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Working Adult Students' Perceptions of Flipped Classroom Videos in an Undergraduate Physics Course

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Abstract

The School of Engineering offers several degree programs across several formats, including one conducted online for working students. It is particularly important to these students to find a productive and efficient way to incorporate the theoretical content of their courses weekly. In turn, it is necessary for educational strategies to enable students to take advantage of such content in line with their capabilities and realities and, thus, help them to arrive fully prepared for hands-on learning activities in the digital classroom. The present study measures the perceptions of a group of such students on the effectiveness of flipped classroom videos designed to introduce theoretical content related to electricity and magnetism. It involves flipped classroom videos being made available, with restricted access, as part of an electricity and magnetism course in an evening undergraduate program for adult learners at a private Chilean university. The number of videos and the time students took to watch them were individually tracked through a learning management system. Subsequently, students completed a perception survey on this flipped classroom strategy and where they were asked to compare the approach to the traditional model of receiving face-to-face lectures before each class. A cross-variable analysis was then conducted to establish student perceptions precisely and accurately. This analysis yielded results on the suitability of the material generated and the applicability of flipped classroom videos in this context. Results show that using flipped classroom videos is a viable alternative for teaching physics content in an e-learning context with adult learners. The study concludes with several recommendations regarding possible improvements for future research.

Keywords: Flipped-classroom, e-learning, Adult education, Higher education, Educational innovation, STEM education

Introduction

Online education has become increasingly important in recent years. The method provides people who, for reasons related to work, family, or geographical location, find traditional face-to-face education unfeasible the opportunity to access higher education.

In the case of core science courses for engineering degrees, such as mathematics and physics, this becomes even more crucial since students require closer guidance, particularly those whose last contact with these disciplines was many years ago. Given the impracticalities of investing large amounts of time in reviewing theoretical content, it is necessary to find a way for students to access this content conveniently and according to their requirements. It also ensures synchronous sessions are devoted primarily to solving exercises and more effective learning activities. Accordingly, the use of the flipped classroom approach is a promising option.

The context of "online education for working students" encompasses two specific and challenging educational scenarios. The literature review conducted for the present study found no material related to such a context. However, it identified material related to either "online education" or "education for working people" separately. On the one hand, online education's most significant challenge is ensuring that the teaching-learning process takes place as seamlessly and productively as possible in non-face-to-face classroom environments. This is particularly salient given that contact between instructors and students in this format is, at best, reduced to a weekly video-conferencing session recorded for students who cannot log in live. On the other hand, "working students" are adults who combine their studies with their work and family life, whose schedules often prevent them from attending class sessions, and who generally lack sufficient time to complete their course activities.

The present research focuses on the specific context of a trimester-long electricity and magnetism course for working students taking an online evening undergraduate program.

Following a two-year exchange of ideas between one of the authors of this paper, an instructor of the course, and his students, the latter has clearly expressed a need to receive clear explanations regarding the most relevant course content. Students have stated that such lessons should be as similar as possible to the well-established lecture format. They must include related exercises to help them understand the topics covered in assignments and formal activities. A weekly 90-minute question-and-answer session is insufficient to cover the content reasonably and, at the same time, undertake exercises and, likewise, needs more time to execute active learning methods. The option of holding a special online synchronous session to study theoretical content is not viable due to the schedules of both teachers and students. Indeed, even if such a session could be implemented, many students would still not attend and opt to watch the online recording instead.

The literature consists of extensive material on flipped classrooms in traditional secondary or higher education settings [1,2], in which students are primarily teenagers and young adults whose careers are financed by their parents or by scholarships. These students tend to have no employment responsibilities and are, therefore, able to dedicate themselves exclusively to their studies. Some of this research, including [3], analyzed the issue in the context of the forced virtualization of education due to the COVID-19 pandemic.

The closest reference found in the literature to the case of working students are [4] and [5]. The study in [5] addressed the use of flipped classrooms in a face-to-face geometry course for engineering students in which much of the class was composed of employed adult learners.

The present study's central aim is to establish further the most productive and efficient way of teaching theoretical content to improve the teaching-learning process for working students. The use of and perceptions regarding specially created flipped classroom material will be assessed using descriptive statistics from a learning management system (LMS) platform and a Likert-type survey. It will describe the methodology used, the results obtained from the study, and the analysis of usage statistics. Furthermore, it will cross-reference all information collected to conclude the workability of the flipped classroom in this context.

Literature review

Research into the use of flipped classrooms has centered on perception studies and comparisons of learning outcomes with other methods. These studies are predominantly conducted in face-to-face secondary, undergraduate, and postgraduate courses. No research focused on situations that could be equated with “online education for working students,” which is the subject of the present article.

Several papers have addressed implementing a flipped classroom strategy within an academic course and measuring its effects on learning and perception. For example, [6] implemented the flipped classroom strategy in a postgraduate medical course of 10 students. The authors conducted a pre-and post-test to measure learning, a Likert-type survey, and an open-ended questionnaire to measure perception. Their results showed the experience to be positive in both aspects. [7] used videos from the Khan Academy platform as flipped classroom material to reinforce calculus skills among undergraduate and postgraduate students in a soil physics course at two US universities. Their results also showed favorable outcomes in terms of both learning and perception.

Another body of research compares two groups of students in the same subject, one taught by a traditional teaching regimen. At the same time, the other is undertaken using the provision of flipped classroom materials. A comparison is made between the two groups regarding learning levels, and a survey is then administered to the flipped classroom group to measure perceptions of and general satisfaction with the strategy of the constituent students. For example, [8] researched a secondary school physics course, achieving improved learning and motivation results with the group that used a flipped classroom approach. Similarly, [1] studied a university course in organic chemistry, using a Likert-type survey to measure the effect on learning through grade comparisons and student perceptions. While no significant differences were noted in grades, most students viewed flipped classroom videos positively. Finally, [9] investigated the topic in a secondary school science course. They measured the effect on learning through a pre-test and post-test and student perception via a Likert-type survey. In this case, more excellent learning was achieved in the flipped classroom group, and there was a positive perception of using this strategy.

Additional research has concentrated on a course that experienced a transformation from a traditional to a flipped classroom format. The process was described, and the performance and perceptions of the initial and final situations were compared. For example, [2] performed a study in a pre-university level course on the fundamentals of physics, which was transformed from a traditional to a flipped classroom-based format. Comparisons were made using perception surveys, pre-tests, and post-tests to measure learning and institutional records. The perception results were mixed, and no significant differences in learning levels were found. On the other hand, the analysis conducted by [10] into the progressive seven-year transformation of a face-to-face applied physics course for graduate students to a flipped online format found that, while average performance levels remained the same, there was an increase in performance dispersion over time.

These studies show that the results of implementing a flipped classroom are varied. While perceptions tend to be positive, the change in learning levels varies from no effect to improvement. In this regard, it is essential to consider the impact of various factors, including student education levels (secondary, undergraduate, postgraduate), the number of students involved (a small group or a large course), and the design and appropriateness of the material(s), among others. Consequently, the results largely depend on the particularities of each situation.

Methodology

The methodology applied in the present study is qualitative data analysis, and it considers the following:

- A perception survey with questions in a Likert-type format and specific open questions.
- Collection of attendance data and access to material provided by the LMS platform.

The course is called "Electricity and Magnetism" and forms part of the Advance evening undergraduate program for working people at a private Chilean university. It runs for 12 weeks plus the exam and covers the contents of a typical electricity and magnetism course for engineering: electrostatics (electric force, electric field, electric potential, and capacitance); electrodynamics (current, resistance, direct current circuits, Kirchhoff's laws, and resistor-capacitor circuits); magnetism (magnetic force, magnetic field, electromagnetic induction, and inductance) and alternating current circuits.

The group selected for analysis was an online course of 58 engineering students held during the third trimester of 2022. The course website, hosted on the LMS platform, featured study material (lecture notes, videos of solved exercises from a YouTube channel, and a guide detailing proposed exercises), arranged by units and assigned every week. The course also included a weekly synchronous online session of 90 minutes that consisted of a brief review of key content and a series of exercises. An additional exercise session was provided on Saturdays. All sessions above were recorded and hosted in the pertinent Virtual Classroom.

The summative assessment instruments include four assignments (two individual and two groups) and two online exams consisting of one-part multiple-choice problems and one-part developmental questions.

The flipped classroom material option proposed by [11] is a suitable alternative in this scenario. This is because it provides students with the "content class" they need in a format that enables them to view that content according to their availability, thus allowing the question-and-answer sessions to be used exclusively for practice purposes.

Seven sets of inverted classroom materials were generated for the following subject areas: capacitance, electrical variables, direct current circuits, magnetic force, magnetic field, induction, and alternating current. Each set consisted of a handout in PDF format comprised of three to four mind maps that summarized the essential content for each topic; and a video in MP4 format in which the content of the mind maps was discussed in greater detail. All material was uploaded to the LMS platform and made accessible to all students. As a means of introduction, the videos of the first two topics were shown at the beginning of the corresponding question-and-answer sessions. The material for the remaining topics was made available in advance for students to review before the corresponding question-and-answer session. This enabled students to familiarize themselves with course content on the platform and in the question-and-answer session devoted entirely to exercise completion.

The videos were created using a laptop, in a “homemade” manner, without sophisticated software. They were designed with the following conditions in mind:

- Limited duration: no more than one hour in length so that students can watch them within a reasonable timeframe.
- Focused on the core aspects of the content: the areas to be covered in the exercises.
- Format as similar as possible to a lecture: preferably a teacher speaking while writing on a whiteboard.

Data on the attendance of question-and-answer and exercise sessions and access to flipped classroom material were collected. At the end of the term, a Likert-type perception survey was conducted using a Google Form in which students were asked about the suitability and usefulness of the videos. The survey was constructed with references to questions used in two previously validated surveys by [1] and [2]. Table 1 outlines the Likert-type survey questions.

Table 1. Likert-type survey items were used, with informative questions marked in blue.

Q1	Flipped classroom materials help to improve the understanding of the theoretical parts of the lesson.
Q2	Flipped classroom materials are an important aid in understanding problem-solving.
Q3	I review the flipped classroom materials before the question-and-answer session in which the respective content is covered.
Q4	After the question-and-answer session, I review the flipped classroom materials in which the respective content is covered.
Q5	The videos from the flipped classroom material are boring.
Q6	After reviewing the flipped classroom materials, I feel confident in my knowledge of physics.
Q7	I re-watch the flipped classroom material when I don't understand a concept.
Q8	The videos were of great value or really useful to my learning.
Q9	The question-and-answer sessions move too fast for me to follow.
Q10	The PDF mind maps were of great value or really useful to my learning.
Q11	The question-and-answer sessions move too slowly.
Q12	I enjoy watching the video lessons.
Q13	I recommend using these flipped classroom materials for other subjects.
Q14	The flipped classroom materials positively impacted my motivation levels for the subject.
Q15	Regarding the theoretical content, I prefer to watch the lessons in a flipped classroom format rather than a traditional lecture from the teacher at the beginning of the question-and-answer session.
Q16	My work and family obligations prevent me from dedicating enough time to review the weekly content.

Regarding the survey, information (including data and graphs) was collected from the Google Form. This information was consolidated across several Excel spreadsheets regarding attendance and access to the material. For analysis purposes, the answers to the questions were aggregated into three categories:

- Favorable perception: “Agree” and “Strongly agree.”
- Neutral perception: “Neither agree nor disagree.”
- Unfavorable perception: “Disagree” and “Strongly disagree.”

Results

Attendance at question-and-answer sessions and access to flipped classroom material

There were 592 instances of accessing the flipped classroom material during the trimester. Of these, 267 (45.1%) related to videos and 325 (54.9%) to documents in PDF format. In addition, 138 (23.3%) occurred on days before the question-and-answer session in which that content was due to be discussed; 28 (4.7%) happened on the day of the session; and 426 (72%) occurred on days after the session.

Of the 58 students, 14 (24.1%) accessed the material at least once, and 12 (20.7%) accessed the material at least 14 times, equating to one visit for each video and one for each PDF file. In addition, 40 (69%) of the 58 students attended the question-and-answer sessions on at least one occasion. Of these, 15 (25.9%) attended at least 50% of the sessions, while 14 (24.1%) did not log in to any of the question-and-answer sessions or access the flipped classroom material.

From the data, it is clear that a significant group of students undertook the subject while neither attending the question-and-answer sessions (or, at best, by watching the recording later) nor accessing the flipped classroom materials.

Survey results

The survey was completed by 14 of the 58 students, 24.1%. The graph in Fig. 1 shows these students’ attendance percentage at the question-and-answer sessions and the number of times they accessed the flipped classroom material. Of these respondents, only three recorded low attendance levels at the sessions and limited access to the flipped classroom material.

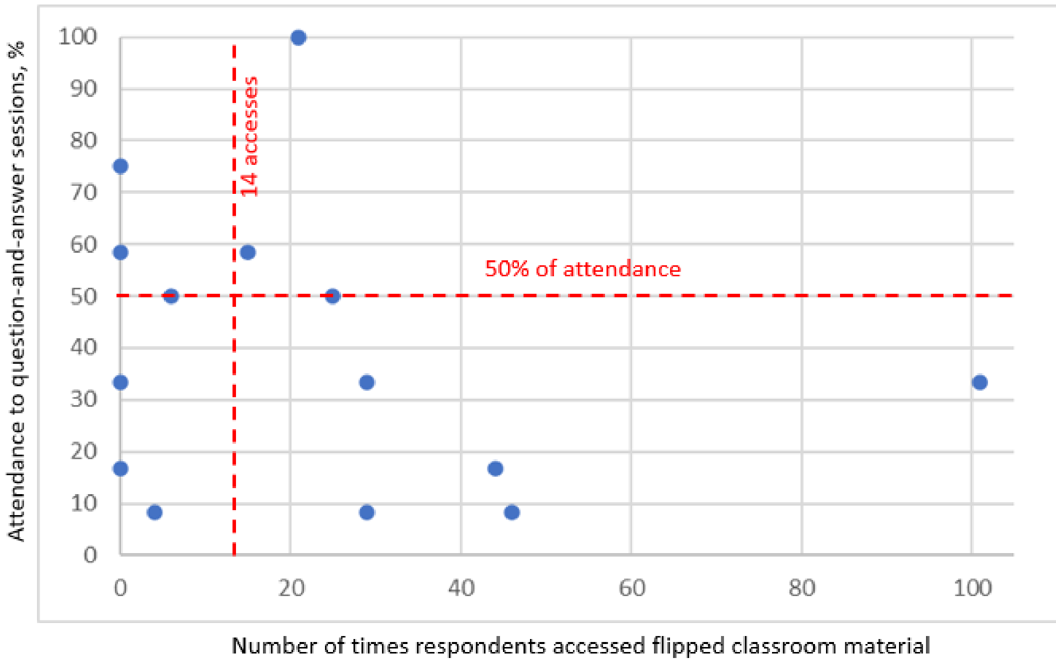

Figure 1. The activity of students who completed the survey.

Considering only the positively formulated questions, the following graphs show the percentages of favorable vs. unfavorable perceptions of the 14 students who completed the survey, divided into two groups.

The group "with high numbers of accesses" (Fig. 2) was composed of eight students who accessed the material more than 14 times (1 access for each video and PDF file).

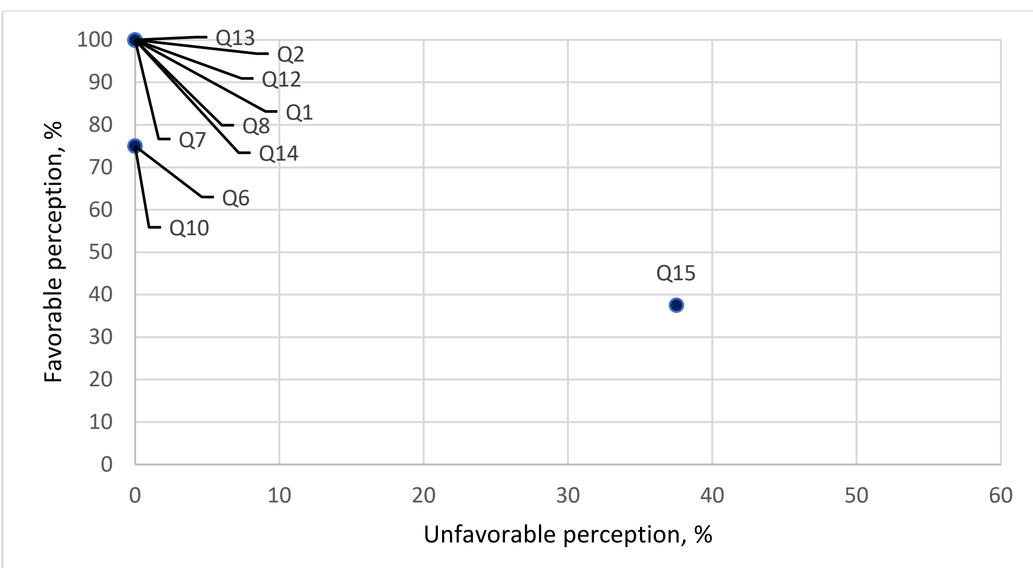

Figure 2. Favorable vs. unfavorable perceptions of respondents with high numbers of accesses.

The group “with low numbers of accesses” (Fig. 3) comprised six students who accessed the material less than 14 times.

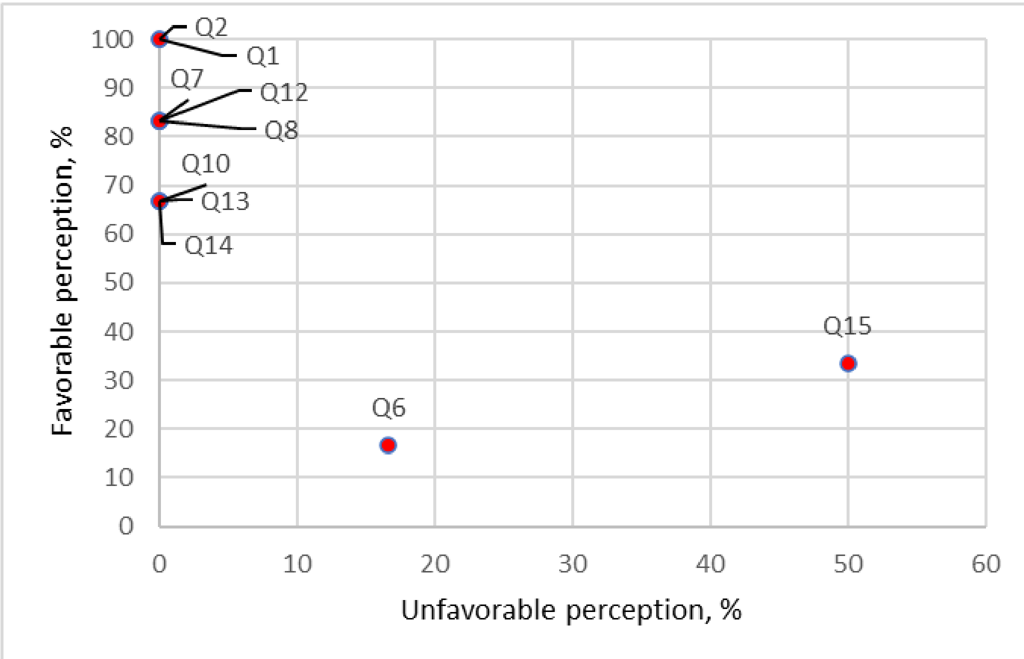

Figure 3. Favorable vs. unfavorable perceptions of respondents with low numbers of accesses

With the exception of questions 6 and 15, positive perceptions are recorded in the majority of both groups. Question 6 (“I feel confident in my knowledge of physics after having reviewed the flipped classroom materials”) exhibits predominantly positive perceptions in the group “with high numbers of accesses” and neutral perceptions in the group “with low numbers of accesses.” Question 15 (“Regarding the theoretical content, I prefer to watch the lessons in a flipped classroom format rather than a traditional lecture from the teacher at the beginning of the question-and-answer session”) indicates predominantly negative perceptions in the group “with low numbers of accesses” and neutral perceptions in the group “with high numbers of accesses.” Regarding the total number of respondents, there is a 35.7% favorable perception and a 42.9% unfavorable perception.

57.4% of respondents reported time constraints when reviewing the weekly content (Q16). Respondents were asked about their current occupation, and replies covered a broad spectrum, including mining (4), finance, biochemistry, unemployed, midwife, nurse, correctional officer, electrician, mathematics teacher, etc.

In addition to Likert-type items, the survey included more open-ended questions, which are discussed in greater detail below.

Question 17 asked about the advantages of flipped classroom materials to identify what students valued most about the information imparted. The responses generally cited the ability to review the available material as required. The question and certain responses to it were as follows:

Q17. "What are the advantages of flipped classroom materials?"

Responses:

- *"They're practical and guide the theory to be covered in class. They give meaning to the question and answer sessions."*
- *"They allow you to repeat videos over and over again."*
- *"They help you optimize your time to study the topics covered in the classes, which, in turn, helps you to get better use out of the question-and-answer sessions."*
- *"They favor learning at a theoretical level since listening to the teacher's voice makes you feel more familiar with the subject and helps you concentrate on the information being discussed."*
- *"They complement and provide extra information about the class subject matter; if necessary, you can review the subjects after the class."*

Conversely, question 18 asked about the disadvantages of the material in an attempt to elicit responses that would prompt suggestions for improving the design of the videos. Few responses were provided to this question, and those given were related to learners who still needed to attend the sessions. The question and specific responses to it were as follows:

Q18. "What are the disadvantages of flipped classroom materials?"

Responses:

- *"I don't see any disadvantages."*
- *"It isn't possible to ask questions in real-time."*
- *"The explanations are too fast, and retaining information in the short term is difficult."*
- *"If you don't watch the videos before the classes, you can't understand the steps to take in the exercises, although this problem can be overcome by reviewing things after the online class."*

Question 19 was intended to elicit more in-depth student feedback regarding the material. The answers did indeed provide feedback on how to improve the videos. The question and certain responses to it were as follows:

Q19. "What changes could improve the flipped classroom materials?"

Responses:

- *"Including a section with more in-depth content, which you can turn to if unsure about something. On several occasions, I had to look things up in other sources to fully understand certain unclear concepts, formulate questions in line with the material, and avoid delaying the rest of my classmates. In my particular case, I never studied electricity before this course."*
- *"The videos could be slower and more instructive, with everyday examples that relate to real-life applications, since not everyone who studies this course necessarily has a background in physics."*

- *“Taking more care of how topics are ordered, since what’s shown is a summary, and also not to write over the text on the screen.”*
- *“More colors.”*
- *“Short and didactic videos with key information relevant to the unit.”*

Finally, question 20 allowed students to express themselves positively or negatively about the experience. In general, the responses were positive and focused mainly on commending the effort made by the teacher. The question and specific responses to it were as follows:

> *Q20. “Please add any other comments you would like to make about the flipped classroom material.”*
>
> *Responses:*

- *“Excellent teacher, very clear and effective. It was all done to a high standard. Thank you.”*
- *“The instructor’s support is greatly appreciated, by investing so much time, he helped the students understand the high-level content involved. I want to congratulate him for all his work during the trimester and the support material he gave us every week.”*
- *“The teacher’s effort in developing this tool is greatly appreciated. I understand the format is in its pilot phase, so it can be improved, as is the case with the PROFIS app, which has been a real help to me in learning physics. Lessons can be learned from PROFIS, such as more gradual explanations. I think there is too much information given in too little time in this format, and maybe content could be separated to facilitate learning and how the information is delivered, with more emphasis placed on core content.”*
- *“I hope this initiative is applied to other subjects because the purely online method involves too few hours with the teachers. In this format, teachers can dedicate more time to teaching theory and interacting more with students via the question-and-answer sessions.”*
- *“The dedication is very much appreciated as it’s been beneficial for learning, especially given the number of hours involved in these synchronous classes.”*
- *“Maintain and promote the inverted classroom method.”*

Discussion

As the answers to question 16 revealed, in addition to the details about the students’ occupations, a heterogeneous group of learners was identified regarding previous training and available time to dedicate to study. With that in mind, the instructional design of the subject must incorporate a significant degree of flexibility to enable the provision of different access alternatives regarding the contents and exercises to meet the diverse realities and needs of students. The results indicate that the flipped classroom in this context may well form part of such alternatives since the students surveyed herein strongly endorse the format.

Overall, the response to the survey was low. However, of the students who did complete the study, and by examining Figs. 2 and 3, differences can be observed between students with few accesses compared to students with many accesses. The group of students "with low numbers of accesses" shows some skepticism towards using the flipped classroom in general. Members prefer receiving content in real-time, which means using part of the question-and-answer session. On the other hand, the group with "high numbers of accesses" is more open to the idea and enjoys more favorable results. In particular, their answers to Question 6, "I feel confident in my knowledge of physics after having reviewed the flipped classroom materials," produced highly favorable scores. Similarly, answers to questions 13, "I would recommend the idea of using these flipped classroom materials for other subjects," and 14, "The flipped classroom materials have a positive impact on my motivation levels for the subject," show that the students who did review the material valued it more highly than those who did not. However, responses to question 15, "Regarding the theoretical content, I prefer to watch the lessons in a flipped classroom format rather than a traditional lecture from the teacher at the beginning of the question-and-answer session," indicate that even students "with high numbers of accesses," who were more open to reviewing the material and showing a positive perception thereof, still adopt a predominantly teacher-centered, rather than a student-centered educational mindset.

Despite their time constraints, some students expressed the need to deepen the content, provide more gradual and detailed explanations, add practical experiments and real-life applications, and introduce ways the theory will be applied in exercises. This would necessitate a more complex instructional design for the flipped classroom materials.

In general, students primarily accessed the material after the question-and-answer sessions rather than beforehand, which contradicts the spirit of the flipped classroom, in which content is essentially intended to be consumed before the sessions. Another point that should be noted is that, although students had a more positive perception of the videos, they accessed the PDF files more frequently.

Conclusions

From the results analyzed, the students with the greatest number of accesses to the flipped classroom material continuously generally had an excellent perception of it. On the other hand, the students who had fewer accesses had a lower positive perception. This result coincides with the one observed in [5]. In addition, they were generally used more as reference and study material after the online consultation sessions than as preparation material before said sessions.

A suggestion for future research would be to consider an improved and more comprehensive version of the flipped classroom than that proposed in the present study. For example, mind maps could be used as the index of a portal that includes different multimedia resources (audio, video, text) in which experiments and practical examples are shown. The flexibility of this approach would allow the needs of different types of students to be met, whether their objective is to merely pass the course or, rather, to delve deeper into the topics at hand. This would require considerably more infrastructure than that used in the material created for this research.

The survey's low response rate requires the results to be treated with circumspection. It would be interesting to reproduce this same experience for several parts of the broader subject and from the beginning of the academic term. This would entail the creation of inverted classroom material for the topics not considered in this process (electric force, electric field, Gauss's law, electric potential).

This study did not consider the effect of flipped classroom material on student performance. Given the course's online format and short duration, developing pre-and post-tests to measure overall learning levels was not feasible. Furthermore, these would necessarily have to be conducted via an online form, which, in turn, would cast doubt on the reliability of the results as it would not be possible to guarantee that student answers fully reflect their accurate knowledge levels.

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