flipped classroom in the teaching-learning process of mathematics in upper secondary education in Ecuador

Source: Own elaboration

The degree of learning satisfaction was analyzed during the process of the didactic conception model for the use of the flipped classroom in the teaching-learning process of mathematics in upper secondary education in Ecuador: the case of the Miguel de Santiago Educational Institution, for tenth grade students.

Table 2 shows the total number of responses given by the students in each interview question, where the options "agree" and "strongly agree" were the most selected by the students; resulting in significant Pearson correlation of groups 1 and 2 of the total degree of satisfaction, since the coefficient is 99%, which means that it is positive, very high and almost perfect.

More specifically, below is a descriptive statistical analysis of the most relevant criteria of the benefits brought by the use of this didactic methodology in the subject of mathematics in upper secondary education in Ecuador: the case of the Miguel de Santiago Educational Institution, in the tenth-grade students.

Table 2. Total level of satisfaction detected

Options	Group 1	Group 2
Strongly disagree	1	0
Disagreement	6	3
Undecided	7	6
OK	10	20
I completely agree	36	21

Source: Own elaboration

Figure 2 shows the growth in satisfaction in both groups regarding digital resources of emerging technologies throughout 2024, with the response being increasing and positive in groups 1 and 2.

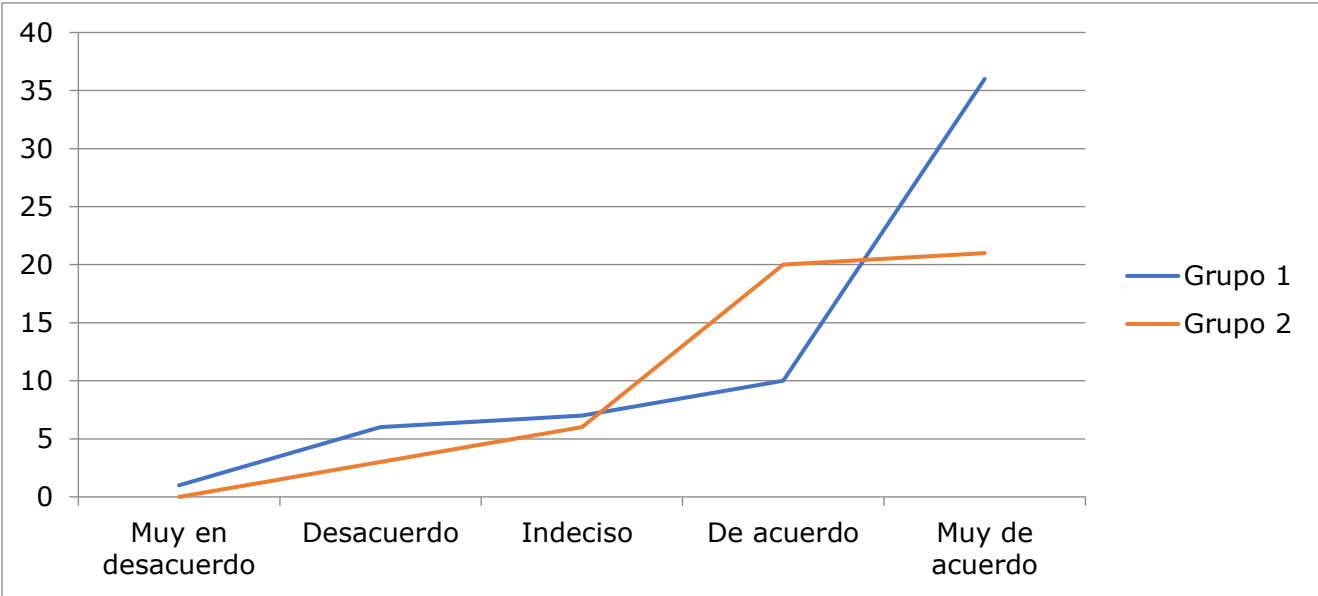


Figure 2. Total satisfaction level detected

Source: Own elaboration

DISCUSSION

Viability of the model in the Ecuadorian context

Despite the technological and economic limitations faced by some educational institutions in Ecuador, the flipped classroom proposal is viable if it is adapted to local conditions. As Weinhandl *et al.* (2020) point out, "the lack of digital infrastructure should not constitute an insurmountable obstacle, but an incentive to seek creative and inclusive solutions" (p. 45).

In the specific case of the Miguel de Santiago Educational Institution, there is basic internet access and sufficient electronic devices to implement a hybrid version of the model, combining digital resources with printed materials when necessary.

Implementation challenges

Among the main challenges are:

- Teacher training: many teachers are not familiar with technological tools or new active methodologies.
- Unequal access to technology: some students come from disadvantaged socioeconomic backgrounds, which affects their access to devices or a stable connection.
- Cultural change: breaking with the traditional model requires a paradigm shift in the perception of the role of the teacher and the student.

However, these challenges can be addressed through ongoing training plans for teachers, flexible learning strategies, and institutional policies that guarantee equity in access to resources.

Expected benefits

The implementation of the flipped classroom in the area of mathematics, it can bring multiple benefits, such as:

- Improvement in academic performance and reduction of school dropout rates.
- Promoting 21st-century skills: critical thinking, collaborative work, autonomy.
- Greater motivation and involvement of students in their own learning.
- Strengthening the teacher-student relationship and greater personalization of teaching.

The proposed didactic approach, based on the flipped classroom model, represents a viable and effective alternative for improving the teaching and learning process of mathematics in upper secondary education in Ecuador, specifically in the tenth grade at the Miguel de Santiago Educational Institution. This strategy, grounded in constructivist principles and supported by empirical evidence, promotes active student participation, responsibility for their learning, and the development of key 21st-century skills.

Its implementation requires detailed planning, teacher training, and contextual adaptations, but the educational benefits are well justified. Future research could explore the experimental application of the model in the classroom and measure its actual impact on students' academic and attitudinal performance.

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APPENDIXES

Appendix 1. Interview applied to tenth grade students in upper secondary education in Ecuador: The case of the Miguel de Santiago Educational Institution.

The purpose of this interview is to gather valuable information about the subject of mathematics in tenth grade students, in order to detect significant problems in basic mathematical content.

1. Could you list some of the content problems presented in the mathematics course?

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.



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