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# Perception Study of an Online Electricity and Magnetism Course for Working Students

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**Abstract**
Teaching basic sciences to engineering students online, specifically for "working students," presents a unique challenge. It is contentious whether the conventional method of instruction employed in traditional daytime undergraduate programs is the most suitable for such a diverse group of students. Working students have limited time and energy due to work and family commitments, weak mathematical and conceptual foundations, and, for most of them, no plans for postgraduate studies or scientific research. This study analyzed students' perceptions regarding developing a quarterly electricity and magnetism course for an engineering program tailored to working students and delivered online. This was achieved through a perception survey across various parallel sections of the same course. This research gathered evidence on the factors and elements that could enhance students' perception and interest in the subject. These findings could serve as input and a precedent for a future reformulation of this and similar courses, transitioning from their current format—a "compressed" version of the analogous course in the traditional daytime undergraduate program—to one that considers the interests and needs of working students and is better adapted to their realities.
**Keywords**: Higher education, STEM education, Working students, Online education, educational innovation

## Introduction

When designing a course for an engineering program in a non-traditional format such as evening and/or online classes, the starting point—the natural and apparent reference—tends to be the analogous course for the same program in the traditional daytime undergraduate curriculum. Due to accreditation requirements, there is an expectation that the quality and level of professionals graduating from non-traditional systems should be equivalent, or at least comparable, to those graduating from traditional formats. Given the time constraints for content review and subsequent study, these courses are conceived as a "compressed version" of their counterpart in the traditional daytime undergraduate curriculum. By "compressed version," we mean teaching the same program as the daytime undergraduate program, with the same level of demand, but in a shorter period and without making significant adaptations to the reality of "working students."

At least initially, there exists a perception that generally, only a minority of students enter university driven by intrinsic motivation [1], and an even smaller portion envisions a career as an academic or researcher [2]. Typically, motivations tend to be more pragmatic, especially acquiring a degree and the necessary learning to gain access to employment or undertaking ventures that allow them to make a living. Working students aim to obtain a professional degree that offers them opportunities for advancement and progress in their field [3].

The traditional university model was initially constructed to provide for young students who have recently completed secondary education. These students typically exhibit established study habits and possess a strong foundation in mathematics and sciences. They are often motivated by the subjects they are studying and are economically secure and free from work and family obligations. Additionally, they have the luxury of dedicating themselves solely to their studies and demonstrate a keen interest in furthering their learning beyond mere grades. These conditions do not exist in a non-traditional modality.

Non-traditional students may face challenges adapting to online learning environments due to their familiarity with traditional teaching methods and expectations of a similar teaching system [4]. Research has shown that non-traditional students, such as those in community colleges, may experience differential outcomes in online versus face-to-face STEM courses, which suggests the challenges in adapting to online learning [4]. Additionally, non-traditional graduate students have been found to perceive emotional presence in online learning experiences, indicating the importance of emotional support in facilitating their adaptation to online learning [5]. Furthermore, the competing life roles of non-traditional students and their specific learning needs suggest that their performance may be better in face-to-face courses [6].

The standard approach to studying science subjects, whose assessments are based on problem-solving, involves practicing various exercises extensively until proficiency is acquired. This requires time and dedication that non-traditional students typically cannot afford compared to their traditional counterparts.

Science subjects also present the additional challenge of being theoretical. Specifically, the content of electricity and magnetism tends to be very abstract and initially less direct to the students' activities. Unlike specialized subjects, adapting the content to meet the students' professional needs becomes difficult.

Given this reality, it is pertinent to pose some questions. What is the profile of "working students" regarding their educational experiences, work reality, and projections? What are their expectations regarding physics teaching in their particular context? To what extent does the current format of physics courses meet these expectations? Therefore, this study aims to analyze students' perceptions regarding developing a quarterly electricity and magnetism course for an engineering program tailored to working students and delivered online.

**Previous studies**

Vergara & Zavala [7] studied the perception of a group of engineering students in an online evening modality for working students regarding flipped classroom materials provided for them to prepare for synchronous sessions. Although these materials were generally wellreceived and evaluated positively, the students did not usually watch them before the session as planned; they predominantly used them after those sessions.

Bravo et al. [8] conducted a qualitative study on the university experience of a group of evening students from five Chilean universities. This study concluded that students are severely constrained by their triple role as parents, workers, and students. It highlighted the need to establish academic support mechanisms. It revealed that institutions have pending tasks in adapting their institutional mechanisms to the reality of these students, such as improving the university experience in terms of academic support and services.

On the other hand, Carvajal & Cervantes [9] conducted a study on university dropout rates in Chile, establishing that dropout rates are higher among students in non-traditional modalities. According to this article, the main reasons for these dropouts were: 1) conditions and personal and situational characteristics (the inability to sustain the previously mentioned triple role); 2) academic capital and performance (low performance due to foundational issues and understandable fatigue due to their lifestyle); 3) unforeseen and adverse circumstances (death or illnesses of children, parents, or close relatives; changing or complicated work conditions); 4) experiences with institutional offerings (lack of flexibility in curricula, attitudes of teachers, lack of institutional support).

The investigation by Ancacoi et al. [10] involved a qualitative exploration into the determinants influencing the academic achievement of adult learners enrolled in two tertiary education schemes in Chile. This article examines the disparity delineating pedagogy and andragogy. While pedagogy concentrates on the educational methodologies pertinent to individuals across various biological and psychological developmental stages, with a particular emphasis on children and adolescents, andragogy is oriented toward the principles of adult education.

An essential differentiation arises here. Despite being legally classified as adults, conventional undergraduate students typically embody characteristics similar to adolescents and young adults who are freshly transitioning from secondary education. They necessitate closer supervision and possess limited life experiences that can be connected to their educational journey. Conversely, non-traditional students, predominantly comprising working adults, may encounter foundational challenges but concurrently bring forth substantial professional and life experiences that can enrich their learning endeavors. Consequently, it becomes evident that educational courses tailored for non-traditional students cannot be uniformly structured like those designed for traditional student cohorts. Moreover, this underscores the inadequacy of extending access to non-traditional educational modalities to recent high school graduates. Such a practice may arise from individuals needing to sustain themselves financially through daytime employment while pursuing higher education via evening programs compatible with their work commitments. However, this scenario poses a dilemma by blending non-adult students, necessitating a pedagogical approach with adult learners who would benefit more from an andragogical approach. This merging significantly complicates the formulation and execution of educational curricula. Consequently, a pressing need arises to devise distinct educational modalities tailored to the unique requirements of both student categories.

***Methodology***

As in [7], the subject is called "Electricity and Magnetism," it is part of the advanced evening in an online modality undergraduate program for working individuals at a private Chilean university. The course lasts 12 weeks plus an exam week, and it covers the contents of a typical electricity and magnetism course for engineering: electrostatics (electric force, electric field, electric potential, and capacitors); electrodynamics (current, resistance, direct current circuits, Kirchhoff's laws, and RC circuits); magnetism (magnetic force, magnetic field, induction).

All content is delivered asynchronously through the platform's materials (videos, guides, notes) in the online modality. There is provision for a synchronous online consultation session and an informal online tutoring session. It is intended (although in practice, it happens little or not at all) that students come to the consultation session with the material already reviewed and that the online sessions are used to answer questions and do exercises. For students' summative assessments, there are four homework assignments, two individual and two group assignments delivered through the platform, two partial tests, and a final exam taken online. The progress of the content is marked by the platform, ensuring that all the subject matter is always covered.

This study's methodology is qualitative data analysis, as it involves a perception survey with a Likert scale and some open-ended questions.

The group analyzed consisted of 4 online modality sections with 220 students. At the end of the quarter, a Likert-type perception survey was conducted in all sections through a CANVAS platform form, in which students were asked about their perception of the course. The questions were based on those used in Zavala & Dominguez [11], Ellis [12], and Bravo et al. [8].

In the following table, the statements in Likert format are listed. The students responded on a five-level scale, from completely disagreeing with the statement to completely agreeing with it. The statements related to the importance of the course for the program and professional career are highlighted in light blue; those related to the attitude towards the course are in light orange; and those related to details of how the course is designed and taught are in light green.

**Table 1**. The 29 items of the Likert-type survey are presented.

| | |
|---|---|
| *1* | I can see how the physics skills that I am currently developing will be useful in an engineering career. |
| *2* | The ways of thinking being taught to me in physics will remain with me long after I graduate. |
| *3* | Physics classes are needed for other courses (mathematics, chemistry, etc.) in my studies. |
| *4* | I feel that the physics course I am currently taking teaches me how to formulate and solve problems that are directly related to engineering. |
| *5* | Physics classes expose me to ideas which I know I will need later on in my engineering degree. |
| *6* | The topics covered in the physics courses will help me later on in my engineering classes. |
| *7* | I see being able to communicate effectively using physics arguments I am taught as an important skill to have |
| *8* | The formal and rigorous aspects that I have learned in physics classes are important for my future engineering career. |
| *9* | It is important to learn physics to find a better job in engineering. |
| *10* | For me, in physics I only want to learn what I feel is likely to be assessed. |
| *11* | At some stage during my degree, I have been so overwhelmed by physics classes that I have considered withdrawing from my engineering degree. |
| *12* | The contents of this course are very relevant to my current job duties. |
| *13* | The contents of this course are very relevant to my future professional plans. |
| *14* | I have a high level of interest in the topic of the course. |
| *15* | I have a high level of experience in the subject matter of the course. |
| *16* | The course would better fit my personal goals if I had more freedom of choice in its contents. |
| *17* | I like the combination of theoretical learning combined with the practical application of the subject matter. |
| *18* | I am very satisfied with my learning experience in this course. |
| *19* | Overall, I find this course very valuable. |
| *20* | The possibility of obtaining a professional degree that will allow me to access better job and income opportunities motivates me to take an evening course. |
| *21* | By learning physics, I will acquire knowledge and skills that will be useful for my personal life. |
| *22* | My main interest in the physics course is related to the need to pass it in order to advance in my career. |
| *23* | I need previous instances of content reinforcement to compensate for the basic academic problems that affect my learning of physics. |
| *24* | I consider that the extension (quantity and variety) of the contents in the physics courses is compatible with the conditions of a trimestral evening context in online format. |
| *25* | I consider that the level of depth of the review of the contents in this physics course is compatible with the conditions of a trimestral evening context in online format. |
| *26* | I consider that the physics courses in a trimestral evening context in online format should be taught with the same extension and depth as the similar courses in a traditional daytime undergraduate context. |
| *27* | The level of demand of the physics courses should consider the context of evening students with work and family commitments. |
| *28* | Asynchronous instances, such as content videos and solved exercises, are very useful for my learning of physics. |
| *29* | I consider that in the physics courses the practical and applied aspects should be privileged over the theory. |

Regarding the survey, information (data, charts) from the CANVAS platform was collected, which was then consolidated and analyzed in Excel spreadsheets.

## Results and discussion

*Descriptive questions*

In the four sections, there was a response rate of 25% from the students (55 in total). The results will be presented in the different sections of the survey below. We will start with the multiple-choice questions. The results are shown in Figure 1.

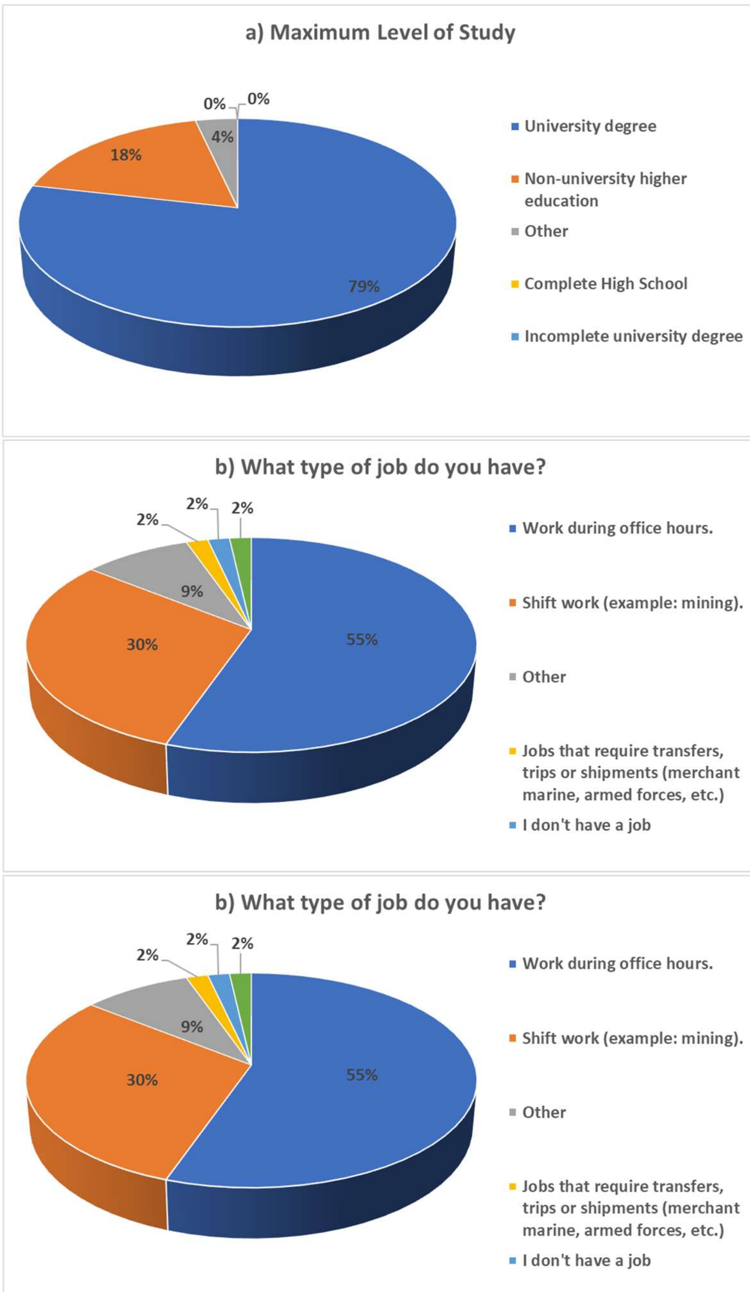


**Figure 1**. Descriptive statistics of students: a) the highest level of education attained before entering the program, b) their current employment, and c) their plans after graduation.

The first question pertained to the respondent's level of education when entering the program (Figure 1, Section a). There is a predominance of students who already possess a university degree and are pursuing a second one, indicating they have prior experience with university studies (79%). There is also a presence of students from non-university higher education (18%).

Regarding their current jobs (Figure 1, Section b), there is a predominance of students with office-hour jobs who could, in principle, opt for the in-person modality if they lived in the areas where the institution has campuses but chose the online option for other reasons (55%). A significant group of students perform shift work, for whom the in-person modality is inconvenient, and therefore, they would opt for the online modality (30%).

Lastly, regarding their plans upon graduation (Figure 1, Section c), most students (82%) seek a degree to improve their job and professional prospects. This is in accordance with the findings mentioned before [3, 8].

*Survey closed questions*

For the presentation of the Likert-type items results, we considered consolidating the responses "strongly agree" and "agree" into a single category, *agreeing* with the statement. Similarly, the responses "strongly disagree" and "disagree" were combined into a single category, *disagreeing* with the statement.

Figure 2 presents 11 items corresponding to the survey on the importance of physics in career and professional life [11]. A point is plotted for each item, summarizing all students' responses to that item with coordinates. The horizontal axis represents the percentage of student responses that disagree with the statement, and the vertical axis represents the percentage of students who agree. The sum of these percentages does not equal 100% because the remainder of the students responded neutrally, and that percentage is not shown.

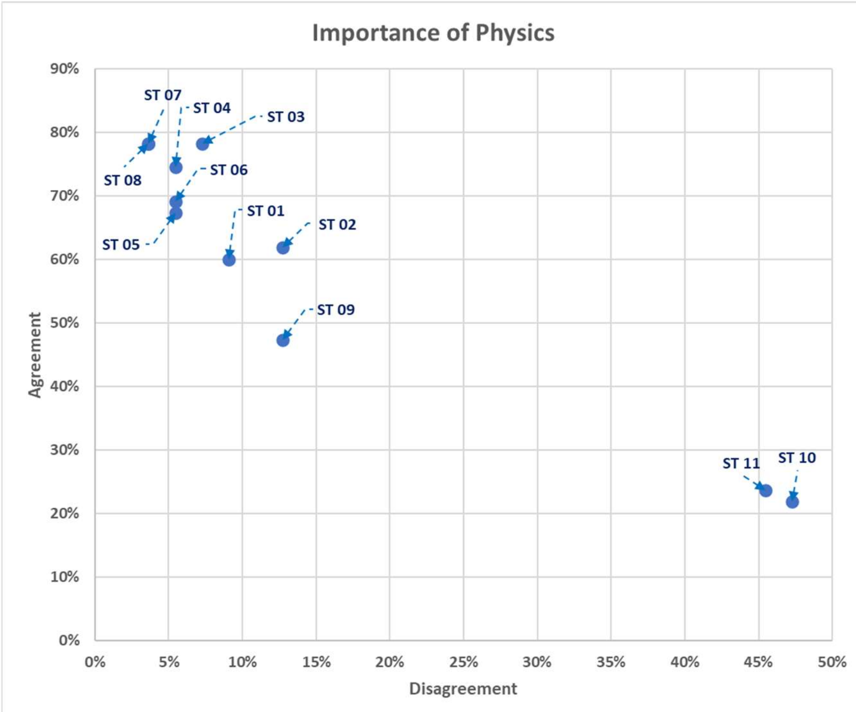


**Figure 2**. The results of the items refer to the importance of physics in engineering.

We can observe that, in general, the perception of the importance of physics in engineering is lower among these adult students compared to what is reported by engineering students but in a daytime program for students who do not work [11]. However, the perception in item 4: "*I feel that the physics course I am currently taking teaches me how to formulate and solve problems that are directly related to engineering,*" is similar to that of daytime students. Interestingly, there are some items, 7: "*I see being able to communicate effectively using physics arguments I am taught as an important skill to have*" and 8: "The formal and rigorous aspects that I have learned in physics classes are important for my future engineering career," where the perception of the adult students is better than that of the younger students. Items 4, 7, and 8 relate to the importance of physics in the professional field. These students, who mostly expect to obtain a better job requiring an engineering degree, may perceive physics as a vehicle to achieve that end.

Figure 3 presents the results of the items related to course satisfaction.

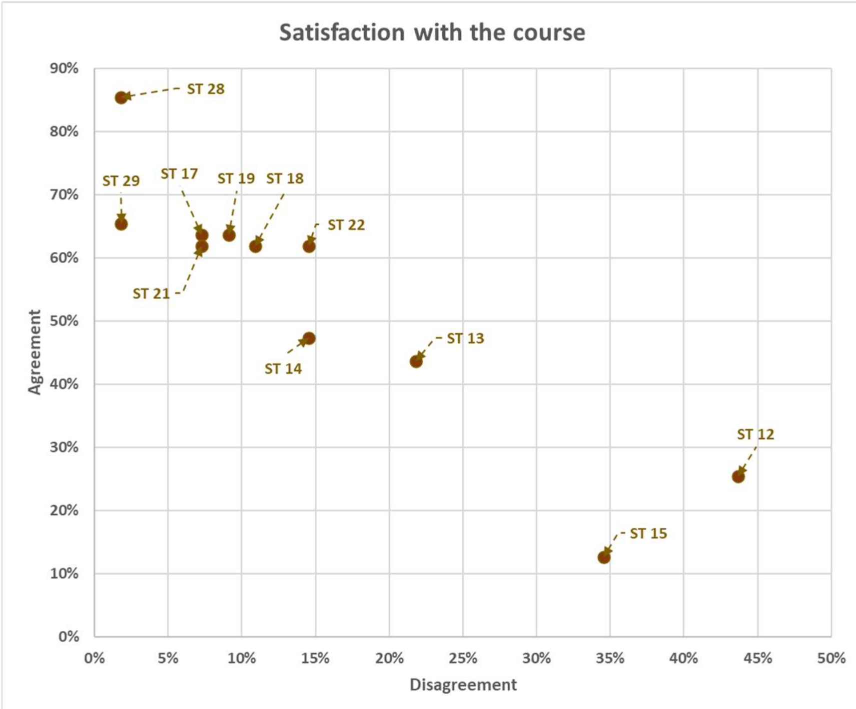


**Figure 3**. Results of the items related to course satisfaction.

The figure highlights item 28: "Asynchronous instances, such as content videos and solved exercises, are very useful for my learning of physics." This result is positive because the asynchronous nature of the course allows students to not be present at the few synchronous sessions but to have access to what is done in the session through videos. This leads to the initiation of recommendations from the study, where the maintenance of these types of resources for students will be advised.

Two items score particularly low: Item 12: "The contents of this course are very relevant to my current job duties" and Item 15: "*I have a high level of experience in the subject matter of the course*." This item suggests that students may not perceive a strong connection between the course content and their current job responsibilities. This could indicate that the course material may not sufficiently align with their workplace's practical needs or demands. It is possible that the content may be too theoretical or not directly applicable to the tasks they perform in their jobs. This lack of perceived relevance could lead to disengagement or lower motivation among students, as they may struggle to see the practical value of their learning.
The results of item 15 indicate that students do not feel highly experienced or proficient in the course's subject matter. This could suggest that many students may perceive themselves as lacking the necessary background knowledge or skills to excel in the course. The course content may be perceived as too advanced or challenging for their current level of expertise. This lack of confidence in their abilities could lead to insecurity or frustration among students, impacting their engagement and performance on the course.

Approximately 50% of students agree with a couple of items. Item 13: "*The contents of this course are very relevant to my future professional plans*," and item 14: "*I have a high level of interest in the topic of the course.*" The fact that approximately 50% of students agree with item 13 suggests a mixed perception regarding the relevance of the course content to their future professional goals. While a significant portion of students see some relevance, the other half may not perceive the content as directly applicable to their career aspirations. This could indicate a need for the course to better align with a broader range of professional paths or to offer more flexibility in content so that students can tailor their learning to their specific career interests.

Similarly, the fact that around 50% of students agree with item 14 indicates a split in student interest in the course topic. While a substantial portion of students express high interest, the other half may not find the topic engaging or compelling. This divergence in interest levels could impact student motivation and engagement with the course material. Addressing this issue may involve exploring ways to make the course content more engaging, relevant, or interactive to capture the interest of a broader range of students.

Figure 4 presents the rest of the items related to the course design and how it is taught.

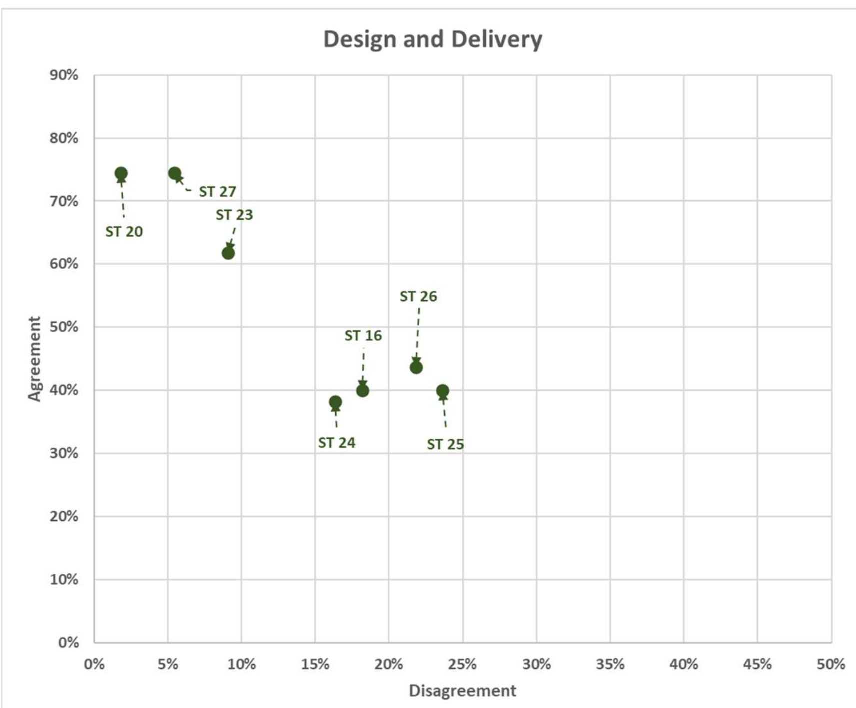


***Figure 4***. Results of those items related to the course design and how it is taught.

There is a very high percentage of agreement and very low disagreement on three items, 20: "*The possibility of obtaining a professional degree that will allow me to access better job and income opportunities motivates me to take an evening course*," 23: "*I need previous instances of content reinforcement to compensate for the basic academic problems that* *affect my learning of physics*," and 27: "*The level of demand of the physics courses should consider the context of evening students with work and family commitments*." The high percentage of agreement in item 20 suggests that many students are motivated to pursue an evening course due to the potential for career advancement and increased income opportunities associated with obtaining a professional degree. This indicates that students are driven by tangible benefits and outcomes that they believe will result from completing the course. It highlights the importance of emphasizing the practical advantages of education, such as improved job prospects and financial stability, to motivate and retain evening students.

The high agreement and low disagreement on item 23 indicate that many students recognize the need for additional support or reinforcement of course content to address fundamental academic challenges they may face in learning physics. This suggests that students acknowledge their academic limitations and seek additional resources or interventions to overcome these challenges. Providing supplementary materials, tutorials, or academic support services could help address the needs of these students and improve their learning outcomes.

The high level of agreement and low disagreement on item 27 suggests that students believe the level of difficulty or workload in physics courses should be adjusted to accommodate the constraints and responsibilities of evening students, such as work and family commitments. This indicates that students recognize the unique challenges faced by evening students and advocate for adjustments to course demands to ensure their success and well-being. Considering evening students' specific needs and circumstances when designing and delivering courses could help improve retention and satisfaction among this student population.

Four items were found to have a low level of agreement, approximately 40%. These were item 16: "*The course would better fit my personal goals if I had more freedom of choice in its contents*," and item 24: "*I consider that the extension (quantity and variety) of the contents in the physics courses is compatible with the conditions of a trimestral evening context in online format*," item 25: "*I consider that the level of depth of the review of the contents in this physics course is compatible with the conditions of a trimestral evening context in online format*," and item 26: "*I consider that the physics courses in a trimestral evening context in online format should be taught with the same extension and depth as the similar courses in a traditional daytime undergraduate context*." Items 24, 25, and 26, particularly, are related to the course design and the need to consider the type of students for its delivery. These results highlight students' concerns regarding the compatibility of course design and delivery with the conditions of a trimestral evening context delivered online. Addressing these concerns may involve reassessing and potentially adjusting the quantity, variety, and depth of course content to better accommodate the needs and constraints of evening students in an online format.

*Survey open questions*

Finally, the results of the open-ended questions in the survey will be presented. The first question invited students to leave additional comments about *the importance of the course in an engineering program*. Student response to the engineering course reflects a mixture of appreciation and criticism. On the one hand, some students value the course for developing and expanding their ability to evaluate everyday situations methodically, which contributes to a better adaptation in the workplace, regardless of the direct use of the syllabus learned. However, others express frustration at being unable to understand key concepts, such as voltage, resistance, impedance, and coil operation, pointing to a disconnect between the resolution of exercises and the practical application of this knowledge in work and daily life.

In addition, students criticize the density and depth of the material delivered quickly, making it difficult for those without a solid foundation to assimilate the content thoroughly, turning the course into a race to pass rather than an opportunity for real learning. The lack of time to solve theoretical doubts and the focus on exercises during synchronous classes, along with notes that do not delve into the why of the phenomena, lead to the memorization of formulas without a deep understanding of them.

Student response to a second question about *the availability of time to dedicate to the engineering course* reflects a shared concern for balancing academic, work, and personal commitments. Students recognize the excellent relationship between teaching and learning and the adequacy of the subject's difficulty to the professional demands of engineering. However, they highlight the difficulties in finding enough time to reconcile the demands of family, work, and student life with the requirements of the course.

Many students find reviewing 100% of the content delivered before classes problematic due to their work obligations. Despite these challenges, some students value the course and find the weekend reinforcement useful. This suggests partially adapting the course structure to accommodate students' time constraints.

The responses to these two questions about the importance of the course and availability of time make sense of some of the results presented in the phrases of the previous section. On the one hand, the response to items 18 and 19, responding to satisfaction with the course, however, contrasts with the response to items 24, 25, and 26, where the percentage of agreement is very low.

Students were also asked about the *structure of the course*. Their response reflects significant concerns about the organization and pace of learning. They identify the early and complex introduction of fundamental concepts, such as the use of vectors in physics without a solid prior foundation, as the main problem. This makes it difficult to understand and apply these concepts in subsequent courses in mechanics and dynamics. The current pedagogical strategy assumes a level of prior knowledge that not all students possess, adapting advanced courses an additional complication. They criticize the density of information and the variety of exercises in quarterly classes, arguing that this prevents deep learning of each topic. The transition to a new format that covers too much information at the expense of depth and practical application is another friction point. The lack of explanatory theoretical classes and the focus on consultation sessions without prior preparation undermines understanding of the subject matter. In addition, they point out the need for more practical examples that relate the theory to real-world applications and express a general need for more time to properly assimilate the contents, arguing that the course progresses too quickly for the amount of material covered.

Finally, students were asked for comments on the t*eacher's strategies and the additional support provided to them in the course*. The student response highlights the importance of the teacher's commitment and methodology in the learning process. They positively value the teacher's knowledge and dedication, especially when complemented with additional resources such as tutoring, extra material on the platform, and tutorials, which they consider fundamental for a deep understanding of the subject. The availability of visual support, such as videos and images, along with reading texts, is mentioned as a significant help in better understanding the complex concepts of the course. Students particularly appreciate it when teachers relate theory to real-world and everyday applications, which makes it easier to understand how various devices and physical phenomena work in daily life.

The didactic strategy of explaining the theoretical content in a summarized and accessible way before proceeding to the practical exercises is especially valued, as it helps students understand the theoretical material and its application. However, they express concerns about the amount of material covered in the quarterly and evening format, suggesting that a greater focus on concepts and theories would be more beneficial for learning than quickly solving a wide variety of problems. Students advocate for a deeper focus on explaining specific types of exercises and the underlying theory, suggesting that this would make it easier to solve problems in personal study and with the help of additional resources provided by the teacher.

These comments reflect the responses to the phrases presented earlier. It should be remembered that item 28 has an exceptional agreement with 85%, and the responses to items 24, 25, and 26 are reinforced, where the problems that students refer to are reflected.

The responses to both the Likert and the open-ended questions show a majority perception of the relevance of physics subjects for their career. Students expect to learn something useful for the university without prejudice to pragmatic and short-term considerations. This, expected in a specialized subject, is striking in a basic science subject. The students surveyed show an open and receptive attitude towards the subject, seeking to learn beyond "what is just and necessary to pass."

Generally, there is satisfaction with the subject and an interest in the training comparable to that of a traditional format student. Notwithstanding the preceding, the need to adapt it to the student's circumstances and with a greater emphasis on topics of direct practical application is evident. The need to review the extension and depth of the contents is evident.

**Conclusions and recommendations**

The results suggest that the subject is generally well-appreciated, that students value the content delivered there, and that they express an interest in learning it beyond the contingencies related to the evaluations.

Notwithstanding the preceding, they express the need to make adjustments that allow it to be better adapted to their reality, both in their available time and in a more practical and applied approach to their work and professional activities. Although they want the teaching, they receive a level that aligns with what they obtained in the traditional mode; they need it adapted to their reality. The idea of designing subjects for non-traditional modalities as "compressed" versions of subjects for traditional modalities serves to make a first approximation, but important adjustments and adaptations need to be made from this point on. What is sought is that the professionals who receive the same degree in the different modalities have training of the same (or at least similar) level of rigor and demand. However, they have different working hours, students have various entry conditions, different study regimes (semestral and quarterly), etc. It is essential then to design adapted versions of the physics subjects for evening students' needs.

There is a complex problem to solve with the delivery of theoretical content. The delivery of content via the platform is not a viable solution since the students do not have time to read it. Instead, they would prefer to receive the content in a more "traditional" way, with synchronous classes dedicated to that. However, this clashes with the idea of an e-learning course based on self-instruction, a scheme they find challenging to enter. It may be that the amount of content considered makes it difficult to study. This forces us to reconsider the dimensioning of the course, both in extension and in-depth.

According to the results and their discussion, we can make the following recommendations:

- Implement teaching strategies that promote the understanding of physical concepts and their practical application.
- Offer learning resources that facilitate the understanding of theory and equations.
- Provide students with the opportunity to apply the knowledge acquired in real situations.
- Implement a flexible schedule policy that allows students to adapt their class schedule to their needs.

- Provide support to students with difficulties in reconciling study with other obligations, such as scholarships, tutoring, and guidance programs.
- Reduce the amount of course content or distribute it over a more extended period.
- Articulate the content of the physics course with other subjects of the degree.
- Provide students with tools and strategies for time management.
- Implement a more extensive and flexible tutoring system.
- Offer a wider variety of visual support resources, such as videos, images, and animations.

The results of this work warrant a deeper dialogue with the students. Unlike the Likert survey in this study, others on this same topic, such as those by [8], [9], and [10], were conducted using semi-structured interviews, which would allow for a deeper exploration of specific topics. While conducting these in person in this online context is very difficult, it is possible to do them through a platform like Zoom, which would also allow the sessions to be recorded. A suggestion for future research is to deepen the study through interviews.

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