IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661, p-ISSN: 2278-8727, Volume 28, Issue 4, Ser. 1 (July. – August. 2026), PP 29-34
www.iosrjournals.org

Impact Of The COVID-19 Pandemic On Higher Education In Mexico: Analysis Of Student Retention In Engineering Courses (2015–2025)

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Abstract:
This study analyzes the impact of the COVID-19 pandemic on student retention in higher education in Mexico, focusing on engineering courses in Programming and Numerical Methods over the period 2015–2025. A longitudinal design was employed using institutional academic records corresponding to enrollment capacity and actual student attendance across different academic terms (winter, spring, and autumn). Student retention was used as an inverse indicator of dropout rates, allowing the evaluation of academic continuity before, during, and after the pandemic.

The results show that student retention remained relatively stable during the pre-pandemic period; however, a marked decline was observed during the pandemic transition and, more significantly, in the post-pandemic period (2022–2025), where dropout variations reached between 30% and 50%. These findings suggest that the most critical effects of the pandemic on academic continuity were not immediate but delayed, manifesting during the return to face-to-face instruction.

Furthermore, the analyzed engineering courses exhibit sensitivity to abrupt changes in instructional modalities, highlighting prolonged adaptation processes in student academic trajectories. Overall, the findings indicate that student retention in higher education is influenced by post-disruption adjustment dynamics rather than only by the immediate effects of emergency remote teaching.

Background*: The COVID-19 pandemic caused an unprecedented disruption to education worldwide. In Mexico, the closure of schools in March 2020 required a rapid transition to emergency remote learning. However, the available technological and financial resources were insufficient to support students across all educational levels, increasing educational inequalities and widening learning gaps.*

The pandemic also affected students' emotional well-being. A study involving 2,555 adults, 78.3% women with an average age of 46 years, reported increased emotional distress associated with social isolation, remote work, information overload, boredom, and limited living space, although family support helped mitigate some of these effects.

International evidence consistently demonstrates significant learning losses following school closures. Global estimates indicate an average loss of 0.17 standard deviations, equivalent to approximately half an academic year. In countries where schools remained closed for extended periods, learning losses reached approximately 1.1 academic years, with only 0.5 years recovered after reopening. A study of 7.7 million students in the United States estimated that students require 4.8 additional months to recover mathematics achievement and 4.4 months for reading. Similarly, international assessments reported an average 14% decline in mathematics, equivalent to approximately seven months of learning loss.

Recent evidence indicates that, in 2024, academic performance remained approximately 0.46 grade levels lower in mathematics and 0.47 grade levels lower in reading than in 2019, suggesting that recovery remains incomplete. These persistent educational deficits may have long-term economic consequences by reducing future workforce

skills and productivity. Consequently, evaluating enrollment, retention, and academic continuity in higher education is essential for understanding the long-term impact of the pandemic and informing educational policy.
***Materials and Methods**: This quantitative longitudinal study analyzed academic records from Programming and Numerical Methods courses in higher education institutions between 2015 and 2025. The dataset comprised programmed course capacity, student enrollment, and retention, the latter operationalized as an inverse measure of dropout. Comparative analyses were conducted across three instructional periods—pre-pandemic, pandemic, and post-pandemic-to assess changes in enrollment and academic continuity under different educational contexts.*
***Results**: The longitudinal analysis of academic records from 2015 to 2025 revealed significant variations in student retention, course capacity, and enrollment in Programming and Numerical Methods courses. Student retention remained relatively stable during the pre-pandemic period, showed a temporary increase during 2020–2021, coinciding with the implementation of remote instruction, and declined substantially during the post-pandemic period (2022–2025). Enrollment and scheduled course capacity also exhibited temporal fluctuations consistent with institutional planning and student demand, while the absence of course offerings in 2016 generated a discontinuity in the time series. Overall, the findings indicate that the educational effects associated with the COVID-19 pandemic persisted beyond the emergency period, with the greatest reductions in academic continuity occurring after the resumption of face-to-face instruction. These results suggest that engineering courses with high cognitive demands experienced a slower recovery in student retention during the post-pandemic stage.*

***Key Word:** COVID-19, higher education, student retention, engineering education, longitudinal study, Mexico.*
Date of Submission: 01-07-2026 Date of Acceptance: 10-07-2026

I. Introduction

The COVID-19 pandemic caused an unprecedented disruption in educational systems worldwide, leading to the temporary closure of institutions at all educational levels. In Mexico, this measure was implemented in March 2020, requiring the rapid adoption of distance education modalities supported by digital technologies. However, limitations in technological infrastructure and unequal access to digital resources affected educational continuity, particularly in higher education contexts.

At the international level, the World Health Organization declared the COVID-19 outbreak a global health emergency in January 2020, following its rapid spread across multiple countries (Aragón et al., 2019). This scenario represented not only a health crisis but also an educational and psychosocial one. Several studies have documented adverse effects associated with lockdown measures, including emotional disturbances, stress, and difficulties adapting to online learning environments (Cervantes et al., 2022).

Globally, significant learning losses have been reported. Patrinos et al. (2022) indicate that school disruptions between 2020 and 2022 generated educational delays attributable to structural inequality and limited conditions for remote learning, with estimated losses equivalent to approximately half a year of learning.

In higher education, recent studies report significant academic performance declines, particularly in cognitively demanding disciplines. Jakubowski et al. (2025) report reductions in mathematics performance, with losses equivalent to several months of learning.

In Mexico, limitations in public policy implementation during the pandemic have been identified as contributing factors to persistent educational gaps (Badillo, 2025). In this context, the present study analyzes the impact of the COVID-19 pandemic on student retention in engineering courses in Mexican technological higher education institutions during the period 2015–2025.

II. Material And Methods

This study follows a quantitative longitudinal design. Academic records from Programming and Numerical Methods courses in higher education institutions were analyzed for the period 2015–2025.

The dataset includes three main indicators: programmed course capacity, enrolled students, and student retention. Retention was operationalized as an inverse indicator of dropout rates, allowing the evaluation of academic continuity across different time periods.

The analysis was structured into three temporal phases: pre-pandemic, pandemic, and post-pandemic, enabling comparative assessment of educational dynamics under different instructional contexts.

Table 1. Programmed Capacity and Enrolled Students in Numerical Methods and Programming Courses (2015–2025)

Year	Course	Winter Scheduled Quota	Winter Present in the course	Spring Scheduled Quota	Spring Present in the course	Autumn Scheduled quota	Autumn Present in the course
2015	Methods	26	22	69	62	66	59
2015	Programming	80	67	41	39	40	35
2016	Methods	67	37	0	0	0	0

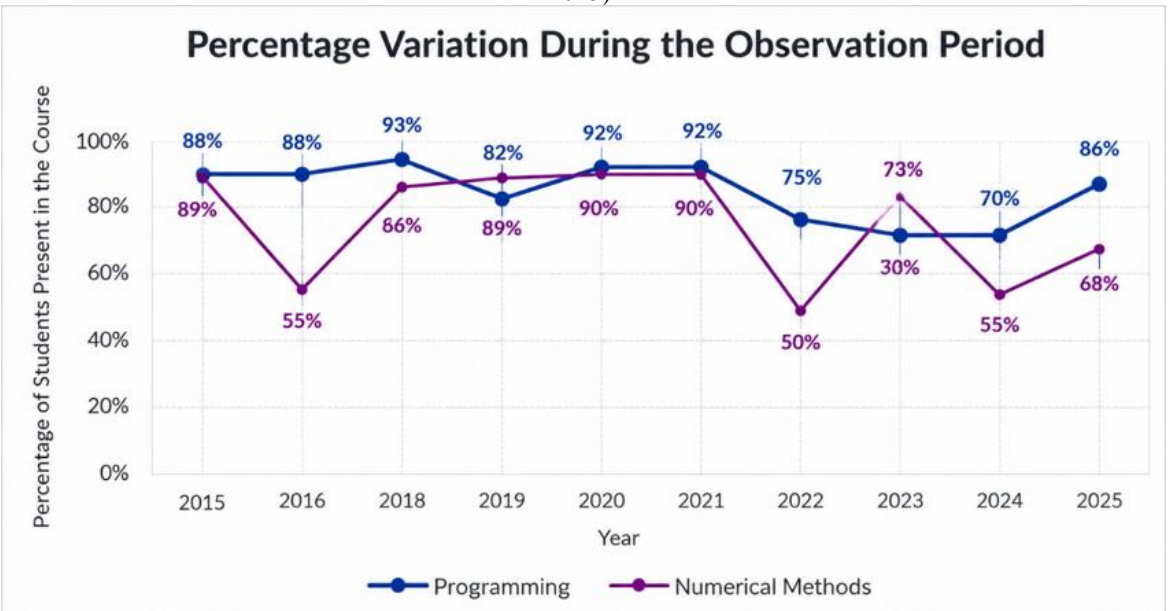
2016	Programming	40	35	0	0	0	0
2018	Methods	41	28	76	67	80	75
2018	Programming	0	0	39	37	15	13
2019	Methods	79	84	40	36	40	31
2019	Programming	15	14	16	11	58	48
2020	Methods	40	29	55	41	40	24
2020	Programming	54	38	12	11	62	59
2021	Methods	70	51	71	67	120	116
2021	Programming	66	64	35	30	45	41
2022	Methods	64	19	62	37	44	29
2022	Programming	25	13	32	28	74	57
2023	Methods	60	22	31	16	31	26
2023	Programming	60	30	70	54	79	63
2024	Methods	72	40	38	14	30	23
2024	Programming	35	24	38	26	44	32
2025	Methods	40	27	0	0	0	0
2025	Programming	44	38	0	0	0	0

Prepared by the author from institutional academic records corresponding to Programming and Numerical Methods courses taught between 2015 and 2025.

III. Result

Figure 1 illustrates the evolution of student retention in Programming and Numerical Methods courses during the 2015–2025 period. Student retention was used as an inverse indicator of dropout, enabling the assessment of academic continuity across the pre-pandemic, pandemic, and post-pandemic periods.

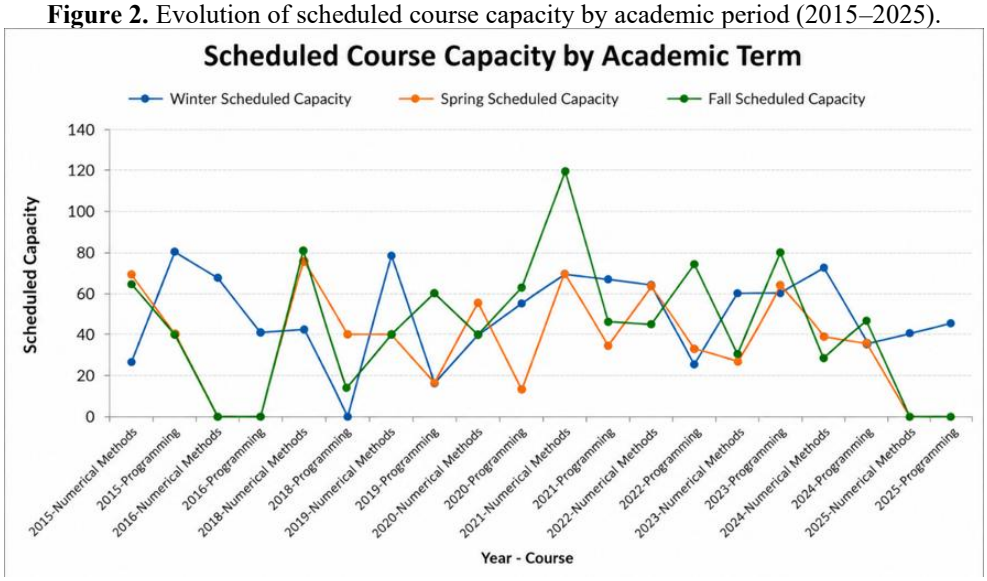
Figure 1. Percentage evolution of student retention in Programming and Numerical Methods courses (2015–2025).



Note. The analyzed courses were not offered in 2016.
Source: Prepared by the author based on institutional academic records.

Figure 2 illustrates the evolution of the scheduled course capacity for Programming and Numerical Methods throughout the 2015–2025 study period. Variations in the number of available seats were observed across academic terms, reflecting changes in institutional planning and student demand. A discontinuity is evident in 2016, when neither course was offered, and this should be considered when interpreting the temporal trends.

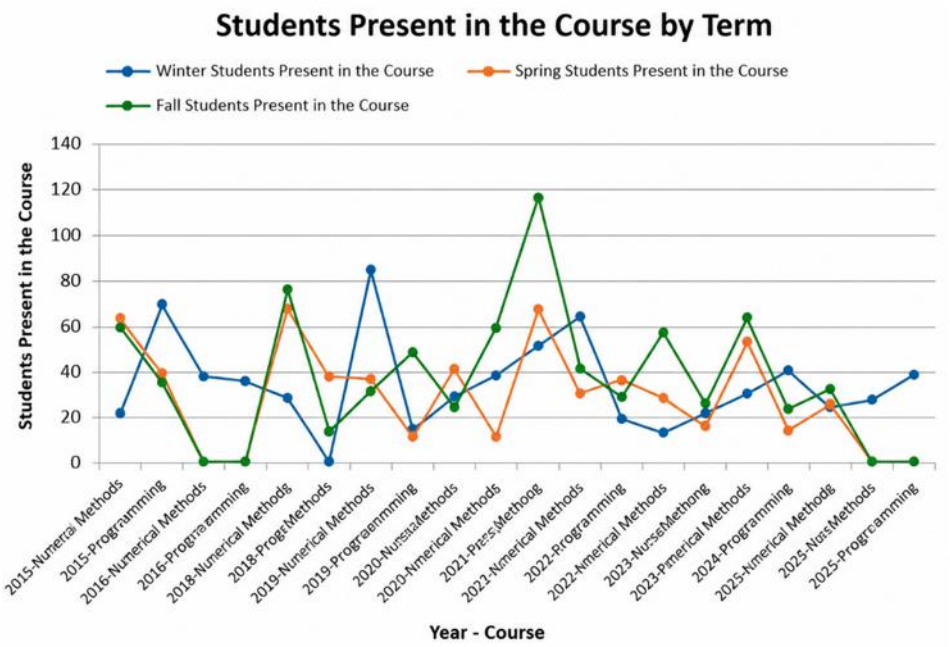
Figure 2. Evolution of scheduled course capacity by academic period (2015–2025).



Note. Programming and Numerical Methods courses were not offered in 2016.
Source: Prepared by the author based on institutional academic records.

Figure 3 presents the evolution of student enrollment in Programming and Numerical Methods courses during the Winter, Spring, and Fall semesters over the 2015–2025 study period. Enrollment fluctuated across academic terms, reflecting changes in institutional planning, student demand, and the effects of the COVID-19 pandemic. Overall, enrollment declined during the pandemic period, followed by a partial recovery in the subsequent years.

Figure 3. Evolution of student enrollment by academic term and course (2015–2025).



Note. Source: Prepared by the author based on institutional academic records.

The analysis presented in **Table 1** indicates that student dropout was already evident before the COVID-19 pandemic, although its pattern changed during the study period. Student retention declined in 2019 compared with previous academic cycles. In contrast, 2020 showed an atypical increase in enrollment in the Programming course, with a similar pattern observed in Numerical Methods. This behavior coincided with the transition to remote learning, suggesting changes in students' academic participation during the pandemic.

IV. Discussion

The findings of this longitudinal study demonstrate that the educational effects associated with the COVID-19 pandemic extended beyond the period of emergency remote instruction. Although student retention remained relatively stable before the pandemic and temporarily increased during the transition to online learning, the most pronounced decline occurred during the post-pandemic period (2022–2025). This pattern suggests that the return to face-to-face instruction did not immediately restore pre-pandemic levels of academic continuity, indicating the presence of delayed effects on student persistence.

These findings are consistent with international evidence reporting persistent learning losses and reduced academic performance following prolonged school closures. Previous studies have estimated learning losses ranging from approximately half an academic year to more than one academic year, depending on the duration of school closures and the educational context. The decline in student retention observed in this study supports the notion that academic disruption affected not only learning outcomes but also students' ability to remain enrolled in demanding engineering courses.

The temporary increase in enrollment during 2020 may reflect institutional adaptations to remote instruction, including greater scheduling flexibility and expanded access to virtual learning environments. However, the subsequent decline in retention suggests that these measures were insufficient to sustain long-term academic continuity once traditional classroom instruction resumed. This finding highlights that the challenges experienced by students during the pandemic extended beyond technological access and included academic, psychological, and socioeconomic factors that may have influenced persistence.

Engineering courses such as Programming and Numerical Methods require continuous practice, analytical reasoning, and cumulative knowledge acquisition. Consequently, interruptions in instructional delivery may have a greater impact on student performance and retention than in disciplines with lower cognitive demands. The prolonged reduction in retention observed after the pandemic suggests that students continued to experience difficulties in adapting to regular academic requirements even after institutional operations returned to normal.

This study contributes longitudinal evidence from a higher education context in Mexico by examining academic trends over an eleven-year period encompassing the pre-pandemic, pandemic, and post-pandemic stages. Unlike studies focused primarily on standardized learning assessments, the present research analyzes student retention as an indicator of academic continuity, providing additional evidence of the long-term educational consequences of the pandemic.

Several limitations should be acknowledged. The analysis was based on institutional records from Programming and Numerical Methods courses, which may limit the generalizability of the findings to other disciplines or institutions. Furthermore, the study did not evaluate individual socioeconomic, psychological, or technological factors that may have influenced student retention. Future research should incorporate multivariate analyses and data from multiple institutions to identify the determinants of post-pandemic academic persistence and to evaluate interventions aimed at improving student retention.

Overall, the findings underscore the importance of developing institutional strategies that support academic continuity in engineering education, particularly during periods of educational disruption. Early academic support, continuous monitoring of student progress, and targeted retention programs may help reduce dropout rates and strengthen student persistence in high-demand STEM courses

V. Conclusion

The longitudinal analysis of student retention in Programming and Numerical Methods courses from 2015 to 2025 revealed substantial changes in academic continuity across the pre-pandemic, pandemic, and post-pandemic periods. The greatest decline in student retention was observed during the post-pandemic stage (2022–2025), suggesting that the effects of the educational disruption extended beyond the period of mandatory confinement.

The findings also indicate that engineering courses with high cognitive demands are particularly sensitive to abrupt changes in instructional delivery, requiring a prolonged adaptation process following the return to face-to-face education. Overall, the results suggest that student retention is influenced not only by the immediate effects of the COVID-19 pandemic but also by subsequent academic adjustment processes, highlighting the need for institutional strategies that strengthen student persistence after large-scale educational disruptions.

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