MENDIVE
REVISTA DE EDUCACIÓN

Original article

Inverted physics classroom implemented in Moodle, learning and acceptance by students

Aula invertida de física implementada en Moodle, aprendizaje y aceptación de los estudiantes

Sala de aula invertida de física implementada no Moodle, aprendizado e aceitação dos alunos

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Received: February 23, 2023
Accepted: September 22, 2023

ABSTRACT
The combination of the didactic strategy of the flipped classroom and the use of virtual platforms is becoming more important every day due to the weighting of the student's role in the self-management of their learning from a collaborative space. The objective of this article is to socialize the learning results and the level of acceptance of the students of an Atomic and Nuclear Physics course applying the flipped classroom modality implemented in the Moodle platform, in the initial training of Physics teachers at the Central University "Marta Abreu" of Las Villas. A dialectical materialist methodological approach was followed that combines quantitative and qualitative methods from a case study made up of a single group. To measure learning, a chronological series design was followed with seven cuts in each of the course topics and to inquire about acceptance, a survey was applied to the students. To process the data and illustrate the results, bar graphs and Chernoff Faces were used, which allowed revealing correlations between the different items of the survey and the final learning results. The learning results and the level of acceptance declared by the students, from their perception, are generally high and corroborate the potential of the flipped classroom implemented in Moodle.

Keywords: Flipped classroom; Moodle platform; Physics learning; Physics teaching.

RESUMEN
La combinación de la estrategia didáctica del aula invertida y el uso de plataformas virtuales cada día cobra más importancia por ponderar el protagonismo del estudiante en la autogestión de su aprendizaje desde un espacio colaborativo. El objetivo del artículo es socializar los resultados del aprendizaje y el nivel de aceptación de los estudiantes de un curso de Física Atómica y Nuclear aplicando la modalidad de aula invertida implementada en la plataforma Moodle, en la formación inicial de profesores de Física en la Universidad Central "Marta Abreu" de Las Villas. Se siguió un enfoque metodológico

dialéctico materialista que combina métodos cuantitativos y cualitativos a partir de un estudio de casos conformado por un grupo único. Para medir el aprendizaje se siguió un diseño de series cronológicas con siete cortes en cada uno de los temas del curso y para indagar sobre la aceptación se aplicó una encuesta a los estudiantes. Para procesar los datos e ilustrar los resultados se usaron gráficos de barras y las Caras de Chernoff que permitió revelar correlaciones entre los diferentes ítems de la encuesta y los resultados finales del aprendizaje. Los resultados del aprendizaje y el nivel de aceptación declarado por los estudiantes desde su percepción, de manera general son altos y corroboran las potencialidades del aula invertida implementada en Moodle.

Palabras clave: Aprendizaje de la Física; Aula invertida; Didáctica de la Física; Plataforma Moodle.

RESUMO
A combinação da estratégia didática da sala de aula invertida e o uso de plataformas virtuais torna-se cada dia mais importante devido à ponderação do papel do aluno na autogestão de sua aprendizagem a partir de um espaço colaborativo. O objetivo deste artigo é socializar os resultados de aprendizagem e o nível de aceitação dos alunos de um curso de Física Atômica e Nuclear aplicando a modalidade de sala de aula invertida implementada na plataforma Moodle, na formação inicial de professores de Física da Universidade Central "Marta Abreu" de Las Villas no ano letivo de 2020. Foi seguida uma abordagem metodológica materialista dialética que combina métodos quantitativos e qualitativos a partir de um estudo de caso constituído por um único grupo. Para medir a aprendizagem, seguiu-se um desenho de série cronológica com sete cortes em cada um dos tópicos do curso e para indagar sobre a aceitação, foi aplicado um questionário aos alunos. Para processar os dados e ilustrar os resultados, foram utilizados gráficos de barras e Faces de Chernoff, que permitiram revelar correlações entre os diferentes itens da pesquisa e os resultados finais da aprendizagem. Os resultados de aprendizagem e o nível de aceitação declarados pelos alunos, na percepção deles, são geralmente altos e corroboram o potencial da sala de aula invertida implementada no Moodle.

Palavras-chave: Sala de aula invertida; Plataforma Moodle; Ensino de Física; Ensino de Física.

INTRODUCTION

In current times, the use of technologies in teaching has set guidelines in educational systems as an alternative to achieve the protagonism of the student who increasingly rejects traditional teaching. "It is common in the field of education and technology to look at new technologies as powerful in helping schools account for increasingly diversified student populations" (Moreira, 2021, p.145).

One of the most promising educational models, in terms of the use of technologies for educational purposes, is the inverted classroom, which consists of "the students will study by themselves the theoretical concepts that the teacher provides them and the class time will be used to resolve doubts, carry out practices and initiate relevant debates with the content" (Aguilera-Ruiz et al., 2017). However, it is agreed with Alarcón and Alarcón (2021), in that:

> …the flipped class postulates a radical transformation for students and teachers, who undoubtedly must feel forced to leave their comfort zone in order to achieve a change in the way of learning and teaching. (p.153)

"In this method, the teacher assumes a new role as a guide throughout the students' learning process and is no longer

the only source or disseminator of knowledge." (Pérez et al., 2018, p. 115). For his part, the student "has to learn the content outside the classroom and work on the procedures inside it" (Pérez et al., 2018, p. 115) so that the student "becomes the protagonist of his learning" (Aguilera-Ruiz et al, 2017, p.262).

According to Pérez et al. (2018):

> The use of the Didactic Strategy of the Flipped Classroom for teaching Physics allows students to engage in self-learning at home through research, developing the skills of observation, analysis, reflection, synthesis, problem solving, etc (p. 113)

It agrees with Cedeño et al. (2021) in that "the flipped classroom model has gained prominence as advances in technology offer progressive opportunities for ubiquitous leadership." (p. 292), this opens up new opportunities for students who can now access teaching materials from different places and times, by following the course asynchronously adapted to their own learning pace.

Such technological advances have given rise to virtual learning environments that "are environments designed to strengthen student learning through virtuality, making use of the tools offered by information and communications technologies (ICT)." (Morales et al., 2021, p. 302). ICT refers to information and communications technology.

One of the most used virtual environments is the Moodle platform, whose learning potential makes it the most widespread online teaching platform worldwide, according to Delgado and Vélez (2021, p. 13).

The combination of the inverted classroom with the Moodle platform enables access to content selected by the teacher, for use before, during and after classes, or as a collaborative space to facilitate interaction between students and teachers outside of class, through the virtual space. (Hernández-Silva and Tecpan, 2017, p.195) It is agreed with Delgado and Vélez (2021) that, given the virtual nature of the platform, communication with students is permanent so control of the progress and possible weaknesses of the learning process. (p. 24) Furthermore, it has proven to be very effective with students who prefer proactive and responsible learning, as suggested by Hidalgo *et al.*, (2021, p. 192).

Based on the theoretical aspects previously presented, this article aims to socialize the learning results and the level of acceptance of the students of an Atomic and Nuclear Physics course by applying the flipped classroom modality implemented on the Moodle platform, in the initial training of Physics teachers at the "Marta Abreu" Central University of Las Villas in the 2020 academic year.

MATERIALS AND METHODS

A materialist-dialectical approach was followed in which quantitative and qualitative methods were combined from a case study made up of a group of six teaching students in the specialty of Physics who followed the Atomic and Nuclear Physics course in the modality of flipped classroom implemented on the Moodle platform. The study aimed to investigate the students' learning, their acceptance regarding the modality used in the course and the possible correlation between learning and acceptance.

To investigate learning, a chronological series design was followed with seven sections corresponding to the seven topics in which the course was structured.

Learning measurements were carried out using three types of resources available on the Moodle platform: discussion forum, homework and exam. For each of these resources, a time series was prepared with

the measurements corresponding to each one. The grades (measurements of learning) were made according to the scale used in higher education in Cuba (2 bad, 3 average, 4 good and 5 - excellent). The data is illustrated using bar graphs for each student in each of the topics in which the subject was structured.

To investigate the students' acceptance of the inverted class implemented on the Moodle platform, a survey was applied with six items that were answered using an estimative scale with three categories: low, medium and high.

The survey items were:

- Did online availability allow you to review topics anytime, anywhere?
- Did the flipped classroom methodology improve your self-learning?
- Does this methodology encourage collaboration between colleagues?
- Did you find the feedback from the teacher helpful?
- Were your computer knowledge and skills sufficient for your performance on the Moodle platform?
- Do you consider it feasible to do the entire exchange with the teacher through the platform?

Chernoff faces which "is a graphic method created for the quick and entertaining visualization of multidimensional data, which allows an iconographic representation of the information, through the features of the face" (Alves de Castro et al., 2012, p.4). With this representation, correlations can be discovered between the statistical variables that are configured on the same face.

Chernoff face was constructed considering their perceptions expressed in the responses to the survey. To do this, a facial feature was assigned to each of the items. It was also considered that each trait could adopt one of three configurations depending on the category (high, medium or low) assigned by the student in the corresponding item.

Chernoff faces and their configurations were associated with each of the survey items and their categories as follows:

- Concavity of the mouth - Did the online availability allow you to review the topics anytime, anywhere? (Concave up - high, no concavity - medium and concave down - low).
- Long of the nose - Did the flipped classroom methodology improve your self-study? (The longer the length, the higher the assigned category).
- Nose width - Does this methodology encourage collaboration between colleagues? (The greater the width, the higher the assigned category).
- Length of the vertical axis of the eye - Did you find the feedback from the teacher helpful? (The longer the length, the higher the assigned category is)
- Length of the horizontal axis of the eye - Were your computer knowledge and skills sufficient for your performance on the Moodle platform? (The longer the length, the higher the assigned category).
- Tilt of the eyebrows - Do you consider it feasible to do the entire exchange with the teacher through the platform? (Inward tilts high; non-tilts medium and outward tilts low).

The size of the face was not associated with any item, so a standard size was taken for all faces. To investigate the possible correlation between learning and acceptance, Chernoff 's faces were colored according to the value of the final grade of the course achieved by each student from the following code (2 red; 3 - yellow, 4 - green and 5 - blue). The faces were constructed automatically using the " Chernoff faces " application available on the site: https://gramener.com/faces/

Context and participants

The Atomic and Nuclear Physics course was structured into seven topics. Each topic was structured into a lecture and two practical classes. The themes were:

1. Wave nature of matter.

2. Structure of the Hydrogen atom.

3. Atomic. X-rays.

4. Atomic. Laser.

5. Nuclear Physics.

6. Radioactive decays. Laws of radioactive decay

7. Nuclear reactions.

In the virtual classroom, the conferences were published in Power point, the bibliography to delve deeper into the contents and the guides for carrying out the practical classes in PDF.

The conferences focused on the theoretical presentation of the content, taking into account three aspects: the historical approach followed in obtaining scientific knowledge, its place within atomic and nuclear theory and its usefulness to explain phenomena from a scientific point of view. and technological. Well, we agree with *Aguilar (2018) on the need to reveal the sociocultural character of science and, in particular, Physics.*

The bibliography contained basic textbooks and updated scientific articles on each topic.

The guides for carrying out practical classes *They* were made up of two parts, one with solved problems and the other with proposed problems. The delivery of the proposed problems was assigned randomly, so that each student had to submit one problem per topic.

Through the discussion forum, topics of deepening theoretical aspects were addressed through the resolution of qualitative problems related to the content discussed. Example: Discussion forum topic 5: Why does man today need to know about the existence of the atomic nucleus? The grading of the discussion forum was carried out by the teacher based on the quality of each student's interventions.

Using the homework resource, students could submit solutions to the problems proposed in the practical class guide. These problems measured the same objective, but the statement was different for each student.

The grading of the tasks was carried out by the teacher following the proposal of Guerra et al. (2022) consisting of communicating to students, through the Moodle platform, the grade accompanied by feedback comments with suggestions and signals in order to help them understand the solutions and identify in which aspect of said solution they had made a mistake.

The exam was used to solve sentence completion questions, relate columns, and order chronologically. Each question on the exam resource had 10 items. Students had the possibility of making two attempts to answer.

The grading of the exams was done automatically on a scale of 0 to 10 points depending on the number of correct items (each item was worth one point). To make the result compatible with the grading scale used in higher education in Cuba, the score obtained by each student was divided by 2 and approximated to the closest integer by default. Except for values equal to or less than four that corresponded to a rating of 2 (bad).

Through private messaging, doubts regarding both the contents of the conference and the practical class problems were clarified.

The data were collected in seven sections corresponding to each of the course topics to form a chronological series, which in each case had three measurements, corresponding to the three types of resources used for the evaluation.

The subject did not have a final exam. The course grade was awarded by averaging the grades achieved in each of the evaluations carried out through the discussion forum, the assignments submitted and the exams. The resulting value was rounded to the nearest integer. Furthermore, this grade could be maintained if the student submitted all the activities on time, otherwise one point was deducted.

The structure of the course was as shown in figure 1.

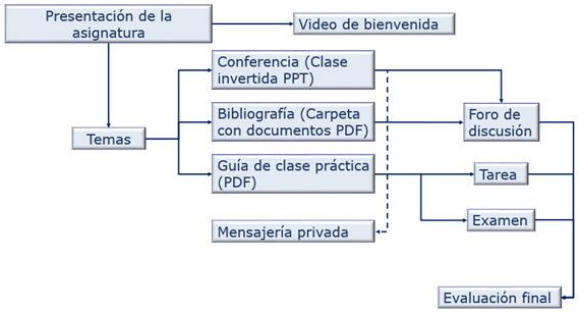

Fig. 1- Structure of the Atomic and Nuclear Physics course on the Moodle platform.

The designed process was applied to a group of 6 students in the fourth year of the Bachelor of Education degree. Physics, in the 2020 course at the Central University "Marta

Abreu" de las Villas, Cuba. The proposal was applied in the only group of the specialty at the stage in which the research was carried out.

The students in the sample had an average academic performance, with an average of 3.78 points at the time of beginning the research. Until that time they had not developed teaching virtually.

Regarding the availability of resources, each of the students had at least one cell phone. The connection to the virtual classroom was made free of charge through the Cuban telephone company "ETECSA".

RESULTS

The course was implemented on the Moodle platform and was monitored through the different resources intended for it.

Student participation in the discussion forums was very little in the first topic, but it increased. Although all students entered each forum at least once. Starting with the third topic, the number of participations by students increased, an aspect that had a positive impact on the quality of the interventions and the grades obtained. Figure 2.

The students with the lowest results were 1 and 3 with one and two failed evaluations respectively. Furthermore, they only obtained an evaluation of 4 points, the rest of the evaluations were approved with the minimum value (3 points).

The rest of the students in most grades reached a score of 4. The best grades were achieved by student 6 with all scores of 4 or 5. Figure 2. The difficulties that led to low scores in the discussion forum were They specified that the interventions were poorly argued.

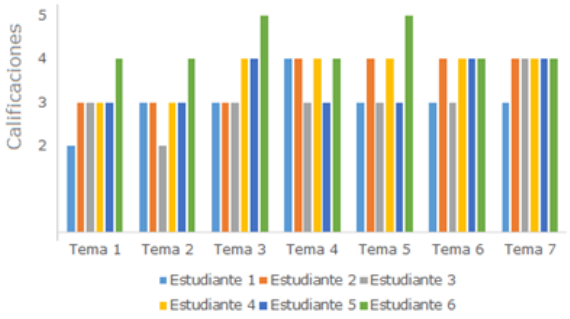

Fig. 2- Results of the discussion forum evaluations, by topic, for each student in the sample

Regarding the homework resource, both in the deliveries and in the solution process, the students presented many doubts that caused a wide flow in private messaging. The doubts referred to the physical content and the way of interacting with the platform to upload the deliveries.

The main drawback in editing the solutions was due to the difficulties presented by the students in working with the equation editor and with applications to reproduce the drawings and graphs necessary to prepare the diagrams and auxiliary modeling in the solutions.

The previous difficulties limited the delivery of the tasks of topic 1 in time, for this reason the possibility was offered of solving the problems on paper, taking photos of the solutions and inserting them in Word, to finally convert the document to PDF format. To do this, it was necessary to prepare a document that described the procedure to carry out these actions and upload it to the platform.

In the results of the assignment grades, it was observed that student 1 was the one who obtained the worst grades with three failed assignments (2 points), Students 2 and 3 had two disapproved assignments each. Student 4, although he passed all the tasks, his scores did not exceed the minimum (3 points). The best results were achieved by students 4 and 5, with scores between 4 and 5, except in the topic 1 task in which student 4 obtained 3 points. Figure 3.

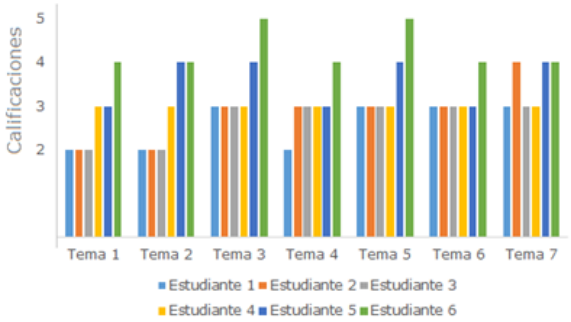

Fig. 3- Results of the evaluations of the topic tasks for each student in the sample

Looking at exam results, most students scored lower than on previous resources. Figure 4 shows that students 1 and 2 achieved the lowest results with 4 and 3 failed exams respectively.

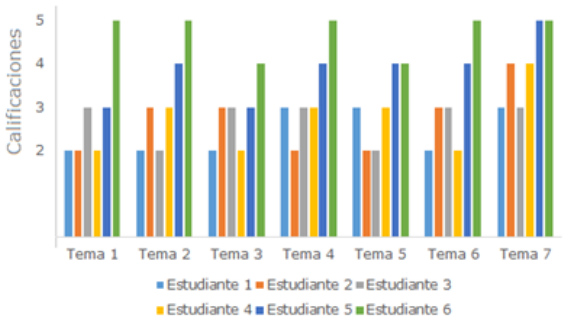

Fig. 4- Results of the exams by topic for each student in the sample

In the final grade, all the students were approved in the average grade, although one was disapproved (student 1) since most of the deliveries were made out of time, so his final grade was deducted one point. This student completed most of the deliveries in the time allocated for the last two topics. Two other students (4 and 2) behaved in a similar way in the assignments, which is why their final grade was penalized, leaving it definitively at 3 points. (Table 1)

Table 1- Final grade of the subject.

Student	Averages	Note	Delivery on time	Final note
1	2.7	3	No	2
2	3.1	4	No	3
3	2.9	3	Yeah	3
4	3.2	4	No	3
5	3.7	4	Yeah	4
6	4.4	4	Yeah	4

The students' acceptance of the flipped classroom was favorable in most of the items, except for the item that inquiries about the sufficiency of computer knowledge and skills for their performance on the Moodle platform. It was recorded that students had better acceptance of: the online availability to allow review of the topics at any time and place and the feasibility of the flipped class to improve their self-learning. Figure 5.

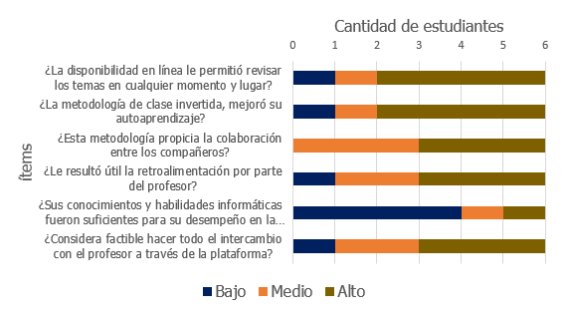

Fig. 5- Frequencies in students' perceptions of the flipped classroom and its Moodle implementation

Regarding the individual correlations of the students' perceptions, it was found that student 1 selected the low category in all items, except in item 4, which selected the medium category. This is evidenced by the fact that the nose is wider than it is long. For this student, the most favorable aspect of the methodology used was the collaboration between classmates. This student also failed, so a correspondence is observed between low acceptance and low learning results. (Student 1 figure 6.)

For students 2, 3, acceptance of the flipped classroom on the Moodle platform was more favorable, which is evident in the configuration of each of the faces, although in some items they selected the low category. Overall, it could be said that there is a tendency towards average acceptance with better acceptance in student 3 than in student 2. (Students 2 and 3, figure 6.)

Something curious happens with student 4, the configuration obtained on the face seems to show a tendency towards high acceptance, however, the short length of the horizontal axis of the eyes causes a configuration in which some difficulty is evident. This corresponds to the difficulties presented by this student in completing assignments, which is why his final grade was 3 points. (Student 4 figure 6).

Finally, students 5 and 6 had a high acceptance of the methodology used and a correspondence was also observed with the degree of acceptance and the final grade. (Students 5 and 6 figure 6)

Fig. 6- Chernoff faces to represent the correlation of student perceptions and learning achieved through the flipped classroom and its Moodle implementation

DISCUSSION

The use of the flipped class through virtual platforms has been increasing in recent times and has shown good results at different levels of education (Cedeño et al., 2021). Also in this experience, encouraging results have been achieved that coincide with those achieved by Cedeño et al. (2021) and by Hernández-Silva and Tecpan (2017); even when some barriers are observed.

Firstly, it was observed that at the beginning of the implementation of the inverted classroom, a lot of work was required on the part of the teacher, not only in guaranteeing the operation of the Moodle platform, but also due to the great accumulation of doubts that it generated in the students, accustomed to face-to-face

classes. These results coincide with those presented by Pérez et al. (2018) who recognize the intensity of the teacher's work in the initial period of the flipped class.

Secondly, also at the beginning, it was detected that the students made a certain rejection of the previous study of the teaching material. To mitigate this difficulty, coinciding with Espinosa, Solano and Veit (2018), it was taken into account that "preparation before classes plays an important role in the assignment of evaluation concepts in the discipline." (p.70) For this reason, starting with the second topic, in general, the results achieved by the students were better.

Finally, an aspect on which no references were found in the bibliography consulted was the way in which computer knowledge and skills affect student performance when a flipped class methodology is applied using virtual platforms. In the investigation, it was confirmed, from the deliveries and the exchange with the students, that they presented difficulties in working with the equation editor and the preparation of automated graphs and drawings, essential resources for communicating solutions to physical problems. These difficulties had a negative impact on the acceptance of this methodology by the students (see length of the horizontal axis of the eyes in figure 6). For this reason, it is suggested to delve into this aspect in future research that reveals more specific particularities in the implementation of this type of methodology in the teaching-learning process of Physics.

The learning results are promising, since of the six students in the sample, only one failed the course. This shows that the use of the flipped classroom was effective, although as Cedeño et al (2021) point out "with the supervision and coordination of the teacher" (p. 306), who has to transform their role in the teaching-learning process.

Regarding the acceptance of the flipped classroom implemented on the Moodle platform, although the small sample used in this research does not offer conclusive results, it was found that the majority of students gave high and medium categories, which coincides with the results published by Hidalgo et al. (2021) and by Ñique-Carbajal and Díaz-Manchay (2021). According to the latter, "the flipped classroom strategy applied to the students was satisfactory from their perception" (p. 247).

The results achieved both in the evaluation of learning and in the level of acceptance corroborate "the potential of the inverted classroom in increasing student motivation and performance" (Estrada et al., 2021, p.12), although it would be timely carried out new research to corroborate these results with larger samples.

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Conflict of interests:

The authors declare not to have any interest conflicts.

Authors' contribution:

The authors participated in the design, analysis of the documents and writing of the work.

Cite as
Guerra Véliz, Y., Fernández Vizcaíno, A., Leyva Haza, J. (2023). Flipped physics classroom implemented in Moodle, student learning and acceptance. *Mendive. Journal of Education, 21* (4), e3405.
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