The Post-Pandemic Recovery in a Software Engineering Course: A Quantitative and Qualitative Analysis

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Keywords: COVID-19, post-pandemic recovery, education, software engineering course, graduate and undergraduate, software engineering professor

Abstract: The COVID-19 pandemic caused unprecedented global educational disruption. In this context, empirical evidence is lacking concerning its long-term impact on the academic performance of the students and their post=pandemic recovery. We applied a quantitative approach to bridge this gap, investigating the pandemic's long-lasting effects and the recovery process within a Software Engineering course. We analyze a set of historical student grades from 2019 to 2023, utilizing statistical methods to compare performance on standardized questions across pre- and post-pandemic semesters. Following this study, our novel approach for this problem also relies on an online survey with 18 respondents to confirm or refute the results of the case study. As one of our results, we identified that the pandemic negatively influenced student performance in 2022, especially in the first semester post-pandemic. However, recovery policies mitigated the impact in the following semesters of 2022 and 2023. The difficulties highlighted when returning to in-person classes were: low grades, lack of student attention, and resistance to returning to the routine. Both groups valued the psychological support and flexibility needed for recovery. However, they had different views on the process. These results are a breath of hope since they suggest that the students have overcome the challenges imposed by the pandemic.

1 INTRODUCTION

Several pandemics have occurred in human history and affected the human life, such as education and economy (Piret and Boivin, 2021). However, the impact of the COVID-19 pandemic on education is both unprecedented and widespread in education history, impacting over 1.5 billion students in 195 countries by school and university closures. In fact, (Willies, 2023) reports that 87% of the world's student population was somehow affected by COVID-19 school closures. As a result, almost overnight, many schools and education systems began to offer education remotely (Barr et al., 2020) (Ravi et al., 2021) (de Souza et al., 2021). Examples of remote learning solutions include learning platforms, educational applications, and resources to help students and educators.

Previous work (Hebebci et al., 2020) (Mooney and Becker, 2021) has investigated the impact of the COVID-19 pandemic on education. Such studies have examined, for instance, the effects of remote learning on student performance and engagement in several education fields, including Computer Science (CS) or Software Engineering (SE) courses. For instance, de Deus et al. (2020) investigated how the Emergency Remote Education (ERE) has been conducted by lecturer in the field of Computer Science in Brazil, in response to the COVID-19 pandemic. Besides, Barr et al. (2020) investigated the impact of the COVID-19 pandemic on their eight-week undergraduate Software Engineering program, particularly during the lockdown period, focusing on the rapid shift to online learning across three distinct modules. In another perspective, Lin and Hou (2023) explored how students' educational background and family income influence their experiences with online learning compared to traditional in-person courses. However, as far as we are concerned, no previous work has quantitative and qualitatively investigated the long-term impact of this pandemic on student performance.

To fill this gap, the previous work (Constantino et al., 2025) presented an empirical study based on historical data to assess the impact of the COVID-19

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pandemic on the performance of students, focusing on a Software Engineering course. We analyzed student grades for five years, from 2019 to 2023, i.e., before and after COVID-19. We established a standardized evaluation protocol, ensuring continuity by the same professor assessing all participant responses consistently throughout the entire study duration. As our focus is not on remote teaching, we excluded 2020 and 2021 from our analysis because these two years did not apply in-person teaching. Therefore, this study involved 297 students in the three years (2019, 2022, and 2023) of a Software Engineering course where all students had in-person classes and exams. The course covers many Software Engineering topics, from requirements analysis to software design, implementation, and testing. Student performance was assessed based on the grades obtained in the course's in-person exams. To make grades comparable across years, we selected 36 exam questions that appeared in more than one semester. With them, we could compare student grades on the same questions in two (or more) semesters.

Based on exam questions that repeated over semesters before (2019-1 and 2019-2) and immediately after (2022-1) the COVID-19 pandemic, we verify that the average grades of students were lower in about 61% of questions after pandemic compared to before pandemic. This result suggests that the COVID-19 pandemic may have had a negative impact on the performance of students. However, fortunately, we also verified a significant improvement in student performance from the first year (2022) to the second year (2023) after the pandemic. By comparing these two years, the grades of students increased in about 86% of the analyzed questions. This result suggests that the pandemic does not have a prolonged impact on students' performance (Constantino et al., 2025).

As extension of the previous work (Constantino et al., 2025), we cross-validated our results to understand better how Software Engineering professors and students perceived the impact of the COVID-19 pandemic on Software Engineering education after the return to in-person instruction. As a result, we identified the strategies adopted by professors and students during the recovery period and the main challenges they encountered. We designed and conducted an email survey of the 171 undergraduate and graduate students enrolled in the Software Engineering course. We also emailed 40 professors of the Software Engineering courses. We received 18 responses, with eight students and ten professors (a response rate of approximately 8.5%). All participants were students or professors during the period under analysis (2022 and 2023). Our findings reveal that professors and students reported difficulties returning to in-person classes, with grades decreasing. For professors, the main problem was students' lack of attention; for students, it was adapting to the routine. Both groups agreed that emotional support and flexible rules were crucial for recovery. However, they had different perceptions of the return

In this paper, we build on our previous work (Constantino et al., 2025) on and extend it with a quantitative and qualitative study to confirm or refute the results of the case study. Our main contributions can be summarized as follows

(i) We describe a quantitative and qualitative research to investigate the impact of the pandemic on student performance. We designed a robust method, with well-defined hypotheses, research questions, and statistical analysis methods;

(ii) This research fills an important gap by analyzing the longitudinal impact of COVID-19 on education, moving beyond immediate effects to explore recovery trends;

(iii) The findings contribute to existing evidence to ongoing debates about the long-term implications of remote learning during the pandemic;

(iv) We provide insights into the barriers and challenges faced by professors and students while returning to in-person classes.

(v) The findings also highlighted the perspectives of both groups regarding the academic and emotional support offered by the educational institution.

(vi) This study provides valuable insights to educators, administrators, and policymakers in higher education.

Our comprehensive replication package is readily accessible online to facilitate future replications and extensions[1]. The structure of this paper unfolds as follows. Section 2 presents the context of our case study which is a Software Engineering course. Section 3 outlines the setup of our study, including its goal, four research questions and steps. Furthermore, we analyze and report the results of this study focusing on the four research questions (Section 4). We also revisit the possible threats to the study validity in Section 5 and related work in Section 6. Finally, Section 7 concludes this paper with directions for future work.

[1] https://github.com/PedroClair/prePosCovid

2 THE SOFTWARE ENGINEERING COURSE

The Software Engineering Course (SE Course) is a 60-hour course offered each semester for Bachelor's degrees in Computer Science and Information Systems. Its primary aim is to provide students with the essential concepts and techniques for creating complex software systems (Sommerville, 2015) (de Almeida Souza et al., 2017). The syllabus encompasses many subjects, including software development processes, agile methods, software requirements analysis and specification, software design, software architecture, implementation, testing, and software quality. We introduce each topic weekly and sequentially throughout the semester. Each lecture uses contextualized problems to help the students understand a given topic. Students practice their knowledge of the topics by solving assessment exam questions throughout the semester (Santos et al., 2015).

We considered six semesters for analysis and discussion. Two semesters for the SE Course before COVID-19 pandemic and four semesters after COVID-19. In each semester, the numbers of enrolled students ware 44, 40, 59, 54, 55, 45 for 2019-1, 2019-2, 2022-1, 2022-2, 2023-1 and, 2023-2, respectively. To allow a fair comparison across semesters, the same lecturer taught the same course syllabus using the same textbook (Sommerville, 2015) in all six semesters under study. However, the social isolation imposed due to the COVID-19 pandemic required drastic changes in how we carry out our daily activities, including teaching activities in 2020 and 2021. That it, the widely spread of COVID-19 has led the educational institutions to invest in online learning (2020 and 2021). For this reason, in this work, we do not analyzed data, such as the student grades, in these two years.

3 STUDY SETTINGS

In this section, we delve into our study settings, highlighting two main pillars. First, we outline the goal and research questions. Following them, we provide a comprehensive guide for data acquisition and analysis, establishing a robust framework for conducting this research study.

3.1 Study Goal and Research Questions

This work aims to assess the impact of the COVID-19 pandemic on students' performance in a Software Engineering course. Besides, we extend this study to know which strategies and challenges professors and students faced in returning to in-person instruction. To achieve this goal, we formulated four Research Questions (*RQs*), which are presented below.

- RQ_1. What was the impact of the COVID-19 pandemic on student performance?
- RQ_2. How long the impact of the COVID-19 pandemic on student performance lasts?
- RQ_3. What factors do professors and students identify as enabling or hindering post-pandemic academic recovery?
- RQ_4. How do student and professors narratives on post-pandemic academic recovery converge and differ?

Therefore, for theses *RQs* our interest is (i) to understand the relationship between the periods before and after the pandemic; (ii) to investigate about the impact of COVID-19 on performance of the students; (iii) to identify specific elements (e.g., 'extra classes,' 'mental health,' 'self-directed effort') in open-ended responses cited as facilitators or barriers to academic recovery, in the two years after the pandemic, and (iv) to compare the assessments from both groups regarding difficulties, recovery, and support effectiveness.

3.2 Hypotheses Formulation

We defined hypotheses for RQ_1: the COVID-19 pandemic impact on student performance. To answer RQ_1, we compare the performance of students across semesters and selected 36 exam questions that appeared in more than one semester. Thus, RQ_1 was turned into the null and alternative hypotheses as follows.

> **H_0**: There is no significant difference related to the impact of the COVID-19 pandemic on student performance in semesters before (2019) and after (2022-1) this pandemic.
> **H_a**: There is significant difference related to the impact of the COVID-19 pandemic on student performance in semesters before (2019) and after (2022-1) this pandemic.

We defined hypotheses for RQ_2: the Long-Term Impact of the COVID-19 Pandemic on students' performance in Software Engineering activities. As mentioned, to answer RQ_2, we compare the grades of the students for each question across semesters. Thus, the null and alternative hypotheses are follows.

Figure 1: The two phases of the case study.

> **H**$_0$: There is no significant difference in students performance from the first year after after COVID-19 (2022) to the second year after COVID-19 (2023).
> **H**$_a$: There is significant difference in students performance from the first year after after COVID-19 (2022) to the second year after COVID-19 (2023).

Let μ be the average grades (RQ$_1$ and RQ$_2$). Thus, $\mu 1$ and $\mu 2$ denote the average grades of the students across semesters. Then, the aforementioned set of hypotheses can be formally stated as:

H_0: $\mu_1 = \mu_2$
H_a: $\mu_1 \neq \mu_2$

To test all theses hypotheses, we considered 95% confidence levels ($\rho = 0.05$).

3.3 Planning of the Study Phase I - Case Study

Planning Study. To answer the research questions, we planned and performed a case study to assess the influence of the COVID-19 pandemic on student performance, focusing on the Software Engineering course, as shown in Figure 1.

Selecting Questions. We selected 36 exam questions that appeared in more than one semester during the "pre" and "post"-pandemic periods throughout the semesters of 2019, 2022, and 2023. This process involves an analysis of the curriculum content. Following this stage, the grades assigned to each question were collected and standardized to the same scale, ensuring a cohesive dataset for analysis. Furthermore, the questions can be closed-ended, which leaves responses limited and narrowed to the given options, or open-ended questions[2], in which the students get 100% control over what they want to respond to. In open-ended questions, they are not restricted by the limited number of options. That is, they can write their answers in more than one word, sentence, or something longer, like a paragraph.

Collecting Data. We collected data from the exams for the students enrolled in the SE Course. Table 1 presents the questions for the seven topics presented in the SE Course. To gather quantitative data on student performance, specific questions about the topics covered in the SE Course were carefully selected and incorporated into assessment activities throughout the

[2]We used "*" in figures and tables to mean that the exam question was open-ended question.

semester. These questions were assigned predetermined scores, which were made public in advance to the students (Figure 1).

Statistical Test. We gather comprehensive quantitative data on the grades of exam questions across different semesters. It is crucial to note that all observations from both groups are independent. Since the data exhibit a normal distribution, we employed the unpaired Student's T-test (Student, 1908) for comparing the two groups. To ensure this assumption holds, we conducted the Shapiro-Wilk Normality Test (Shapiro and Wilk, 1965) to verify if the population follows a Normal distribution. However, if the data deviate from normality, indicating a non-normal or skewed distribution, we opt for the Mann-Whitney U Test (Mann and Whitney, 1947) instead.

Analyzing Data. Finally, the grades assigned to each of these questions were standardized to the same scale, ensuring a cohesive dataset for analysis. All data were analyzed, interpreted and reported in the results. Besides, all questions and procedures we followed are available online for future replications/extensions at `https://github.com/PedroClair/prePosCovid`.

3.4 Planning of the Study Phase II - Quantitative and Qualitative Study

Planning Study. In this study, we used a online questionnaire to complement and deepen the results observed in the case study (Phase I), providing a qualitative perspective on the professors' and students' perceptions of their post-pandemic academic recovery in the SE course, as shown in Figure 1.

Selecting Respondents. As mentioned before, we sent invitation emails to 171 undergraduate and graduate students formally enrolled in the SE course. We also sent emails to 40 professors of the SE programs. All respondents were at least 18 years old. In the invitation email, we clarified that respondents were not required to participate and that we would keep their personal data anonymous. We surveyed in 2025, after completing the courses (2022-1, 2022-2, 2023-1, and 2023-2), and we did not have access to respondents' names to reduce potential bias (Figure 1).

Questionnaire Survey. We sent a short questionnaire to the respondents regarding their post-pandemic academic recovery perceptions. In this questionnaire, we asked the following questions presented in the Tables 2 and 3; and we received responses from all 18 respondents. Tables 2 and 3 describe the survey script for professors and students, respectively. Each script is composed of 7 questions, named SQ1 to SQ7.

Data collection. We collected data from the questionnaire survey related to the perceptions of the respondents for the post-pandemic academic recovery in the SE course. All data were analyzed, interpreted and reported in the results.

Quantitative and Qualitative Analysis. We collect quantitative and qualitative data from the online questionnaire (Figure 1). Section 4.5 presents the descriptive analysis of these data. Sections 4.5 and 4.6 presents the quantitative and qualitative analysis.

4 RESULTS

This section presents the key findings of our investigation into the impact of COVID-19 on student performance and the perceptions of professors and students from the SE course on the post-pandemic academic recovery. We address four fundamental aspects. First, we examine the overall impact of COVID-19 on student performance. Second, we analyze how this impact has evolved throughout the pandemic. Third, we conduct a year-by-year comparison to highlight trends and identify any variations in performance. Moreover, we investigate the changes in average grades throughout the study period. Besides, we analyzed the facilitators or barriers to academic recovery by professors and students. Finally, we analyze responses from both groups regarding the drivers of recovery, difficulties, and support effectiveness. These analyses provide a comprehensive understanding of the multifaceted impact of the pandemic on educational outcomes and the post-academic recovery.

4.1 Assessing the Impact of COVID-19 Pandemic (RQ_1)

The goal of RQ_1 was to assess the impact of the COVID-19 pandemic on the performance of the students in the SE Course before (2019) and immediately after (2022-1) COVID-19. Figure 4 compares the general average grades obtained by students in the class for each question. Only common questions for the semesters (2019 versus 2022-1) were analyzed. We considered the 2022-1 semester because it is just after pandemic. That is, in 2022-1, the students returned to in-person classes and exams. We observed a decline in the average scores for 11 questions, including Q01, Q11, Q12, and others.

To illustrate a decrease in student performance over time, consider the Figure 2 used in assessments across multiple semesters. This question asks students to identify the agile method that aligns best with

Table 1: Topics and their questions (Constantino et al., 2025).

Topics	Question IDs
SE Introduction	Q01, Q02, Q03*, and Q04
Software Processes and Agile Methods	Q05, Q06*, Q07, Q08, Q09, Q10, and Q11
Software Requirements and Use Cases	Q12, Q13*, Q14*, Q15, Q16*, Q17, and Q18*
Software Architecture	Q19 and Q20
Design with UML	Q21, Q22, Q23, Q24*, Q25*, and Q26*
Implementation	Q27*, Q28*, Q29*, and Q30*
Software Testing and Software Quality	Q31, Q32*, Q33*, Q34*, Q35*, and Q36*

Note: We used "" to mean that exam question was open-ended question.*

Table 2: Questions used in survey for professors. All were open-ended except for SQ1 and SQ3, which was multiple-choice

ID	Questions
SQ1	A significant proportion of my students exhibited difficulties adjusting to in-person instruction after remote learning. (1) Strongly Disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree
SQ2	What were the most common adjustment challenges you observed? (open question)
SQ3	I observed that institutional support significantly improved students' academic adaptation post-pandemic. (1) Strongly Disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree
SQ4	Were there changes in the depth of content or pacing of classes during the return to in-person teaching? Which? (open question)
SQ5	Which institutional policies were most effective in mitigating the pandemic's impact? (open question)
SQ6	How did the increased workload and stress experienced by professors during the pandemic affect their transition back to in-person teaching? (open question)
SQ7	Additional comments. (open question)

each practice. The answer choices are based on materials provided by the course instructor. Students have the opportunity to check their answers and request a review if they find discrepancies.

On the other hand, there was an increase in the average scores for 7. It is interesting to observe that the most increases in grades after pandemic occur in open-ended questions, such as Q06 and Q29, indicated by * in Figure 4. The reason might be related to more flexible grading criteria applied to open-ended questions after the COVID-19 pandemic. Our overall findings suggest that the pandemic may have had a detrimental influence on the performance of the students.

To test the hypotheses, we formulated in Section 3.2, we applied a unpaired Mann-Whitney U Test. Firstly, we applied the Normality Test using the Shapiro Test (W = 0.874, $\rho < .001$). Note that, the low $\rho - value$ suggests a violation of the assumption of normality. As we hypothesized, according to the results of this non-parametric test (U = 378020, $\rho = 0.007$), there is significant difference related to the impact of the COVID-19 pandemic on student performance across semesters ($\mu_{2019} \neq \mu_{2022-1}$).

> *RQ_1 **Summary:** The findings indicate that the COVID-19 pandemic may have had a negative impact on the performance of students across semester.*

4.2 The Long-Term Impact of the COVID-19 Pandemic (RQ_2)

The aim of RQ_2 was to assess the long-lasting impact of COVID-19 on students' performance in Software Engineering activities. Figure 5 compares the average grades students achieved for each question from 2022 to 2023. Based on these data, we observe a decrease in the average grade for only two questions (Q02 and Q19) related to SE Introduction and Software Architecture topics, respectively (they are both

Table 3: Questions used in survey for students. All were open-ended except for SQ1 and SQ4, which was multiple-choice

ID	Questions
SQ1	By 2023, my academic performance returned to pre-pandemic (2019) levels. (1) Strongly Disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree
SQ2	What were the biggest challenges you faced when returning to in-person classes after remote learning?(open question)
SQ3	How would you describe your motivation and engagement during the first in-person semester post-pandemic (2022-1) compared to the following semesters (2023)? (open question)
SQ4	Institutional support aided my post-pandemic adaptation. (1) Strongly Disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree
SQ5	What personal or institutional strategies helped improve your performance after 2022? (open question)
SQ6	Was the emotional or academic support provided by the university relevant to your adaptation? (open question)
SQ7	Additional comments. (open question)

Q11: For the following practices, identify the agile method with the best fit. Use the following legend: (X) for the e**X**treme Programming, (S) for **S**crum, or (B) for **B**oth:

( ) Test-driven development
( ) Refactoring
( ) Pair programming
( ) Customer involvement
( ) Collective code ownership
( ) Daily 15-minute meetings
( ) Sustainable pace without overtime
( ) Short interactions and frequent deliveries
( ) 8-hours sprint planning meeting

Figure 2: Statement of the Question 11 (Q11) (Constantino et al., 2025).

closed-ended). Otherwise, there is an increase in the average for 12 questions, such as Q01, Q12, Q34, and Q35. As an example, Figure 3 shows the Q1 of our database. Q01 allows for the possibility that none of the options are correct. Q01 and Q12 questions are closed-ended questions with answers limited and narrowed to the given options. However, Q34 and Q35 are open-ended questions; as mentioned before, the students had 100% control over the questions' answers. Besides, we can consider the flexible grading criteria applied to open-ended questions. Thus, it is evident that student performance significantly improved from the first (2022) year to the second year (2023) post-pandemic.

To test the hypotheses outlined in Section 3.2, we conducted an unpaired Mann-Whitney U test. Before, we assessed normality using the Shapiro-Wilk test (W = 0.875, $\rho < 0.001$) which indicates a departure from normality assumptions. As hypothesized, the results of this non-parametric test (U = 666506, $\rho < 0.001$) reveal a significant difference related to assess the long-lasting impact of COVID-19 on students' performance in Software Engineering activities ($\mu_{2022} \neq \mu_{2023}$).

> *RQ_2* ***Summary:*** *Our findings reveal a significant improvement in student performance from the first year to the second year following the pandemic. Therefore, we argue that the pandemic impact on the student performance does not last long.*

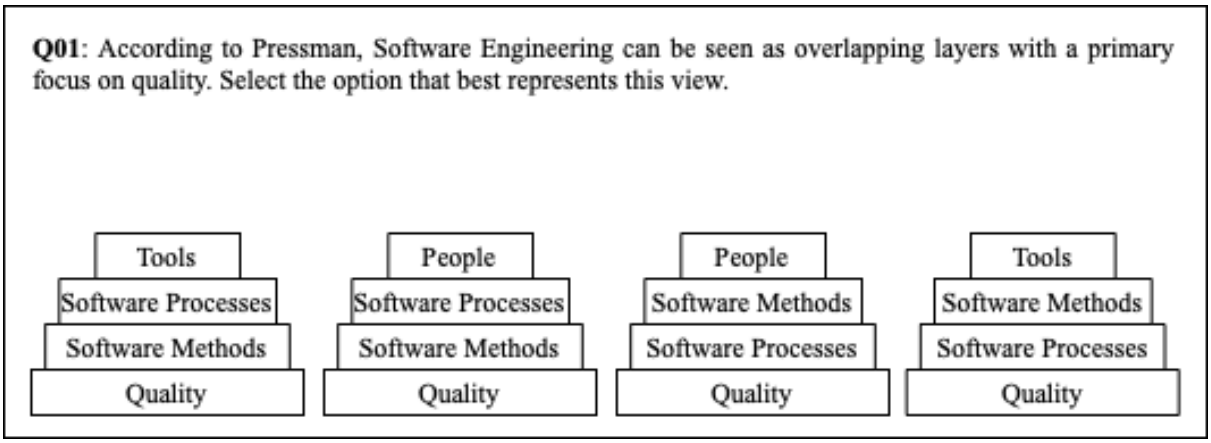

Figure 3: Statement of the Question 01 (Q01) (Constantino et al., 2025).

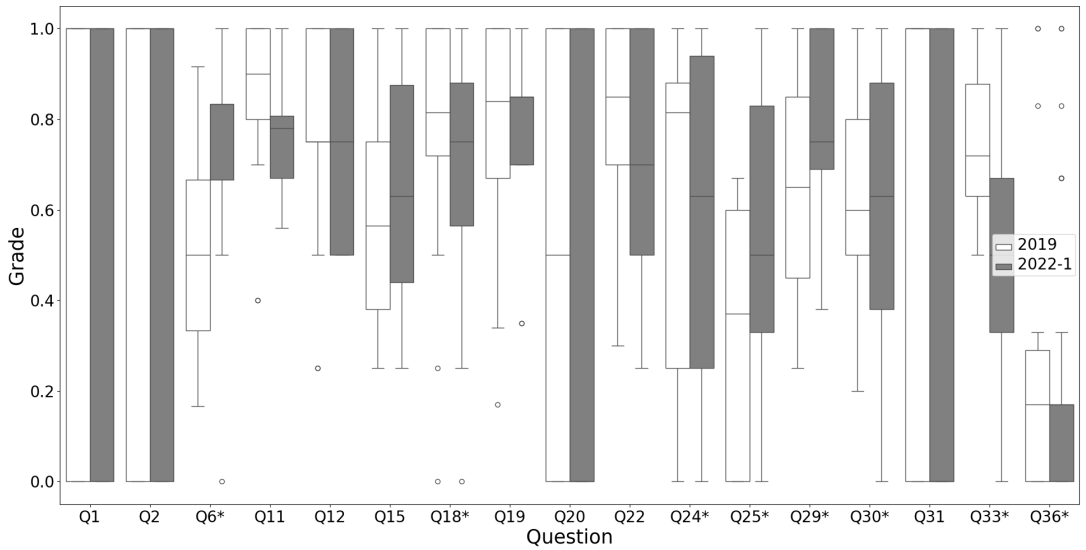

Figure 4: Common questions analyzed during the semesters in 2019 (prepandemic) and 2022-1 (post-pandemic). The exam questions Q6, Q18, Q24-Q25, Q29, Q30, Q33, and Q36 are open-ended questions (Constantino et al., 2025).

4.3 Year Comparison

In 2019, before the COVID-19 pandemic, the median student grade was around 70%, as depicted in Figure 6. However, in 2020 and 2021, during the pandemic, we implemented emergency remote teaching with an online model, prompting us to exclude data from these years. By 2022, a real negative impact of the pandemic on student performance emerged, with grades decreasing to around 60%, as illustrated in Figure 6. Nonetheless, in the second year post-COVID-19 (2023), there was an improvement in student performance, with results recovering to pre-pandemic levels (i.e., around 70%). We also noticed a larger spread of grades in 2022, as indicated by the interquartile range (Q3-Q1).

4.4 Average Grade

Table 4 presents the historical data on the general average grades obtained by questions in the Software Engineering course over the three analyzed years (2019, 2022 and 2023). As mentioned, we discarded data obtained during the pandemic (2020 and 2021). The first column corresponds to the set of questions from the SE topics as presented in Table 1. The second column ("Open?") refers to whether the question is an open-ended question (1) or closed-ended question (0). The other columns correspond to the year and semester in which they occurred. The general average grade that the students obtained was calculated for the semesters in which it occurred. The "-" means the question did not occur in the semester. Questions Q01, Q11, Q12, Q18, Q30, and Q33 are examples

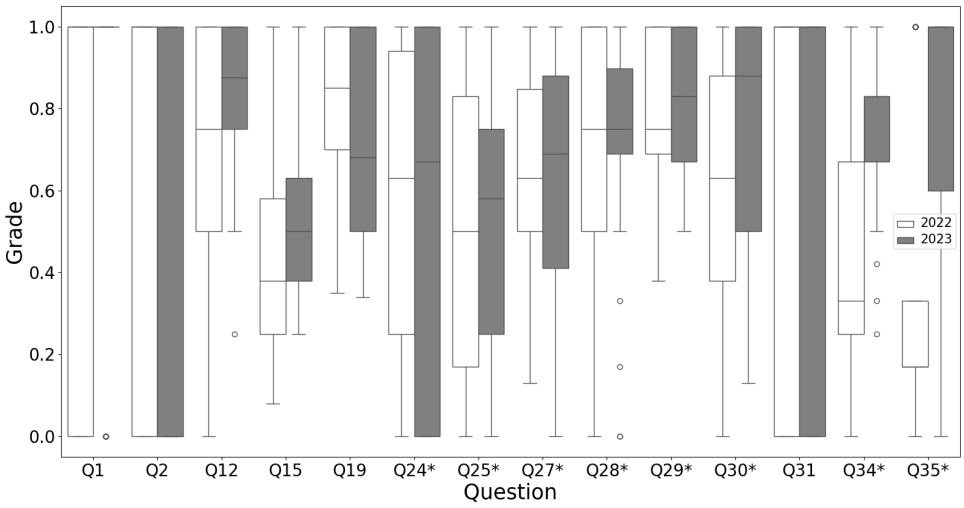

Figure 5: Two years after COVID-19 pandemic. The exam questions Q24, Q25, Q27-Q30, Q34, and Q35 are open-ended questions (Constantino et al., 2025).

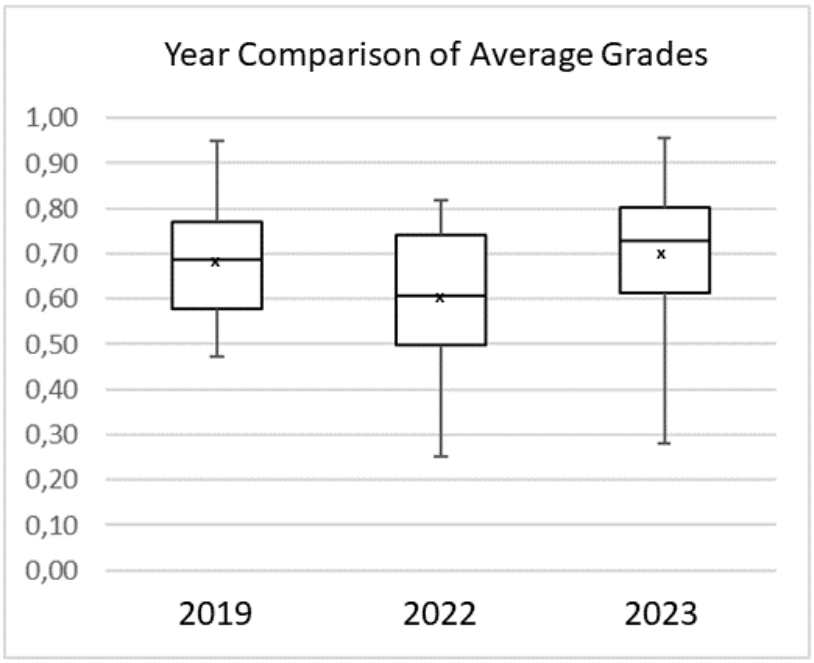

Figure 6: Year comparison (Constantino et al., 2025).

of average student grades showing a decline in the first or second semester of 2022, the first year after the pandemic. We can also see that students have improved their grades in the following year (2023). Therefore, the pandemic may not have a prolonged impact on student performance.

4.5 Factors of Facilitators and Barriers (RQ_3)

RQ_3 aimed to analyze the responses from professors (P01-P10) and students (S01-S08) to identify specific points cited as facilitators or barriers to academic recovery.

Table 4: Average Grade (Constantino et al., 2025).

ID	Open?	2019-1	2019-2	2022-1	2022-2	2023-1	2023-2
Q01	0	-	0.72	0.68	0.65	-	0.80
Q02	0	-	0.53	0.60	0.48	-	0.40
Q03	1	0.58	-	-	-	0.64	-
Q04	0	0.82	-	-	-	0.77	-
Q05	0	0.95	-	-	-	-	0.95
Q06	1	-	0.52	0.76	0.68	-	-
Q07	0	-	-	0.75	0.76	-	-
Q08	0	0.67	-	-	-	-	0.61
Q09	0	0.73	-	-	-	0.89	-
Q10	0	-	-	0.69	0.73	-	-
Q11	0	-	0.85	0.77	0.82	-	-
Q12	0	-	0.83	0.75	0.73	-	0.84
Q13	1	-	0.66	-	-	-	0.80
Q14	1	0.51	-	-	0.41	-	-
Q15	0	-	0.58	0.65	0.35	-	0.52
Q16	1	0.71	0.71				
Q17	0	0.88	-	-	-	0.91	-
Q18	1	-	0.78	0.68	0.83	-	-
Q19	0	-	0.78	0.79	0.84	-	0.73
Q20	0	-	0.51	0.47	0.74	-	-
Q21	0	0.72	-	-	-	-	0.63
Q22	0	-	0.81	0.74	0.82	-	-
Q23	0	0.70	0.84				
Q24	1	-	0.59	0.56	-	0.58	
Q25	1	-	0.32	0.54	0.48	0.51	-
Q26	1	0.47	-	-	0.37	-	-
Q27	1	0.72	-	-	0.63	-	0.64
Q28	1	-	-	-	0.67	-	0.73
Q29	1	0.63	-	0.79	-	0.80	-
Q30	1	-	0.63	0.60	-	0.74	-
Q31	0	-	0.54	0.49	0.55	-	0.58
Q32	1	0.48	-	-	-	0.28	-
Q33	1	-	0.75	0.49	-	-	-
Q34	1	-	-	0.44	-	0.72	-
Q35	1	-	-	0.35	-	0.83	-
Q36	1	-	0.22	0.19	0.32	-	-

RQ3 aimed to analyze the responses from professors and students to identify specific points cited as facilitators or barriers to academic recovery. Seven of the 10 teachers agreed that many students struggled adjusting to in-person instruction after remote learning. One of the pieces of evidence was the passive engagement of the students during lectures. For example, P06 reported that *"many seemed to lack patience, without focusing or discouragement in class, and too many distractions from cell phone use"*. P01 (supported by P02 and P10) alerts that *"students prefer to stay at home and do not fully understand the need for in-person activities."* Similarly, P09 emphasized the challenge of *"teaching students to focus on the content taught"*.

Furthermore, P03 and P04 reported the difficulty of the students carrying out group activities, especially regarding the quality of the task results. For example, P09 (supported by P05 and P08) related that *"another issue was in-person exams; grades were lower after the pandemic."* In addition, P01 mentioned, *"I believe the learning was highly impacted, although grades may not reflect this impact because educators had to adjust their grading criteria (more flexible)."* Cross-validating these results with the first findings (see Sections 4.1 and 4.4), we observed that in the first year following the pandemic (2022), average student grades showed a marked decline compared to pre-pandemic levels.

Regarding the pacing of classes, P01 and P04 related to some changes. For example, P01 mentioned, *"I needed to slow down due to absent students who preferred to stay at home (or had health conditions)."* Furthermore, P08 said, *"During the pandemic, I could not complete the coursework in almost any of the courses I taught."* Concerning the changes

in the depth of content during the return to in-person teaching, P02 said that *"there was more available time to approach each topic,"* and P07 mentioned that they applied more practical exercises.

Of the eight students who responded to the questionnaire, five (S02, S03, S06, S07, S08) expressed that the biggest challenge was readapting to daily activities, that is, their routines. For example, S03 mentioned *"time management, rush to attend a busier schedule."* Regarding the adjustment of activities, S05 mentioned the need for practical Software Engineering activities closer to the day-to-day operations of the software development industry. Considering hybrid learning (in-person and distance learning), S01 emphasized *"I prefer distance learning,"* supported by S04, who mentioned the commute to university. On the other hand, S06 stated, *"losing the courage to ask live questions."* Finally, S07 encountered no challenges, perhaps because he wants in-person classes to return soon.

When asked about motivation regarding returning to in-person classes, S02 (supported by S01, S05, and S06) emphasized *"I was more engaged right after returning, as I was eager for the pandemic to end and for everything to return to normal. In 2023, I felt everything had returned to normal, even making me miss the pandemic period, when I could do everything from home."* Furthermore, S03 (supported by S04 and S07) stated that motivation was the same. However, S03 emphasized that *"the fear of failing subjects was slightly greater, which led to more stress."* S01 also mentioned stress, particularly regarding the continued use of safety equipment like face masks. These statements cross-validate the findings that students still had difficulties at the beginning of the pandemic's return, but they adapted the following year (2023).

After the pandemic ended, things did not immediately return to how they were before; the repercussions remained. Thus, the relaxations during the pandemic had to be extended for longer, even after the pandemic ended. All these results suggest that the isolated learning environment had a lasting effect, forcing professors and students to actively relearn the immediate social and interactive dynamics of the classroom.

> RQ_3 ***Summary:*** *Our findings reveal that, according to professors, students struggled to return to in-person classes, particularly due to a lack of attention. Furthermore, it also reveals that student grades declined. For students, their main barrier was adjusting to the routine.*

4.6 Post-Pandemic Recovery Perceptions(RQ_4)

The aim of RQ_4 was to analyze responses of the perceptions from both groups regarding the drivers of recovery, difficulties, and support effectiveness.

P01, P02, P04, P08, P09, and P10 mentioned that flexible rules helped. For instance, P03 reported *"when classes gradually returned to in-person classes, students could choose between taking online (and live) classes or attending in person."* P08 mentioned *"flexible rules for course deadlines and submissions,"* and P09 said they had *"more flexible rules for student dismissal."* Moreover, P05 mentioned the psychological support. On the other hand, P09 related that *"at the institution where I worked, there was no psychological support or flexible rules."*

P01 (supported by P02, P03) stated that *"the workload and stress for teachers and students increased during the transition back to in-person teaching."* Indeed, the transition back to face-to-face teaching required new adjustments. For instance, P03 reported, *"I often did not know whether to teach specific content or practice meditation in class to calm the students."* Conversely, P07 affirmed *"there was a desire to return to normal and prepare the best classes,"* which increased the workload to adapt the material, tutorial, and other online resources.

When asked for students about personal or institutional strategies that helped improve their performance, S01 stated a preference for continuing to study from home. The need to seek a health professional to treat issues related to mental health was one of the strategies mentioned. For example, S02 (supported by S04) noted that there was significant emotional support *"from friends, family, professional colleagues, and also specialized professionals (doctors and psychologists)."* Furthermore, students mentioned academic and professional strategies. For example, S03 focused on a few complex subjects and chose the most enjoyable subjects to complete the semester's workload. S06 stated that they *"had access to recorded video classes and former study lists provided by the professor."*

Regarding professional issues, S01 (supported by S05) stated that *"the strategic acceptance of remote learning by institutions made it easier to balance their personal and professional life after the pandemic, despite requiring some adaptation from professors."* Concerning the emotional support offered by the institution, S04 said that *"the university did not offer any relevant support."* This statement coincides with one of the professors' statements. On the other hand, there was little uptake of the support offered. For ex-

ample, S01 (supported by S03 and S06) stated, *"I did not use any of the services offered."* In contrast, S07 stated that her adaptation was quick; perhaps she did not need any other support.

The analysis of the narratives of professors and students revealed a complex scenario of post-pandemic academic recovery. Important convergences include the flexibility of institutional rules, such as content and schedules. The need for emotional and psychological support was also highlighted as a convergence. Ironically, the existing support services suffered from low engagement, revealing a deep divide between what the university offered and what students felt they needed or were aware of. As a divergence, students seemed more resistant to the return to classes. Professors even highlighted a lack of attention and understanding of the in-person return.

> *RQ_4* ***Summary:*** *Our findings reveal that for faculty and students, the flexibility of institutional rules and emotional support were important to post-pandemic academic recovery. They differed in their understanding of returning to in-person classes.*

5 THREATS TO VALIDITY

In this section, we delve into the comprehensive examination of potential threats to the study's validity and discuss biases that could have influenced the results. Drawing from Wohlin et al. (2012) proposed categories, we discuss these threats and our respective actions to mitigate them below.

Construct Validity: Construct validity concerns the alignment between theory and observation (Wohlin et al., 2012). This type of threat may arise when formulating the set of questions for each test. As part of this case study, we selected questions for each class over six semesters. To mitigate this threat, we thoroughly reviewed and discussed all experimental procedures. Another threat may arise when selecting the questions for each test, which may not reflect student performance. To mitigate this threat, we ensure that the selected questions align closely with the learning objectives of the software engineering course.

Internal Validity. The internal validity is related to uncontrolled aspects that may affect the study results (Wohlin et al., 2012). Several studies (Dominik et al., 2021) (Kanij and Grundy, 2020) have delved into the ramifications of the COVID-19 pandemic on the lives of professors. These investigations have highlighted specific challenges, such as a significant increase in workload due to the transition to online teaching, the need for rapid adaptation of teaching materials to suit the online format, and the daily stressors of managing personal and professional responsibilities in a pandemic. The heightened stress levels may significantly influence the assessment process, particularly in the context of open-ended questions. Consequently, our results may not reflect the reliability of open-ended question evaluations. To address this limitation, we implemented a consistent evaluation approach, where a single professor assessed all responses of the participants throughout the study period. However, it is important to note that if different professors had been involved in evaluating the questions, the outcomes might have varied, potentially compromising the reliability of the study. This underscores the need for a standardized approach in our assessment process. In our survey study's target population consisted of professors from the SE program teaching in 2022 and 2023. Likewise, the invited students enrolled in the SE course during the post-pandemic periods analyzed in this study. All were invited to participate in the survey without any compensation.

External Validity. The external validity concerns the ability to generalize the results to other environments (Wohlin et al., 2012). Since the study participants were exclusively from the Software Engineering course at a single university in Brazil, the findings are applicable only to similar contexts. This limitation is shared with all case studies (Wohlin et al., 2012). To enhance generalization, further studies based on our findings should be conducted across other courses and universities. Despite these limitations, the findings provide valuable insights into the advantages, limitations, and recommendations for improvements to the Software Engineering courses.

Conclusion Validity. The conclusion validity concerns issues that affect the ability to draw the correct conclusions from the study (Wohlin et al., 2012). The findings outlined in this study primarily consist of observations, recommendations, and insights intended to guide future research endeavors. While we have provided our own interpretation of student performance analysis, it is important to acknowledge that there may be additional significant insights within the collected data that have not yet been explored or reported.

6 RELATED WORK

Several studies investigated the academic performance on Computer Science (CS) or Software Engineering (SE) courses (Cruz et al., 2015) (Falessi et al., 2018) (Akbulut et al., 2018) (Berkling and Neubehler, 2019) (Gürer et al., 2019) (Ouhbi and Pombo, 2020) before COVID-19 pandemic. For instance, Gürer et al. (2019) examined the effects of various factors such as, demographic characteristics, achievement in computer programming courses, perceived learning, and computer programming self-efficacy on pre-service computer science teachers' attitudes towards computer programming (ATCP). They identified and analyzed the impact of various factors (performance, self-efficacy, perceived learning) on these attitudes, providing valuable insights into how to motivate and support future computer science educators.

Other studies has been extensively researched the impact of the COVID-19 pandemic on education (Adnan and Anwar, 2020) (de Deus et al., 2020) (Barr et al., 2020) (Crick et al., 2020) (Akhasbi et al., 2022) (Lin and Hou, 2023) (Singh and Meena, 2023). These studies have examined the effects of remote learning education on student performance, engagement, and well-being across various Computer Science (CS) or Software Engineering (SE) courses.For example, Adnan and Anwar (2020) investigated the attitudes of Pakistani higher education students towards compulsory digital and distance learning university courses during the COVID-19 pandemic. De Deus et al. (2020) investigated how professors conducted Emergency Remote Education (ERE) in the field of Computer Science in Brazil in response to the COVID-19 pandemic.

Barr et al. discussed their experience delivering an eight-week undergraduate Software Engineering program during the pandemic, particularly during the lockdown period. Reflecting on the rapid shift to online learning across three distinct modules, they emphasized the importance of prioritizing well-being of the students. From this, they concluded that there is no "one-size-fits-all" approach to online delivery in Software Engineering education. Nevertheless, they believe it is still possible to offer a pedagogically sound learning experience, even under lockdown conditions, by adhering to established best practices. These include breaking online lectures into smaller, more accessible units, carefully structuring group work and team composition, and actively using student feedback to make real-time adjustments.

In contrast, other studies found no significant differences between remote and in-person instruction (Crick et al., 2020), these studies also highlighted the challenges of remote learning, such as lack of access to technology, limited opportunities for collaboration, and increased distractions at home. They analyzed various aspects, such as attitudes towards online education, challenges faced by educators, strategies adopted during emergency remote teaching, and the overall impact on teaching practices and institutions. Therefore, the distinctive feature of these papers lies in their exploration of the unprecedented challenges and adaptations in education caused by the pandemic.

Nowadays, studies have begun to examine the long-term effects of the pandemic on CS education. Some studies suggest that the pandemic may have exacerbated existing inequalities in CS education, with students from disadvantaged backgrounds disproportionately affected (Lin and Hou, 2023). Additionally, they explored how students' educational background and family income influence their experiences with online learning and compare traditional in-person instruction from the perspective of Taiwanese students. Other studies have explored the potential benefits of remote learning, such as increased flexibility and accessibility (Singh and Meena, 2023). Their study highlighted the discrepancy between expected and actual benefits of virtual classrooms, shedding light on challenges faced by both faculty members and students, and examining the moderation effects of these challenges on perceived benefits. Our study complements these previous works by examining the comparative student performance in computer science, specifically within the context of a SE course, before and after the onset of the pandemic.

The topics have been studied in various countries worldwide, including but not limited to Australia (Kanij and Grundy, 2020), Brazil (de Deus et al., 2020), India (Singh and Meena, 2023), Israel (Fitoussi and Chassidim, 2021), Moroccan (Akhasbi et al., 2022), Pakistan (Adnan and Anwar, 2020), Taiwan (Lin and Hou, 2023), the UK (Crick et al., 2020), and potentially others given the global nature of the COVID-19 pandemic and its impact on higher education systems globally. It might have highlighted the potential benefits and drawbacks of online education in the field of Computer Science. During the pandemic, studies provided crucial insights into how faculty members and students have adapted to virtual classrooms and the challenges they have faced. After the pandemic, they offered valuable lessons for improving online learning experiences and ensuring resilience in higher education systems. Utilizing a software engineering course as a case study, we aim to provide a more focused analysis of how the pandemic has impacted student learning outcomes, we employ quantitative methods, and overall educational expe-

riences in this particular field of Computer Science. This provides valuable insights into the long-term effects of the pandemic on educational outcomes in this field.

7 CONCLUSION AND FUTURE WORK

The COVID-19 pandemic depicts an unprecedented global phenomenon with implications, especially within the educational sector. This study is composed of two phases. First, we examined its effects on academic results among students in the Software Engineering Course. To this end, we used historical exam data from 2019, 2022, and 2023, such as average grades from recurring assessments across multiple semesters. As one of the results, we identified a notable decline in performance during the first semester of 2022. Nevertheless, we observed a gradual recovery in succeeding semesters, reducing the pandemic's adverse effects over time. In the second phase, we extended with quantitative and qualitative analysis, in which professors and students reported difficulties returning to in-person classes, with grades decreasing. The main problem for professors was students' lack of attention; for students, it was adapting to a new routine. Both groups agreed that emotional support and flexible rules were crucial for recovery. However, they had different perceptions of the return.

We intend to investigate the pandemic's impact on the students' performance in SE course topics, such as requirements, development processes, or Software quality. By exploring these topics in more detail, we aim to discover new insights to improve the course teaching. Finally, we can explore the impact of the pandemic on different groups, such as genders (male versus female).

ACKNOWLEDGEMENTS

This research was partially supported by Brazilian funding agencies: CNPq (Grant 312920/2021-0, PROFIX-JD 155774/2023-9 e 157416/2024-0), CAPES, and FAPEMIG (Grants BPD-00460-22 and APQ-01488-24).

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