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Effectiveness and Student Perceptions of Online Research Methodology Intersemester Courses in Engineering

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This study aims to evaluate the effectiveness and student perceptions of online intersemester courses in engineering, specifically the Research Methodology course at a Mexican public university. A mixed-methods approach was applied, combining surveys, statistical analysis, and qualitative feedback. Data were collected from 522 students who took the course in either online or face-to-face modalities over five academic terms (2022–2024). Findings reveal statistically significant differences in academic performance between modalities, with greater variability observed among online students. While participants reported enhanced autonomy, adaptability, and time management in the online format, they also experienced reduced interaction and self-regulation challenges. Students preferred synchronous or blended formats, particularly those with visual and multimodal learning styles. The study concludes that online intersemester courses are viable when effective instructional design and equitable technological access are supported. These insights contribute to improving course planning and institutional policies for intersemester online education.

Keywords: online education, intersemester courses, engineering students, student perceptions, instructional design, mixed methods

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INTRODUCTION

The constant advancement of information and communication technologies has rapidly benefited society in various application areas. Education is an area that is constantly changing due to the diversity of learning strategies implemented for optimal student learning, considering that each student faces a generational gap and the presence of new advances. Traditionally, education focused on the teacher, the primary source of knowledge, and an entirely face-to-face model was used.

The COVID-19 pandemic forced educational institutions to adapt their teaching techniques quickly, accelerating the adoption of online learning technologies and changing the teaching style. There are a variety of studies that analyzed teaching techniques in courses during the pandemic (Pishchukhina et al., 2024; Mbunge et al., 2021; Toti & Alipour, 2021), where they state that the transition to online learning did not affect student performance. Various learning techniques were implemented depending on the nature of the subject. Some used simulation as the most viable teaching medium for experimental phenomena (Salazar-Peña et al., 2023; Kalúz et al., 2012).

Due to the accelerated growth of virtual environments in higher education, the need to establish clear conceptual distinctions between online education, e-learning, and distance education has intensified, given that their indiscriminate use can generate methodological and epistemological confusion (Singh & Thurman, 2019; Garrison et al., 2003; Phipps et al., 1999). In this sense, online learning is defined as access to educational experiences mediated by digital technologies, characterized by its temporal and spatial flexibility, its potentially asynchronous modality, and the use of various digital platforms that allow greater accessibility and personalization of learning, factors directly associated with improvements in student performance (Akpen et al., 2024; Hiltz & Turoff, 2005; Carliner, 2004; Ally, 2004; Conrad, 2002; Benson, 2002). For its part, e-learning is conceptualized as a mediated technological modality enabling learning through electronic devices, integrating content such as videos, podcasts, and online assessments, and facilitating autonomous and collaborative learning (Díaz Redondo et al., 2021). Unlike these approaches, distance education remains focused on overcoming geographical and temporal barriers. It stands out for its attention to instructional design and transactional presence, which compensate for the separation between teachers and students (Achuthan et al., 2024; Moore et al., 2011). Furthermore, recent studies have highlighted that these interrelated models respond to different pedagogical and technological logics; therefore, their differentiation is key to advancing digital educational research (Zou et al., 2025).

A crucial element in the design of online courses is the synchronous or asynchronous modality. Recent studies show that synchronous forums and activities promote greater engagement and social connection among students, which translates into improved academic performance compared to the exclusive use of asynchronous activities (Duncan et al., 2012). For example, Jarrah et al. (2025) report that synchronous interaction strengthens active student participation, facilitating immediate questions and clarifications, even more so than in face-to-face environments. Similarly, a recent review by Hung et al. (2024) concludes that predominantly synchronous environments

offer greater interpersonal support, increase social interaction, and generate greater student satisfaction than mostly asynchronous environments.

From another perspective, as online education expands, it is essential to consider student diversity regarding learning style, gender, accessibility, and access equity. Various studies highlight the effectiveness of inclusive instructional design (Ismailov and Chiu (2022); Wladis et al., 2015; Shea & Bidjerano, 2014; Xu & Jaggars, 2013). For example, Mackey et al. (2023) show that applying Universal Instructional Design (UDL) practices in experience-based educational environments significantly improves student engagement, facilitates the elimination of learning barriers, and promotes inclusive pedagogical strategies aligned with the three UDL guidelines. However, they emphasize that the lack of real-time interaction limits student relational satisfaction in these contexts (Rodriguez, 2015). In any online learning modality, active interaction between students and teachers significantly enhances student satisfaction, positively impacting their academic performance. This assertion is supported by the findings of Capinding (2024), who demonstrated that the effectiveness of online teaching and teacher preparation are significantly correlated with student satisfaction and academic performance (Nandi et al., 2012; Slagter van Tryon & Bishop, 2009; Fish & Wickersham, 2009; Appana, 2008; Gallien & Oomen-Early, 2008; Shea et al., 2005; Thurmond & Wambach, 2004; Rovai, 2002).

Several recent studies have shown that while asynchronous distance education offers substantial advantages in terms of temporal and spatial flexibility, it also poses significant challenges related to a lack of structure, cognitive overload, and communication limitations (Hazaymeh, 2021). Of particular concern are the barriers associated with the interaction gap between teachers and students, divergent pedagogical expectations, and deficiencies in information provision. These factors, taken together, compromise the effectiveness of asynchronous learning and generate tensions in the virtual educational dynamic.

Multiple higher education institutions in Mexico have adopted online intersemester courses to expand educational coverage, improve operational efficiency, and facilitate academic progression. However, there remains a notable lack of empirical studies that rigorously evaluate the impact of these short-term courses on the academic performance and learning experience of engineering students, particularly in asynchronous environments. This lack of evidence limits the possibility of developing adaptive, data-driven pedagogical models for virtual contexts.

Additionally, specialized literature has only marginally addressed differential aspects related to gender, learning styles, and access to technology, which critically impact student interaction with digital platforms. The omission of these variables prevents a comprehensive understanding of the latent inequalities and specific needs of an increasingly diverse and technologically heterogeneous student population.

Within this framework, this study aims to reduce this gap through a convergent analysis that articulates quantitative data on academic performance with students' qualitative perceptions of their learning experience in online intersemester courses. It also recognizes the potential of this modality to optimize institutional resources, reduce dependence on physical infrastructure, foster independent learning, and make students'

academic trajectories more flexible. Many students use these courses to earn credits, reduce the overall duration of their studies, and maintain continuity during intersemester periods.

Purpose Of The Study

The present study aims to analyze the factors influencing engineering students' preference for online courses compared to face-to-face courses in Research Methodology during the intersemester period. Relevant findings from the literature were considered to provide a deeper understanding of the elements that contribute to the success of online courses and to develop a basis for designing effective pedagogical strategies. These strategies promote the availability of courses and their participation in future intersemester periods.

During the COVID-19 pandemic, studies conducted on students at a public university in Mexico, showed that many prefer a visual learning approach. Considering the technological advances and the experience gained in education during this time, it makes sense to see if offering fully online courses during the regular semester is possible. This initiative aims to capitalize on the positive perceptions that students have developed towards online courses, mainly based on their intersemester experiences. Implementing an instructional design that provides clear and concise guidance is critical to ensure the effectiveness of academic activities, promote students' autonomous development, and minimize potential challenges.

METHOD

This study employed a convergent mixed-methods design to assess students' perceptions and academic performance in intersemester courses offered online and face-to-face. The unit of analysis was the Research Methodology course. The quantitative approach focused on analyzing the final grade obtained by students in the course enrolled during the intersemester period and in other courses taken during that period to identify possible variations in academic performance associated with the course modality. The qualitative component was developed using a natural context and interpretive perspective, utilizing thematic or narrative analysis based on open-ended responses collected through surveys. This analysis sought to understand students' needs, experiences, and perceptions of online courses. The integration of both methodological approaches provided a more complete view of the effects of the educational modality on learning and competency development in high-intensity academic contexts, such as intersemester courses.

Participants

Data were collected from 4,249 students enrolled in intersemester courses at a public engineering university in Mexico, between the summer of 2022 and 2024. For quantitative and qualitative analyses, we focused on 522 students enrolled in the research methodology course in both modalities (online and face-to-face) over five academic terms. For qualitative feedback, a subsample of 212 students completed detailed perception surveys. For their identification, the nomenclature "-4" is used for summer and "-5" for winter. Table 1 shows information for each intersemester period on the total number of courses offered in both modalities and the total number of

enrolled students by gender. The courses offered during these periods are predominantly Theoretical Subjects, including Research Methodology, Probability and Statistics, Administration, Statistics, the Internet of Things, Environmental Engineering, and Intellectual Property.

Table 1.
Students enrolled per intersemester period

Academic cycle 2022-4			
		Female	Male
Number of courses offered in online mode	2	33	47
Number of courses offered in face-to-face	24	222	470
Total	26	255	517
Academic cycle 2022-5			
		Female	Male
Number of courses offered in online mode	6	61	127
Number of courses offered in face-to-face	24	194	399
Total	30	255	526
Academic cycle 2023-4			
		Female	Male
Number of courses offered in online mode	5	50	126
Number of courses offered in face-to-face	24	197	394
Total	29	247	520
Academic cycle 2023-5			
		Female	Male
Number of courses offered in online mode	6	59	150
Number of courses offered in face-to-face	26	220	390
Total	32	279	540
Academic cycle 2024-4			
		Female	Male
Number of courses offered in online mode	10	87	254
Number of courses offered in face-to-face	30	279	490
Total	40	366	744

Data Collection and Analysis

Two separate survey instruments, specifically designed for each teaching modality, were used. Both instruments assessed key dimensions such as student engagement, usability of the learning platform (Blackboard), quality of interaction, and self-perceived learning.

The face-to-face student questionnaire included 21 items, while the online questionnaire included 30. In both cases, responses were measured using a 5-point Likert-type scale.

Additionally, students' final course grades and cumulative GPA were collected to compare academic performance between the two modalities. The Shapiro-Wilk test was applied to assess the normality of the grade distribution. Since the data did not exhibit a normal distribution, the Mann-Whitney U test was used to compare group performance. Levene's test was also used to verify the homogeneity of variance.

Regarding the qualitative data, thematic analysis was applied to the open-ended responses to identify and categorize the main challenges perceived by students, their preferences regarding the teaching modalities, and their teaching suggestions.

Research Methodology course in face-to-face mode

Table 2 presents the number of students in the subject in person during each intersemester school cycle. It should be noted that, in each period analyzed, only one course was offered in this modality.

Table 2
Students enrolled in the face-to-face research methodology course

Academic cycle 2022-4	
Female	Male
9	16
Academic cycle 2022-5	
Female	Male
5	10
Academic cycle 2023-4	
Female	Male
12	26
Academic cycle 2023-5	
Female	Male
7	21
Academic cycle 2024-4	
Female	Male
12	17

In total, 135 students enrolled in the face-to-face course. The university's grading scale is set from 0 to 100, with 100 being the highest possible score.

Figure 1 presents scatter plots of data by period, reflecting the academic performance of the course students. In these graphs, the green circle represents the final grade obtained by each student, the red dashed line indicates the group's overall average, and the blue dashed line shows the overall average of each student in all the courses they have taken during their academic career. It is worth mentioning that students who abandoned the intersemester course were excluded from the graphical representation. In the 2022-2024 academic year, there is a general trend toward high grades, albeit with some dispersion; some students are considerably below the overall average. The 2022-2025 academic year shows greater homogeneity in grades, with both averages (course and overall) very close. In 2023-2024, there is a greater concentration of grades above 90 points, although cases below the blue line indicate variability within the group. In 2023-2024, the distribution remains relatively stable, with most values above the overall average. Finally, the 2024-2024 academic year shows a very marked concentration of high grades (close to 100) with little dispersion, and the course average is clearly above the overall average.

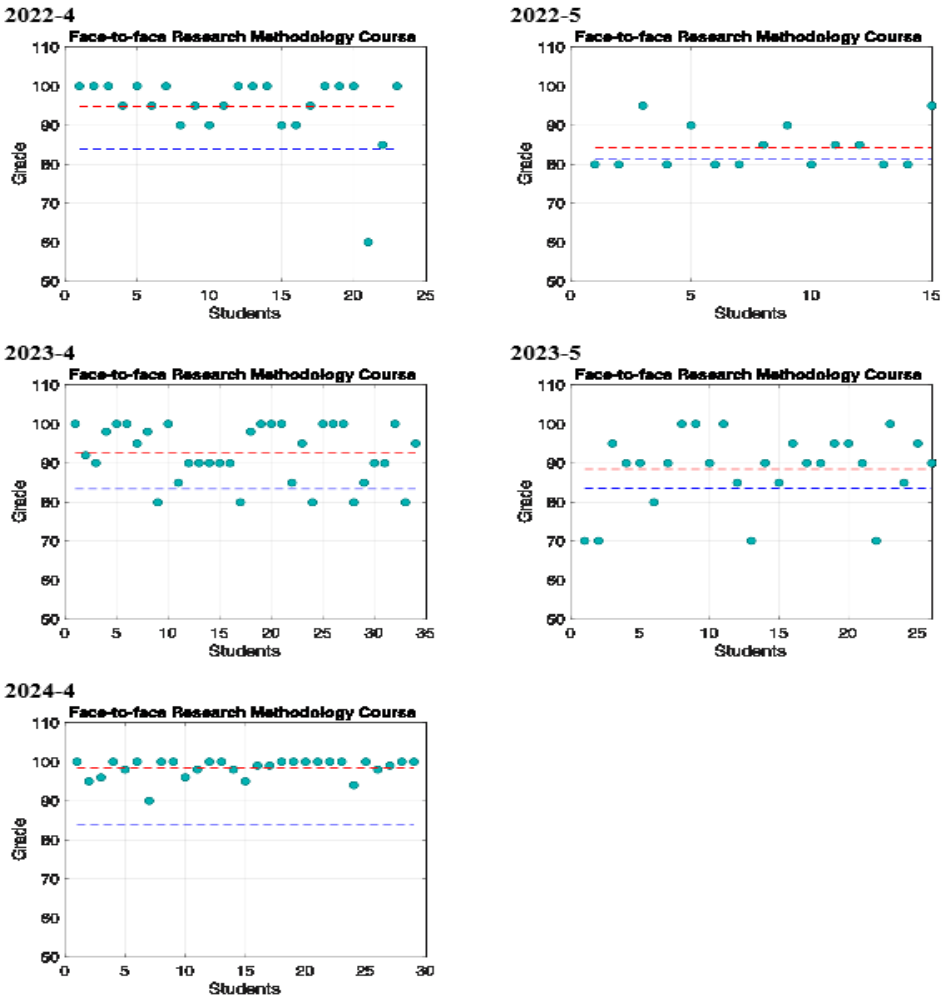

Figure 1
Grades obtained by students in the intersemester Research Methodology course face-to-face mode, organized by academic cycle. The indicators: ● represent each student's final grade in the course, – – indicate the overall average of the group, and – – indicate the overall average of each student considering all the courses taken throughout their career

Research Methodology course in online mode

Table 3 presents the data of the students who enrolled in the online modality for each intersemester school cycle. Unlike the face-to-face modality, two research methodology courses were offered in this modality during each period.

Table 3
Students enrolled in the online Research Methodology course

Academic cycle 2022-4	
Female	Male
47	33
Academic cycle 2022-5	
Female	Male
23	48
Academic cycle 2023-4	
Female	Male
25	53
Academic cycle 2023-5	
Female	Male
30	44
Academic cycle 2024-4	
Female	Male
28	56

In total, 387 students registered for the face-to-face modality.

Figure 2 shows the scatter graphs of the student's academic performance in this modality, organized by teaching period. The indicators used are the same as in Figure 1.

In the 2022-2024 academic year, grades cluster around high values (between 90 and 100), with a slight margin above the overall academic average. In 2022-2025, a greater dispersion in grades is observed, with several students scoring below 80 points and, in some extreme cases, close to 50, suggesting considerable heterogeneity in performance.

The 2023-2024 and 2023-2025 academic years also show notable dispersion, with students achieving very high grades while others fall significantly below the overall average. This variability indicates differences in how students approach the online course.

In contrast, in the 2024-2025 academic year, a greater concentration of high grades is observed, similar to the visual pattern of the 2022-2025 academic year, suggesting a more homogeneous group in terms of performance.

In general, comparing the red and blue lines across all academic years shows that, in most cases, the online course average is higher than the overall average, albeit with greater individual dispersion, suggesting significant variability in the use of the intensive virtual environment.

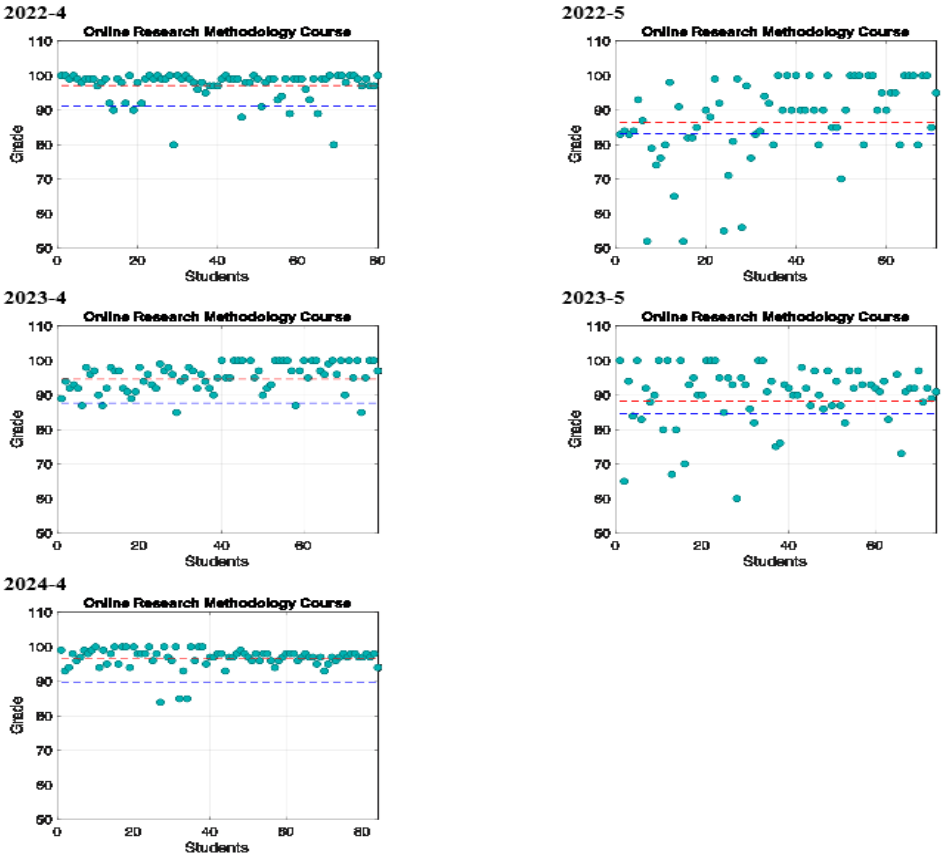

Figure 2
Grades obtained by students in the intersemester Research Methodology course in online mode, organized by academic cycle. The indicators: ● represent each student's final grade in the course, -- indicate the overall average of the group, and -- indicate the overall average of each student considering all the courses taken throughout their career

Instructional Design for an Online Course

Instructional design is a fundamental tool for the pedagogical structuring of courses in virtual and blended learning environments. It enables the systematic planning of activities aligned with learning objectives. Its proper implementation directly impacts the effectiveness of the educational process by facilitating the coherent integration of teaching strategies, technological resources, and assessment criteria.

In this study, the course was designed using the Blackboard platform, as shown in Figure 3, which provides a comprehensive teaching-learning environment, combining synchronous and asynchronous tools that facilitate interaction, academic management,

and continuous monitoring of student performance. Its key features include video conferencing and internal messaging for communication between teachers and students, a digital calendar for efficient time management, assessments in various formats, and an automated grade book that allows immediate feedback on academic progress (Anthology, n.d.). These capabilities contribute to improving the educational experience and foster student autonomy and personalized monitoring of their learning path.

The course's instructional design was based on the strategic selection of activities and learning resources aligned with the learning objectives and the tools available on the educational platform. Implemented resources included discussion forums, interactive quizzes, collaborative projects, individual assignments, educational videos, multimedia presentations, readings in PDF and web formats, thematic infographics, academic databases, and access to a digital library. This multimodal resource integration enabled a dynamic, student-centered learning experience for active and meaningful learning.

However, the survey revealed that 83% of students preferred instructional videos, stating that they learn more effectively in visual environments. Secondly, they highlighted readings on websites as a valuable resource for their learning. In contrast, in a face-to-face format, the course lacked a structured instructional design that systematically integrated diverse teaching resources. In this context, students searched for information in digital libraries primarily based on instructions provided by the face-to-face instructor, which limited the use of multimodal strategies in the teaching-learning process.

Figure 3
View of the Blackboard platform

FINDINGS

Analysis of Grades in the Research Methodology Course

To assess whether there were significant differences between students' academic performance in the intersemester Research Methodology course and their cumulative grade point average, normality analyses and nonparametric tests were applied, differentiating by educational modality (face-to-face and online) and academic year. First, the Shapiro-Wilk test was used to determine the data distribution. The results (Table 4) show that, in both types of modalities, the final grades for the intersemester course did not follow a normal distribution in any of the cycles analyzed ($p < 0.05$). In contrast, the student's overall academic average was normal in most cycles, especially in the face-to-face modality. This lack of normality in the data justifies using nonparametric tests for group comparisons.

Table 4
Shapiro-Wilk coefficient analysis for data normality

Research Methodology in face-to-face mode		
Academic cycle	Shapiro-Wilk Coefficient for Final Course Grade	Shapiro-Wilk Coefficient for Academic Trajectory Grade
2022-4	0.616, p-value=0.00000136	0.9682, p-value=0.646
2022-5	0.7628, p-value=0.001274	0.9578, p-value=0.655
2023-4	0.842, p-value=0.0001862	0.9655, p-value =0.3497
2023-5	0.8477, p-value=0.001287	0.9781, p-value =0.8323
2024-4	0.6998, p-value=0.000002087	0.9581, p-value =0.2945
Research Methodology in online mode		
Academic cycle	Shapiro-Wilk Coefficient for Final Course Grade	Shapiro-Wilk Coefficient for Academic Trajectory Grade
2022-4	0.6701, p-value=4.078×10^{-12}	0.9282, p-value=0.0002381
2022-5	0.8454, p-value=4.156×10^{-7}	0.9945, p-value=0.9906
2023-4	0.5939, p-value=2.318×10^{-13}	0.968, p-value=0.04657
2023-5	0.7037, p-value=6.268×10^{-11}	0.9807, p-value=0.3181
2024-4	0.7472, p-value=1.209×10^{-10}	0.9209, p-value=0.00007821

The Mann-Whitney U test was then applied to compare intersemester course grades with the overall academic average for each semester (Table 5). In the face-to-face modality, statistically significant differences were observed in four of the five academic years analyzed ($p < 0.05$), while no significant difference was found in the 2022-2025 semester ($p = 0.276$). On the other hand, in the online modality, all academic cycles showed significant differences ($p < 0.001$), with U values consistently outside the acceptance region.

Descriptive statistics for the final grades of students enrolled in the online modality showed a mean of 87.5 and a standard deviation of 9.2, while the mean and standard deviation for students enrolled in the face-to-face modality were 82.1 and 6.8, respectively.

Effect sizes (r) ranged from 0.30 to 0.44, suggesting moderate practical significance.

Table 5
Mann-Whitney U test

Research Methodology in face-to-face mode			
Academic cycle	U	Region of acceptance	p-value
2022-4	482	[176.1593 : 352.8407]	0.000001476
2022-5	139	[65.7224 : 159.2776]	0.276
2023-4	964	[418.719 : 737.281]	0.000002099
2023-5	484	[231.2829 : 444.7171]	0.007534
2024-4	818.5	[295.8282 : 545.1718]	4.128×10^{-10}
Research Methodology in online mode			
Academic cycle	U	Region of acceptance	p-value
2022-4	5302	[2627.8234 : 3772.1766]	5.94×10^{-13}
2022-5	3328.5	[2040.5407 : 3000.4593]	0.0009755
2023-4	4993.5	[2489.6443 : 3594.3557]	4.426×10^{-12}
2023-5	3893.5	[2227.1141 : 3248.8859]	0.000009378
2024-4	5908.5	[2839.2791 : 4049.7209]	1.776×10^{-15}

The graphical overview and the analysis indicate that student performance in the intersemester course differs significantly from their previous academic trajectory, which is more pronounced in the online format. This variability could be associated with factors such as instructional design, the intensive pace of the course, and the self-regulation skills required in virtual environments.

Results of the survey conducted with students from face-to-face and online courses

A survey was administered to 56 students who took the subject face-to-face and 156 students who took it online. Among the aspects analyzed, the perception of distance education stands out. The results are presented in Figure 4.

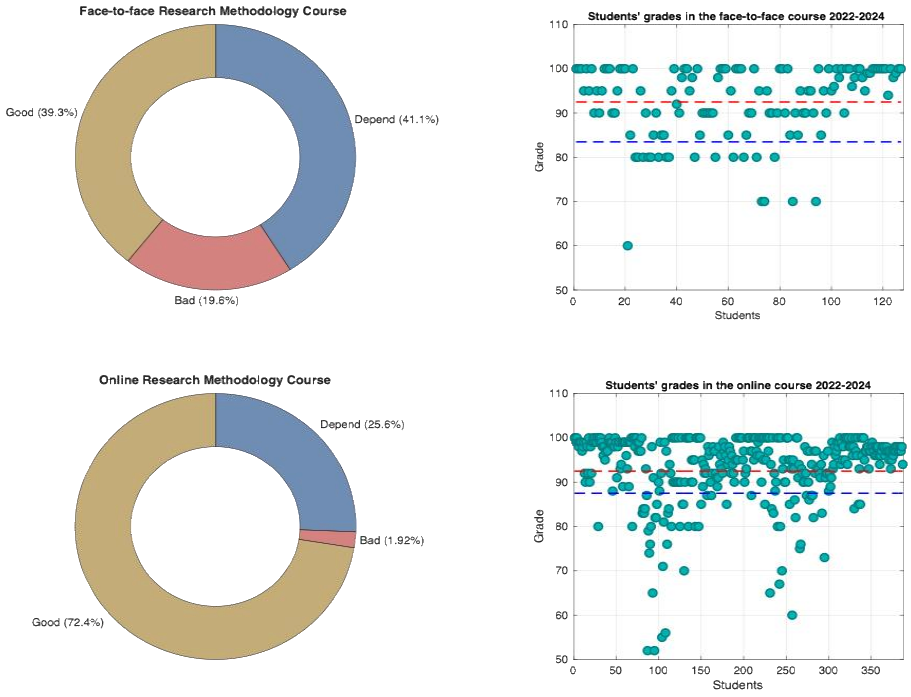

Figure 4
Results of the perception of the students who filled out the survey: *What do you think about distance education?* (a) Result of the perception of the students who took the Research Methodology course face-to-face. (b) Result of the grades of the students who took the course face-to-face. (c) The result of the perception of the students who took the Research Methodology course online was that (d) Result of the grades of the students who took the course online

Figure 4(a) shows that 39.3% of students consider online education a good option, while 41.1% think it depends on the circumstances. According to the collected

comments, this perception varies depending on the subject being taught and the quality of the instructional materials provided by the instructor. On the other hand, 19.6% of respondents consider this modality inappropriate, mainly due to distractions and lower efficiency than face-to-face teaching.

Figure 4(b) presents the total grades sample for each face-to-face Research Methodology course student. Meanwhile, Figure 4(c) shows the perception of those who took the online course, indicating that 72.4% of students consider this modality appropriate. Additionally, Figure 4(d) illustrates the grades obtained by each student in the online mode, with a minimum recorded grade close to 50.

The most suitable learning modality for an intersemester course was also analyzed, revealing that 48.1% of students prefer synchronous online education (Figure 5).

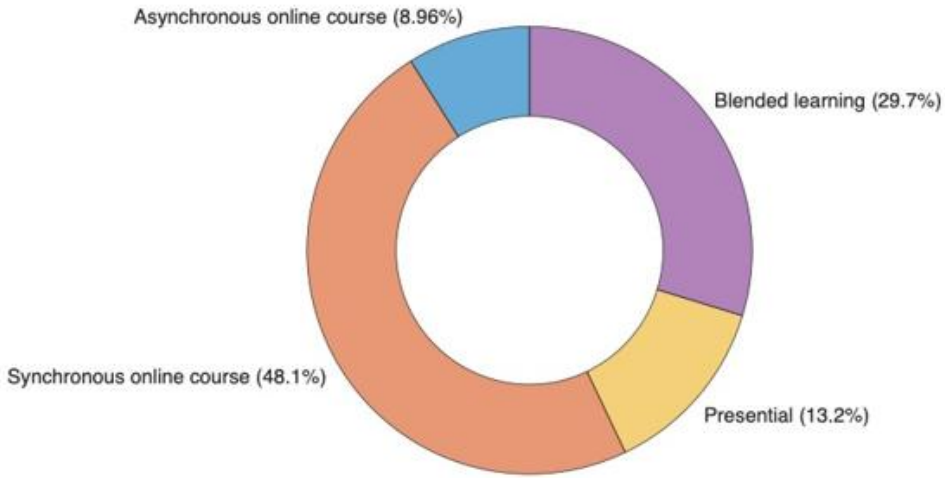

Figure 5
Results of students' perceptions from the survey item: *Which learning modality do you consider most appropriate in an intersemester period?*

Regarding learning type, Figure 6 shows that the multimodal style (blue) is consistently the most prevalent, with values between ~41% and 48%. The visual style (yellow) also has a notable share in second place. The auditory, kinesthetic, and verbal styles have smaller proportions: auditory (red) appears between ~3% and 10%, kinesthetic (purple) 10–20%, and verbal (green) is always less than 5%.

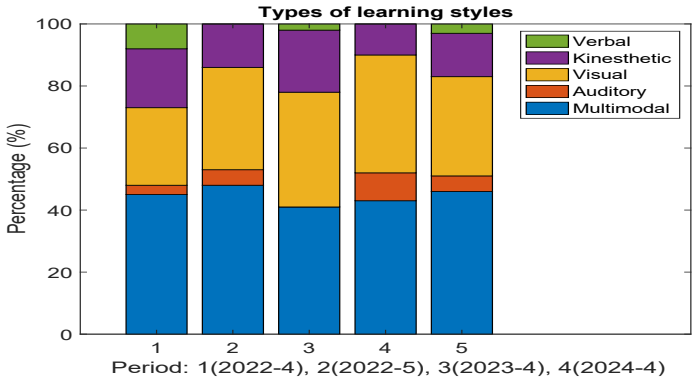

Figure 6
Type of learning among students who took the intersemester online Research Methodology course

In the context of the development of the activities of the students who took the course online, 86% did so through a laptop, while 10% did so through a desktop computer. Only 3% used a smartphone, and 1% used a tablet. Among the most appropriate teaching resources, according to the analyzed sample, it is decided that videos complemented with some readings are the best for learning the subject's content.
According to the analyzed sample, the most suitable instructional resources were videos complemented by readings, which were considered the most effective for learning the course content. Students indicated that an online course should be taught 60% synchronously.

Finally, Figure 7 presents the preferred modality for future intersemester courses, showing that 78.3% of students prefer the online mode.

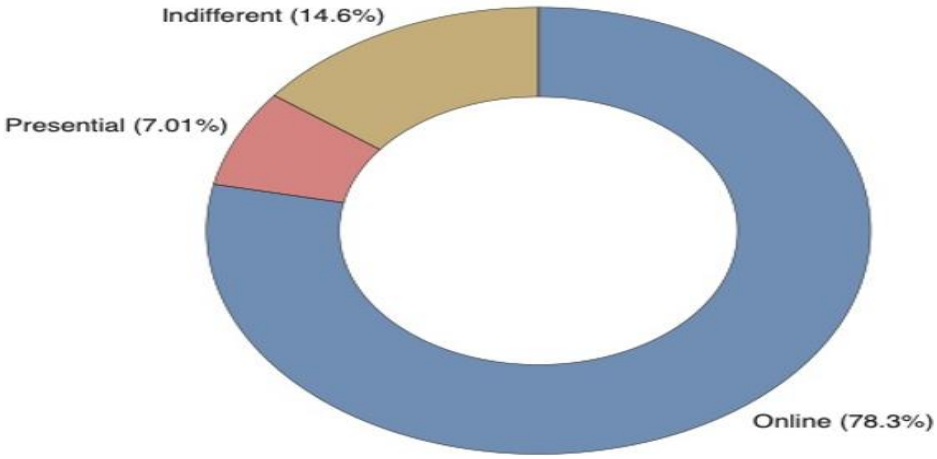

Figure 7
Students' preference for enrolling in an intersemester course in a future period

Teaching Skills and Competencies for Online Courses

The students identified the following key skills for a teacher to teach an online course effectively: mastery of the subject, assertive and effective communication, handling of digital tools, patience, discipline and adaptability, dedication and availability, accessibility and responsibility, and flexibility.

These results coincide with previous findings in the literature on online education (Lasekan et al., 2024; Dos Santos, 2024; Ibrahim, 2020; Akdemir, 2008).

Students agreed that theoretical subjects and those that include programming are the most appropriate for teaching online. In contrast, they considered subjects with complex mathematics or practical laboratories unsuitable for this modality.

DISCUSSIONS AND CONCLUSION

This study demonstrates statistically significant differences between the grades obtained by students in the intersemester Research Methodology course and their overall academic average, especially in the online format. The lack of uniformity in course grades and the consistency of results across different academic years support the importance of considering the educational modality as a factor influencing academic performance. This evidence reinforces the relevance of implementing differentiated teaching and assessment strategies based on the course format.

Regarding student perception, the results indicate that most participants spent between one and three hours daily on course activities, reflecting considerable engagement. However, significant challenges were also identified, such as a lack of face-to-face interaction with the instructor and difficulties managing time efficiently. Regarding modality preference, the data in Figure 5 show that only 13.2% of students prefer a fully face-to-face modality, while 91% value the opportunity to interact directly with the instructor, highlighting the importance of strengthening emotional engagement and social interaction in virtual environments.

This study confirms the viability of online intersemester courses as an effective strategy for strengthening students' comprehensive education by promoting the development of key skills such as self-discipline, time management, adaptability, and communication. Focusing on a single subject allows students to optimize their dedication and commitment, particularly in contexts where external conditions may limit face-to-face attendance.

A relevant contextual factor is the presence of extreme climates in certain regions, where high temperatures hinder face-to-face attendance in intensive courses. In this context, online education is consolidated as a viable alternative for students and the institution by reducing energy consumption and preserving academic infrastructure. However, socioeconomic limitations that affect the online learning experience were also identified, especially related to access to adequate study spaces and a stable internet connection. In this sense, it would be pertinent to conduct future research to evaluate the academic performance of students taking intersemester courses using only mobile

devices and to analyze how these conditions impact the quality of the academic work submitted.

From an equity perspective, 67% of the sample were men, and 33% were women, consistent with the national trend of greater male participation in engineering programs. This finding emphasizes the need to promote gender equity in these academic programs, encouraging female participation in traditionally male-dominated fields.

The results also indicate that the effectiveness of online intersemester courses depends largely on instructional design, which must consider the diversity of learning styles, content structure, interaction modalities, and technological support. Students also expressed the need for innovative, interactive, and motivating digital materials that promote independent learning. Therefore, specialized teacher training in designing and implementing these types of resources is recommended.

In conclusion, online intersemester courses are suitable for flexible and efficient academic progress. To maximize their impact, it is essential to strengthen effective interaction between teachers and students, guarantee access to structured educational resources, and ensure equitable learning conditions. Finally, further analysis of the link between teacher training and student academic performance should be conducted, which could offer new avenues for continuous improvement of distance education in intensive settings.

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