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Aligning Physics Education with Professional Realities: Insights from Working Students in an Online Course

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Aligning Physics Education with Professional Realities: Insights from Working Students in an Online Course

Abstract

Balancing professional responsibilities and academic demands makes it difficult for working students to fully engage in traditional physics courses, particularly in rigorous subjects such as electricity and magnetism. This study explores the perceptions, expectations, and experiences of nontraditional students enrolled in a quarterly online electricity and magnetism course in an engineering program at a private university in Chile. Using a qualitative approach with semi-structured focus groups, this research identifies key factors influencing student engagement, including prior training, the balance between theory and practice, content depth, and the teaching modality. The findings reveal that while students value the flexibility of the online format and the emphasis on analytical skills, they face challenges related to the compressed course schedule and limited synchronous interaction. Students expressed a strong preference for practical, work-related applications of theoretical concepts and emphasized the value of adaptive support resources and hybrid learning models. The study underscores the importance of aligning course design with the realities of working students, integrating active learning strategies, and leveraging innovative teaching modalities to enhance accessibility, engagement, and academic outcomes in STEM education.

Keywords: Physics Education, STEM Education, Higher Education, Electricity and Magnetism

Introduction

Physics subjects are integral to engineering programs, as they provide essential conceptual and analytical foundations for addressing complex problems in mechanics, electricity, and magnetism. The importance of physics in engineering education is well-documented, emphasizing its role in developing problem-solving skills and fostering a deep understanding of fundamental principles that underpin engineering practices.

Integrating physics into engineering curricula is crucial for cultivating analytical skills that are vital for tackling real-world engineering challenges. Studies have shown that students' self-perceptions of their abilities in mathematics and science significantly influence their success in engineering disciplines, highlighting the foundational role of physics in shaping these perceptions and skills [1]. Furthermore, the relationship between physics and mathematics is emphasized in educational frameworks that aim to enhance student's understanding of both subjects, facilitating a more cohesive learning experience [2] [3]. This interconnectedness is essential for engineering students, as they often encounter complex problems requiring a solid grasp of physics and mathematical principles.

However, several studies have pointed out that students often perceive these subjects as challenging, affecting their motivation and performance. Research indicates that students usually view physics as one of the more difficult subjects within the STEM (Science, Technology, Engineering, and Mathematics) fields. This perception can lead to decreased motivation and increased anxiety, which in turn affects their performance. Students who perceived physics as challenging were less likely to engage deeply with the material, leading to poorer performance [1].

This phenomenon is accentuated in educational contexts where students face multiple responsibilities, such as online or evening programs designed for working adults. In previous research [4] [5], students have stated that they give interest and importance to the subject but would prefer the subject's contents and modalities to be more focused on practical applications than on the study of theory and that the workload would be more compatible with their limited time.

Online courses initially tend to be "compressed versions" of traditional undergraduate equivalents, a modality designed (at least in theory) for students who are exclusively dedicated to their degree and whose top priority in life is successfully completing their studies. Previous research [4], [5] has shown that students seek valuable knowledge for their professional and working life or to understand the operation of systems of their interest. In the case of electricity and magnetism, they seek to understand the elements that make up an electrical circuit and in which devices we find them, how electricity is generated, how cities are supplied, etc. On the other hand, there are contents such as Coulomb's Law, Gauss's Law, and Biot-Savart's Law that are very abstract and of interest to those studying careers directly related to physics but with little practical application in work environments.

The present research aims to evaluate engineering students' perceptions of their physics education in an evening and online program, identifying their expectations, experiences, and challenges. Key aspects such as career projections, the effectiveness of teaching methodologies, the balance between theory and practice, and the impact of previous training are explored. This approach responds to the need to understand how these factors influence learning and how more inclusive and effective pedagogical strategies can be designed.

While existing studies have explored the role of physics in engineering education, limited attention has been given to the unique experiences and challenges of nontraditional students in online and evening programs. This study seeks to fill this gap by providing insights into their expectations, perceptions, and learning outcomes.

Methodology

A qualitative, focus group-based study explored students' perceptions of physics courses in an evening and online engineering program. This approach was selected because it generates rich, dynamic, and collaborative discussions, allowing participants to reflect and build on their experiences [6] collectively.

Participants

The study included seven students enrolled in an engineering program at a private university in Chile. The participants were divided into two focus groups: one composed of four students and the other of three. Participants were selected by purposive sampling, ensuring diversity in terms of academic background, career paths, and experience in the program. Although the sample size is small, it aligns with qualitative research practices prioritizing depth of insight over breadth. The focus group methodology was selected to generate rich, detailed data, which is particularly valuable for understanding the nuanced experiences of nontraditional students [6].

The course analyzed in this study is part of a quarterly academic calendar, consisting of approximately 8 to 10 hours of coursework per week, combining asynchronous content with synchronous sessions of about 2 hours each. The course is typically completed in a ten-week period and covers foundational topics in electricity and magnetism. Students are expected to have completed introductory mathematics and mechanics courses prior to enrollment. Further contextual details about the course structure and the diversity of academic and professional backgrounds among students in this program can be found in previous studies by the authors [4][5], which explore the design of online physics courses and student demographics in greater depth.

Data collection instrument

A semi-structured protocol was used to guide the focus groups, designed to explore topics such as career projections, expectations toward physics, balance between theory and practice, and perception of the teaching modality. The protocol questions were informed by previously published literature on physics teaching and learning in this setting [4] [5]. This design allowed flexibility for participants to express their opinions in an open-ended manner, encouraging an exchange of ideas.

Procedure

The focus groups were conducted virtually, using videoconferencing platforms to facilitate student participation. Each session lasted approximately 60 minutes and was recorded with the participants' informed consent. Subsequently, the recordings were transcribed in full for analysis.

Data analysis

The focus group transcripts were analyzed using the six-phase thematic analysis process proposed by Braun and Clarke [7], which includes familiarization, coding, theme development, review, definition, and reporting. Codes were generated inductively, then systematically organized into themes that emerged across both focus groups. The process was guided by the principle of reflexivity to reduce bias and ensure that the themes were grounded in the data. This method allowed the identification of key patterns and emerging themes related to students' perceptions and experiences. In addition, representative verbatim quotations (translated into English) were used to illustrate the findings and give voice to the students' perspectives.

Results and Discussion

This research analyzes students' perceptions of various aspects of their engineering education, with special emphasis on physics courses. The interviews identified key themes, such as career projections, initial expectations towards the subject, the balance between theory and practice, the appropriateness of the online/evening format, and the influence of previous training. These categories reflect the academic program's challenges and strengths, allowing a better understanding of students' needs, experiences, and opinions regarding their academic and professional development.

Career Projections

Participants consistently mentioned this theme across both focus groups, highlighting shared motivations and career-related aspirations. Students shared varied professional aspirations after completing their engineering degrees, highlighting trends such as professional growth, job transitions, and entrepreneurship. Many expressed a desire for roles with greater responsibility and better remuneration, reflecting aspirations for upward mobility in their careers. For instance, one student stated, "*I hope to have developed more experience in my area so that I can apply for higher positions in the organization*" (Student 1, Interview 1). These findings align with research on the career motivations of nontraditional students, who often prioritize professional advancement as a key driver for returning to education [8].

The desire for entrepreneurship among some students reflects an emerging trend in engineering education, which increasingly emphasizes developing entrepreneurial skills. However, students also cited significant barriers, including time constraints and economic risks, limiting their ability to pursue entrepreneurial goals. For example, one student noted, "*At the moment, I am doing it at the family level. We have a company... with machinery with my parents*" (Student 7, Interview 2). This highlights the need for tailored institutional support, such as entrepreneurship workshops or networking opportunities with industry professionals, to help students overcome these challenges.

Moreover, the expressed interest in changing careers, often motivated by dissatisfaction with current work conditions, underscores the critical role of engineering programs in preparing students for flexible and transferable career paths. Previous studies emphasize integrating interdisciplinary and practical experiences into engineering curricula to facilitate these transitions [2].

Given these findings, universities could consider developing targeted initiatives to support career transitions and entrepreneurial aspirations among nontraditional students. For example, mentorship programs connecting students with industry leaders or former students who have successfully navigated career transitions could provide valuable guidance and inspiration. Additionally, embedding interdisciplinary projects within the curriculum could help students acquire the versatile skills needed for both career advancement and entrepreneurial endeavors.

Expectations About Physics

Students' expectations toward physics varied significantly. Many initially approached the subject with fear, shaped by negative past experiences. One student shared, "*The expectation was terrible because in college Physics 1 was a terror; Physics 2 was a horrible terror. So, I was* *coming with much fear*" (Student 5, Interview 2). These sentiments reflect the long-lasting impact of traditional teaching methods, which often emphasize memorization and rigid assessments, leading to anxiety and disengagement in physics courses. Similar findings have been documented in studies on STEM education, where the perceived difficulty of subjects like physics discourages students from fully engaging [9].

However, the introduction of active methodologies, such as problem-solving exercises and practical applications, significantly transformed students' perceptions. One student remarked, "*I knew it was a difficult course...but I chose you and said, yeah; hopefully, everything will be better.' And it did get better. I think I learned a lot*" (Student 6, Interview 2). These shifts, reported by most participants, highlight the critical role of innovative pedagogical approaches in addressing cognitive and affective barriers to physics learning among nontraditional students. Active methodologies have been shown to reduce student anxiety and foster a deeper engagement with complex material, particularly in physics [10].

Additionally, while some students acknowledged that physics might not directly relate to their future careers, they valued the course's emphasis on analytical and problem-solving skills. This perspective aligns with existing research that positions physics as foundational for broader cognitive development in engineering programs [11]. As one student noted, "*I consider it a base course to continue advancing in the career proper*" (Student 6, Interview 2). By framing physics as a means of developing transferable skills rather than solely as a subject with direct career relevance, educational programs can better align the subject's perceived utility with students' professional aspirations.

Given these findings, institutions should consider leveraging active learning techniques more widely in physics courses. For example, integrating real-world problems or interdisciplinary projects into the curriculum could make the content more relatable and reduce initial resistance among students. Furthermore, addressing student anxiety early through orientation sessions or introductory workshops could create a more supportive learning environment and help students transition from fear to confidence in their ability to succeed in physics.

Extent and Depth of Content

Most students acknowledged that the course content was well-structured, though they expressed concern about the pace imposed by the condensed schedule. Students generally found the level of physics content appropriate but identified challenges in the condensed quarterly format. One student commented, "*I feel that it is a lot of information in very little time. I feel like sometimes it could be more lectures like to decompress a little bit*" (Student 6, Interview 2). These observations reflect the inherent difficulty of covering complex and abstract physics concepts within a limited timeframe, a challenge often amplified in accelerated programs. Education psychology suggests that condensed course formats can increase cognitive load, making it harder for students to engage deeply with the material and retain knowledge [12].

Despite these challenges, students appreciated the depth and clarity of the curriculum. "*I think the content we take is clear and precise. They lead us to make the classes a little bit faster and everything, but yes, they are adequate*" (Student 7, Interview 2). This suggests that while students recognize the curriculum's quality, the pace at which it is delivered could be better aligned with their learning needs. Cognitive load theory emphasizes the importance of balancing the volume and complexity of information presented with students' capacity to process and retain it effectively [12].

These findings underscore the need for course designs that allow students more time to engage with complex material without feeling overwhelmed. One potential strategy is adopting a hybrid format, where synchronous sessions focus on interactive and application-based learning, while asynchronous resources, such as recorded lectures and simulations, provide additional support. Another approach could involve extending the duration of specific courses or offering optional review sessions to reinforce foundational concepts.

Aligning content delivery with students' cognitive load is especially critical for nontraditional learners who balance academic commitments with work and family responsibilities. Providing opportunities for self-paced learning through online platforms or modular course designs could empower students to engage with the material at their own pace, improving comprehension and satisfaction. Future research could explore the long-term impact of such adaptations on students' academic performance and perceptions of physics courses. These responses point to a shared recognition that while content quality is appreciated, its delivery must consider cognitive load and time constraints typical of nontraditional learners.

Balance Between Theory and Practice

Students expressed diverse opinions on the balance between theory and practice in physics courses, reflecting varied learning preferences and professional objectives—some prioritized practical applications as essential for consolidating knowledge and fostering engagement. "*I practice all the time. There should be more weight given to the practical subject*" (Student 5, Interview 2). Others emphasized the importance of theory as the foundation for understanding and applying complex concepts. "*For me, the theoretical part will always have more weight since it is like the fundamental pillar*" (Student 6, Interview 2). These perspectives underscore the challenge of designing courses that cater to both preferences while maintaining academic rigor.

This diversity reflects broader debates in STEM education about the optimal balance between theoretical instruction and hands-on learning. Research highlights that while theoretical knowledge is crucial for developing analytical and problem-solving skills, practical experiences provide the context to apply these skills effectively [1]. Theoretical concepts, such as those in physics, often serve as building blocks for advanced applications, but without practical reinforcement, students may struggle to see their relevance to real-world scenarios.

To bridge this gap, educational programs should consider integrating project-based learning or interdisciplinary activities that connect theoretical principles with authentic, context-based problems. For instance, students could design and simulate an electromechanical system or analyze energy efficiency in real-world devices. Simulations and virtual labs are valuable tools for providing practical experience in online formats, but these should be complemented by opportunities for collaborative, hands-on projects whenever possible.

Future research could explore how different pedagogical strategies, such as blended learning or flipped classrooms, impact the integration of theory and practice in physics education. Investigating the long-term benefits of these approaches on students' career readiness would provide valuable insights for curriculum design in engineering programs.

Previous Training

The academic background of participants varied widely, with some returning to formal study after decades, and others having more recent exposure to STEM content. Students' preparedness for physics varied significantly, reflecting the diversity of their educational backgrounds. Some struggled to reintegrate into academic settings after years away. One student shared, "*It has been more than 20 years since I stopped studying... I started like from 0*" (Student 5, Interview 2). These comments highlight nontraditional students' challenges, particularly when re-engaging with subjects that require cumulative knowledge, such as physics. In contrast, other students noted that their prior training provided a solid foundation, albeit with challenges in integrated areas like physics and mathematics. "*My degree still had a good scientific background, so at least it did not cost me that much, although in mechanics, it was a bit more difficult because of the mix with calculus*" (Student 2, Interview 1).

These findings align with research that underscores the importance of a strong foundation in mathematics and physics for success in engineering education. Students with insufficient prior training often experience heightened anxiety and reduced confidence, which can hinder their engagement and performance. Conversely, those with robust foundational knowledge are better equipped to tackle advanced concepts, although interdisciplinary challenges, such as integrating physics and calculus, can still pose difficulties [2].

A recurring suggestion from students was the inclusion of leveling courses or reinforcement activities to bridge knowledge gaps. "*It would have been quite good to have some additional leveling course, as it was for calculus. That would help us enter more prepared*" (Student 7, Interview 2). This aligns with previous studies' evidence that remedial or preparatory programs can significantly improve student outcomes by addressing disparities in prior knowledge [13].

To address these challenges, institutions could implement diagnostic assessments at the beginning of physics courses to identify students' strengths and weaknesses. Based on these assessments, personalized leveling modules or workshops could be offered to reinforce foundational concepts before introducing advanced material. Adaptive learning technologies, which tailor content to individual student needs, could also be crucial in supporting diverse learners.

Creating a supportive learning environment is especially critical for students returning to academia after long breaks. Strategies such as peer mentoring, where more experienced students guide less confident students, or online resources that allow self-paced review of key concepts could help reduce anxiety and improve confidence. By addressing the disparities in prior training, engineering programs can create more inclusive learning experiences that enable all students to succeed.

Teaching Modality

The online and evening format was widely appreciated for its flexibility, allowing students to balance work, family, and academic commitments. "*Being online is the only way for me to be calm and be able to pay full attention in class. It favors me a lot*" (Student 5, Interview 2). This flexibility is a significant benefit for nontraditional learners, who often face competing demands on their time. Studies confirm that online and evening formats provide essential accessibility for students who might otherwise be unable to pursue higher education [4] [5].

However, students identified challenges within this modality, particularly the limited synchronous contact hours. One student expressed, "*If it were up to me, I would increase the synchronous contact hours, but not the content. Maybe explain it more leisurely*" (Student 6, Interview 2). This finding highlights a tension between flexibility and the need for real-time interaction. Research in online education emphasizes the importance of synchronous sessions in fostering engagement, building community, and providing immediate feedback, particularly in complex subjects like physics [14]. At the same time, asynchronous resources, such as recorded lectures and interactive guides, play a critical role in allowing students to revisit content at their own pace.

Students also praised the quality of support materials, such as guides and videos, which they found invaluable for autonomous learning. "*The support material you deliver, such as the guides and videos, is spectacular. It is fundamental and should not be missed*" (Student 6, Interview 2). This aligns with existing research showing that well-designed asynchronous resources enhance student understanding and accommodate diverse learning styles [15].

To address the identified challenges, institutions could consider adopting a hybrid teaching modality that combines the flexibility of asynchronous learning with the engagement of synchronous sessions. For example, synchronous classes could focus on interactive, application-based learning, while asynchronous materials provide foundational knowledge and opportunities for self-paced review. Advanced tools, such as virtual labs or simulations, could enhance the online learning experience, especially in STEM fields.

Additionally, leveraging learning analytics to monitor student progress and identify areas of difficulty could allow instructors to tailor their teaching strategies and provide targeted support. For instance, identifying students who struggle with specific concepts through quiz results or activity logs could enable timely interventions, such as personalized feedback or additional tutorial sessions.

Conclusions

While the study is based on a small sample typical of qualitative research, the consistency of themes across both focus groups and the depth of student reflections provide meaningful insights into the design of online physics instruction for working professionals. The research revealed that students' perceptions of physics subjects in an engineering program are influenced by their previous experiences, expectations, and teaching methodologies. Students positively valued the flexibility of the online/evening format and the methodological approach that promotes problem-solving and the use of practical resources, highlighting its impact on meaningful learning. However, they identified challenges related to the content load in limited time and the need for greater integration between theory and practice. The diversity of student profiles was a key factor affecting the educational experience, reflecting the importance of offering inclusive pedagogical strategies that reduce preparation gaps.

This study contributes to the growing body of literature on inclusive STEM education by highlighting the unique needs of nontraditional learners. Its findings underscore the importance of flexible yet engaging pedagogical models to support diverse student populations. By addressing these needs, engineering education can enhance learning outcomes and broaden access to STEM careers for underrepresented groups.

It is recommended that leveling programs or introductory courses be implemented to strengthen students' foundations, especially in physics and mathematics. In addition, it would be beneficial to increase synchronous contact hours or explore hybrid formats that allow more significant interaction and personalization of learning. Integrating activities that connect theory and practice and using interdisciplinary projects or case studies that reflect real scenarios is crucial. Finally, it is suggested that pedagogical tools such as simulations and digital material be maintained and expanded, guaranteeing access and quality.

The research was based on a limited group of students within a specific program, which may restrict the generalizability of the results to other educational contexts or disciplines. In addition, data collection was conducted solely through interviews, which may not fully capture all perspectives or experiences. It was also identified that external factors, such as students' work and family responsibilities, may have influenced their responses and perceptions.

Future research could explore the long-term impact of active methodologies on the retention and application of knowledge in physics. Likewise, analyzing how remedial strategies or reinforcement programs impact academic performance in engineering programs would be valuable. Further research could also focus on developing pedagogical models that optimize the integration of theory and practice, considering individual differences in learning styles. Finally, it is suggested to investigate how hybrid and online formats can be adapted to more diverse contexts and maximize their effectiveness in different student populations.

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