A Long-Term Study of the Pandemic Impact on Education: A Software Engineering Case

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Abstract: The COVID-19 pandemic has had an unprecedented and widespread impact on education, significantly affecting students worldwide. Although many studies have investigated this impact in the last 5 years, we still lack empirical knowledge about the long-lasting impact of this most recent pandemic on performance in the 2020's generation of students. This quantitative study aims to evaluate the long-term impact of the pandemic on student performance, especially in the Software Engineering course. To achieve this goal, we collected historical data from Software Engineering students three years – prior to (2019) and post (2022 and 2023) COVID-19 – such as their grades in repeated questions throughout the semesters. We employed statistical methods to analyze this quantitative data. As one of our results, we identified that the pandemic negatively influenced student performance in 2022, especially in the first-semester post-pandemic. However, we also observed that the impact was mitigated in the following semesters of 2022 and 2023. This result is a breath of hope since it suggests that the current generation of students has overcome the challenges imposed by the pandemic period.

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 quantitatively investigated the long-term impact of this pandemic on student performance.

To fill this gap, this paper presents an empirical study based on historical data to assess the impact of the COVID-19 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 par-

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ticipant 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.

Our primary contributions can be summarized as follows:

(i) We describe a quantitative 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) 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].

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

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, two research questions and steps. Furthermore, we analyze and report the results of this study focusing on the two 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.

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

The goal of this work is to assess the impact of the COVID-19 pandemic on the performance of students in a Software Engineering course. To achieve this goal, we formulated two Research Questions (*RQs*) 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?

Therefore, for RQ_1 and RQ_2, our interest is (i) to understand the relationship between the periods before and after the pandemic and (ii) to investigate about the impact of COVID-19 on performance of the students, in the two years after the pandemic.

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.

> **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 Study Steps

Planning Case 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. Figure 2 presents the proposed database model, which includes three entities: Semester, Does, and Question.

The Semester entity represents the academic period and is uniquely identified by the attribute Code, which serves as the primary key. This attribute ensures that each semester entry is distinct in the database, supporting tracking and management of specific academic terms.

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

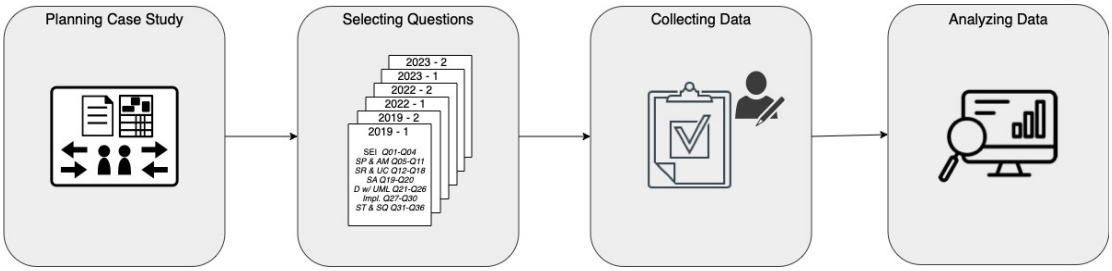

Figure 1: The phases of the study.

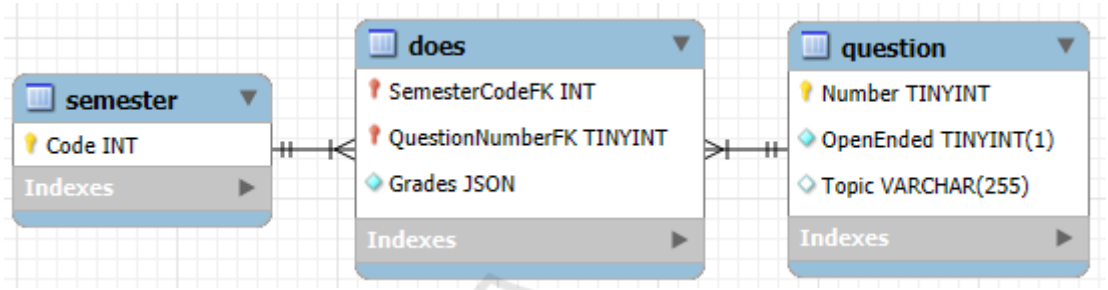

Figure 2: Entity-Relationship Data Model Concept. Generate by Reverse Engineering in MySQL Workbench.

The Question entity represents individual questions used within semesters. It includes the attributes Number, Open-Ended, and Topic. The Number is the primary key, uniquely identifying each question. Open-ended is a Boolean attribute indicating whether the question requires an open-ended response. The Topic attribute specifies the subject matter or theme of the question, allowing for categorization and retrieval based on topic areas. Together, these attributes support diverse question types and flexible question categorization.

The Does entity captures the relationship between semesters and questions, incorporating the attributes of Grades. Grades record the score or grade associated with each semester-question combination. This setup enables tracking of specific grades for each question as it appears in different semesters.

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 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.

4 RESULTS

This section presents the key findings of our investigation into the impact of COVID-19 on student performance. 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. Finally, we investigate the changes in average grades throughout the study period. These analyses provide a comprehensive understanding of the multifaceted impact of the pandemic on educational outcomes.

Table 1: Topics and their questions.

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.*

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 5 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 3 used in assessments across multiple semesters. This question asks students to identify the agile method that aligns best with 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 5. 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 6 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 closed-ended). Otherwise, there is an increase in the average for 12 questions, such as Q01, Q12, Q34, and Q35. As an example, Figure 4 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,

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 3: Statement of the Question 11 (Q11).

Q01: According to Pressman, Software Engineering can be seen as overlapping layers with a primary focus on quality. Select the option that best represents this view.

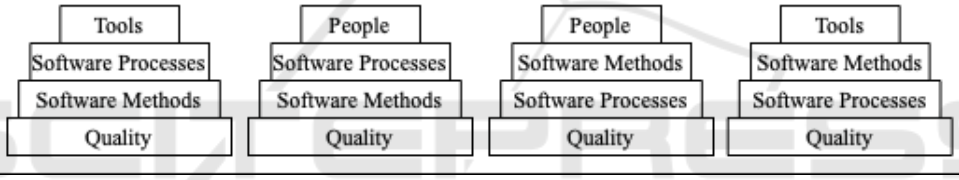

Figure 4: Statement of the Question 01 (Q01).

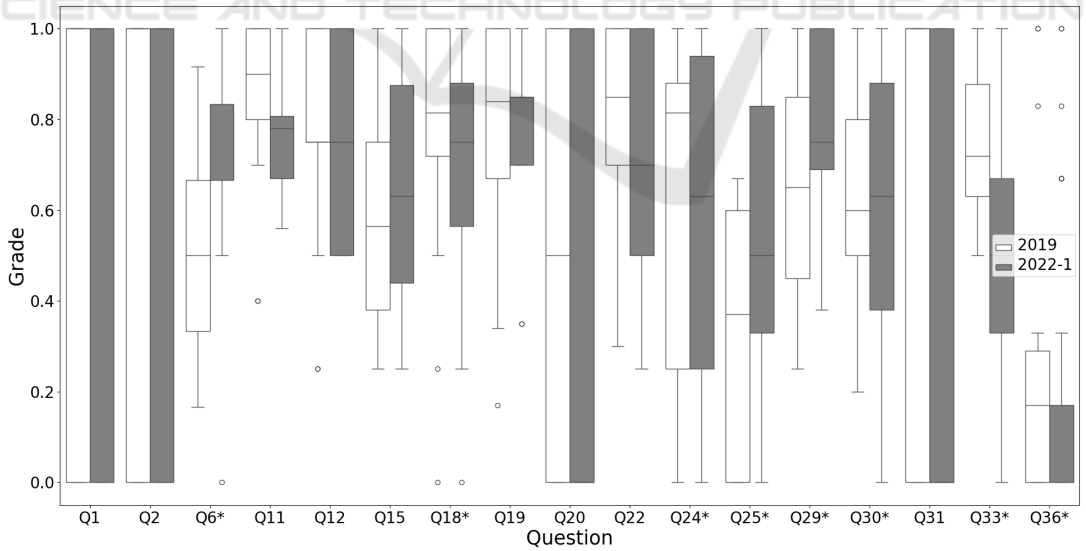

Figure 5: Common questions analyzed during the semesters in 2019 (prepandemic) and 2022-1 (post-pandemic). The exam questions Q6, Q18, Q24-Q25, Q29, Q30, Q33, and Q36 are open-ended questions.

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 ($\mu_{2022} \neq \mu_{2023}$).

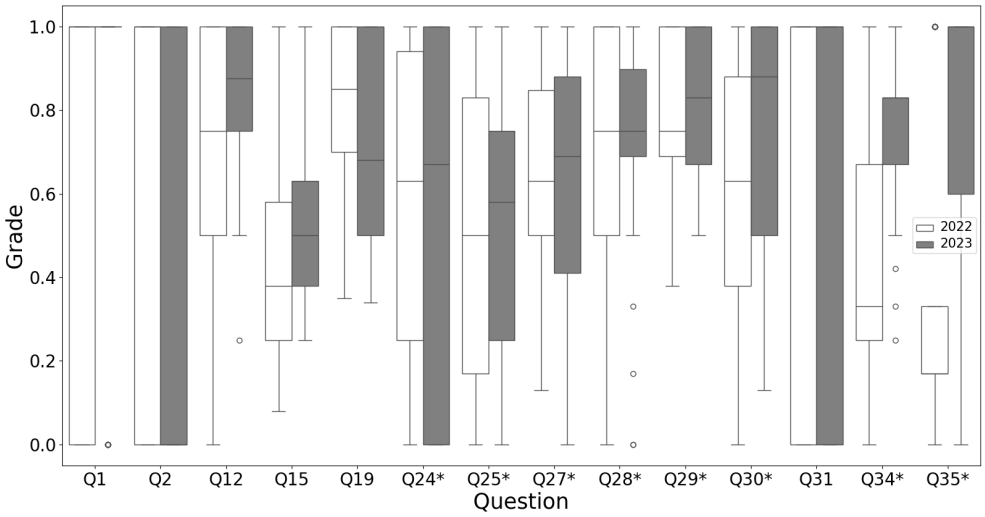

Figure 6: Two years after COVID-19 pandemic. The exam questions Q24, Q25, Q27-Q30, Q34, and Q35 are open-ended questions.

*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.*

4.3 Year Comparison

In 2019, before the COVID-19 pandemic, the median student grade was around 70%, as depicted in Figure 7. 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 7. 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 2 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 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.

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

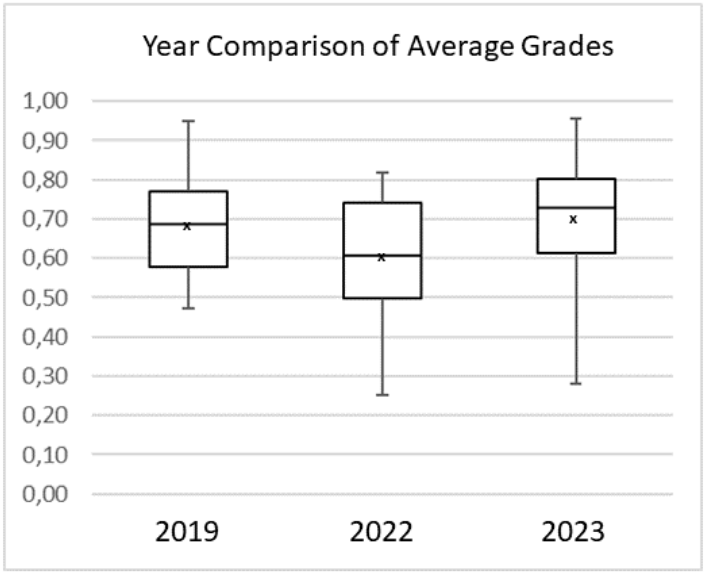

Figure 7: Year comparison.

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.

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 ana-

Table 2: Average Grade.

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	-	-

lyzed 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 dif-

ferences 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 experiences 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 is a unique and vast event that has profoundly impacted various aspects of human life, particularly education. This study aimed to investigate the impact of the pandemic on student performance, focusing on the Software Engineering Course. To this end, we collected historical data for 2019, 2022, and 2023 from the exams for the students enrolled in the SE Course, specifically the average grades of recurring assessments across semesters. Our findings reveal an impact on student performance, particularly during the first semester 2022. However, we also perceived that the impact decreased in the following semesters.

Future Work. We plan to conduct surveys among the students (Souza et al., 2019) (Braun. et al., 2023) to triangulate our results and better understand the perspective of the students related to the impact of the COVID-19 pandemic on their performances. Following this, we can investigate the impact of the pandemic on the performance of the students in SE course topics, such as requirements, development processes, or Software quality. By exploring these topics in more detail, we aim to uncover new insights to improve the course teaching. Another research opportunity is to investigate the student frequency in the course to understand their engagement and participation in the educational process (Figueiredo et al., 2014). Finally, we can explore the impact of the pandemic on different groups, such as genders (male versus female). we can conduct further studies based on our findings in other courses and universities including qualitative insights, such as student surveys.

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