The Impacts of Emergency Remote Learning in a CS Programming Course: a Case Study

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ABSTRACT

With the COVID-19 pandemic, universities had to close their campuses. The need to continue teaching in these circumstances has led to the adoption of an Emergency Remote Learning (ERL) model by many universities. Computer Science related courses needed to adapt to this model, adopting strategies and tools to keep teaching. Thus, this article presents an analysis of the impact of ERL adoption on the students' learning outcomes in an object-oriented programming discipline. An Explanatory Case Study is carried out involving six classes, three from before and three after the ERL. The results indicate that there were no statistically significant impacts on the students' learning outcomes, raising initial evidence that the adaptation strategies adopted may have been effective to minimize the impacts.

CCS CONCEPTS

• **Social and professional topics** → Computing education; • **Applied computing → Distance learning**; • **Software and its engineering → Object oriented development**.

KEYWORDS

Emergency Remote Learning, Case Study, Object Oriented Programming, Virtual Programming Lab.

1 INTRODUCTION

Universities have faced, and are still facing, several challenges in maintaining education during these harsh times of the COVID-19 Pandemic. The WHO statement that COVID-19 was a Pandemic [11] led universities around the world to physically close their campuses to people, leading to the need to adapt classroom teaching to remote teaching [12][5].

Initially, the expectation seemed to be the adoption of Distance Learning as a way to enable the continuity of teaching without the need for in-person teachers and students. However, there is a big difference between Distance Learning and the Remote Emergency Learning that was actually embraced. Distance Learning (or Online Learning) as an area of research and practice already existed for decades, with millions of students around the world benefiting from the resources of online learning long before the pandemic [9]. Over the years, researchers in educational technology have defined terms, techniques, tools and designed solutions that have been successfully developed and implemented, such as: distance learning, distributed learning, blended learning, online learning, mobile learning, and others [8]. Emergency Remote Learning, however, is a temporary shift of instructional delivery to an alternate delivery mode due to crisis circumstances [9][8]. Thus, ERL cannot emulate regular face-to-face teaching, nor does it try to recreate the robust Distance Learning ecosystem, but rather to provide temporary access to instruction and instructional support in a manner that is quick to set up and is reliably available during an emergency or crisis [2].

In this sense, the OECD released a framework [12] with recommendations based on information collected in 98 countries, offering suggestions for educational response actions to the emergency of COVID-19 to guide the development of an education strategy during the Pandemic, suggesting that actions be taken to, among others: ensure access to all, re-prioritize curriculum goals to adapt curricula to the essentials, identify means of education delivery, define appropriate mechanisms of student assessment, develop a communication system with students.

At Brazilian universities, and more specifically at the Federal University of Santa Catarina, it was no different. From March 15, 2020, face-to-face activities were suspended [6] and strategies began to be defined to provide access to educational resources for all students, especially the most vulnerable. A survey for this purpose revealed that 12.48% of students did not have access to an individual computer to carry out educational activities, and 7.96% depended on access to the university's computer lab equipment for this purpose.

In the area of Computing teaching, specifically, despite some natural advantages in implementing the ERL in relation to other areas, the adaptation to the ERL has also faced difficulties, such as: carrying out assessments, preparation/adaptation of educational materials, discipline organization, monitoring students in the process of moving to the ERL and teaching without visual feedback from students [15].

After more than a year of ERL being used in several universities for teaching, we can observe what have been the ERL impacts on Computing education [5][14] and more specifically on teaching programming disciplines [15]. However, so far, it was not possible to find studies specifically reporting a case study analyzing the impact of the ERL on the various facets of student's performance in specific programming disciplines.

Thus, the main research question of this paper is "What is the impact of Emergency Remote Learning on the learning outcomes of Object-Oriented Programming students?". In order to answer this research question, a case study is carried out in an Object-Oriented Programming (OOP) discipline, with data collected during two semesters before ERL implementation and two semesters after implementation from six different classes taught by the authors.

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Thus, the main contribution of this work is to present the adaptations made to implement the ERL in programming teaching and the comparative analysis of the impact of the ERL on students' learning outcomes.

2 RELATED WORK

With the COVID 19 pandemic hitting the most diverse countries, several universities needed to migrate their teaching modality to a format that can be named Emergency Remote Learning (ERL). In higher education courses in the area of Computer Science the same happened and some studies have already sought to analyze, from different perspectives, the different impacts of this change in these courses.

Dwivedi et al. [7] present a very broad analysis of the impacts of COVID-19 on IS-related research and practice over life, work and education, from the perspective of 12 experts. Crick et al. [5] conducted a large-scale international study on the impact of COVID-19 and ERL on Computer Science education practitioners, reporting significantly more positive attitudes towards ERL than in other disciplines, although there were concerns about the feasibility of applying the types of assessments.

More specifically on the impact of the ERL on programming courses in Brazil, Silveira et al. [14] reported the experience of adapting a course of Programming Paradigms, involving the use of Virtual Learning Environments, tools for video classes recording and specific software for the programming activities. The results indicate that the academic performance of the students was satisfactory and even recommend that the teaching modality can be adopted in other courses. Souza et al. [15] presented an adaptation of a software engineering course to ERL using a Project-based Learning approach, reporting that, despite some benefits observed, ERL brought some challenges in carrying out assessments, especially tests; preparation/adaptation of materials; discipline organization; monitoring students in the process of moving to the ERL, teaching without visual feedback from students.

It was not possible to find, so far, a study of the impacts of ERL on the students' learning outcomes of an OOP course. The present paper contributes in this sense.

3 METHODOLOGY

In order to understand how the ERL impacted the students' learning outcomes, an Explanatory Case Study is carried out, which seeks to identify relationships in a specific phenomenon [4]. In this case study, the phenomenon consists of the implementation of the ERL and its impact on learning outcomes. We consider learning outcomes as what a learner is expected to know, understand and/or be able to demonstrate at the end of a period of learning [1]. In the context of this research, these learning outcomes are demonstrated through practical programming activities exercises and projects.

Thus, our main research question "What is the impact of Emergency Remote Learning on the learning outcomes of OOP students?" was detailed in the following questions:

- RQ1. What is the impact on students dropout during the course?
- RQ2. What is the impact on learning outcomes of practical activities?
- RQ3. What topics in the discipline's curriculum were most impacted?
- RQ4. What is the impact on students failing the course?
- RQ5. What is the student's evaluation regarding the adaptation to the ERL?

Based on the main research question, the main hypothesis for the case study is: "The adoption of the ERL has a negative impact on the learning outcomes of the OOP course students" (H1).

4 CASE STUDY

In this section we present the case study design and execution. In the case study design, the context and the sample are detailed and in the case study execution, the changes made to adapt the course to the ERL are also presented.

4.1 Case study design

This Case Study is carried out in the "*Development of Object-Oriented Systems I*" course, which is offered in the second semester of the Information Systems undergraduate course at the Federal University of Santa Catarina, Florianópolis, Brazil.

Context

The programming course has a workload of 90 hours, divided in two classes a week, during one academic semester (18 weeks). Classes are typically limited to 30 students per instructor, given the size limitations of computer labs. The course's main content topics are presented in Table 1, covering the basic concepts of object-oriented programming. The programming language used is Python. The Moodle virtual learning environment (https://moodle.org) is used as a content repository, centralizing communication between students and teachers and for carrying out/delivering practical programming activities, as well as for recording grades. It is important to mention that Moodle has been used at the university for years, which means that students and professors are somehow familiar with the environment.

Before the implementation of the ERL, the didactic strategy consisted of an expository-dialogue presentation of each of the content topics by the instructor, using slides (PowerPoint) and also live coding in each class. After the presentation of the content, the students performed the practical programming activities corresponding to the content in the computer lab under the supervision of the teacher.

As the programming course is eminently practical, the formative assessment is carried out through practical programming activities, where students usually have biweekly programming exercises, together with two major programming projects during the semester (see Table 1). During in-person classes, students also had two paper-based summative assessments, which were removed once ERL started (see more details in the next section).

Practical programming activities are automated assessed through the Virtual Programming Lab (VPL) tool (https://vpl.dis.ulpgc.es). VPL is a Moodle plugin that allows professors to set up programming assignments with automated assessment. Students can submit their assignments on VPL and test whether their programming code is correct or needs improvements. For the instructor, the VPL allows flexible definition of test codes, with their automated grading. In addition, the tool allows the analysis of the similarity of student

Table 1: Course contents, duration and programming activities

Content topics	hs	Activities							Projects	
		A1	A2	A3	A4	A5	A6	A7	P1	P2
Principles and concepts of OOP	12	X	X	X					X	X
Relationships between objects	24		X	X	X				X	X
Abstract classes and polymorphism	12					X			X	X
OO systems design with MVC	10						X		X	X
Exceptions Treatment	8							X	X	X
Graphical User Interface	12									X
Persistence and serialization	12									X

codes (to detect possible copies), a history of code versions submitted by each student, among other functionalities. Figure 1 shows an extract of practice activity A3 - "Implementation of classes and objects" defined in VPL.

The Projects are not assessed using VPL. Students are supposed to submit a report with the modeling of their solution using Unified Modeling Language (UML), together with their source-code. After that, students need to present their solution. The students' practical activities grade is calculated as follows: $SUM(An) * 0.2 + (P1 + P2) * 0.8$.

Sample selection

The case study sample is considered as non-probabilistic by convenience [3], as we selected all students from the six classes taught by the authors, three classes before the ERL adoption and three classes after the ERL. We analyzed data collected from a total of 159 students, 79 students from classes before ERL adoption and 80 after ERL adoption. Data were collected during two semesters before the ERL (2019) and two semesters after the ERL (2020-2021).

4.2 Case study execution

This Explanatory Case Study consists of an analysis of the impacts of ERL deployment in the programming course presented in the previous section. However, before analyzing the impacts, it is necessary to understand the main changes made in the course with the implementation of the ERL.

In order to restart the educational activities in a non-presential manner, the University Council established a set of norms for the migration to the ERL model. This extensive set of rules established the limits and criteria to enable the migration to the ERL model. Thus, the programming course was adapted by the authors in order to meet the university's guidelines and make the content available in the best possible way, using the tools already mentioned and seeking other tools and strategies. Next, we present the main changes applied, in terms of strategy, tools and evaluation.

Changes in Tools usage

To enable the rapid adoption of the ERL, numerous tools were tested by the authors, the following being additionally adopted:

- Google Meet (https://meet.google.com) for conducting live classes, as the university signed a contract with Google for this purpose;
- An institutional local installation of JupyterLab (https://jupyter.org), providing explained code examples;
- H5P (https://h5p.org) to add interactive exercises to recorded videos, which was available as a plugin for Moodle. See Figure 2.
- Kahoot tool (https://kahoot.com) to add interactive quizzes for the synchronous classes.

Changes in the Educational Strategy

As the course has two encounters per week, one encounter changed to asynchronous format (without live participation of students and teacher) and the other to the synchronous format (live classes using Google Meet with the participation of all students and the teacher). For the asynchronous classes, videos for each topic were pre-recorded with non-evaluative exercises associated. Thus, in the weekly asynchronous class, students watched the video and performed the exercises and in the next synchronous live class, they reviewed the content and performed the practical programming Activities (see Table 1) with the support of the teacher.

For the synchronous classes, interactive quizzes were created using the Kahoot tool. For each topic of the course content, an interactive quiz was created on Kahoot. The quizzes were applied at the beginning of all synchronous classes, reviewing the content of the last asynchronous class. Depending on the student's answers, the instructor explained again the topic addressed by the question.

Jupyter Notebooks were also developed for each content topic, as additional material to support the contents that were previously available to students.

Changes in the Assessment

As mentioned, in the previous face-to-face learning, the assessment also had two paper-based tests. In the impossibility of performing this type of test, they were removed from the assessment. All the other seven programming Activities and the two Projects were kept, strictly maintaining the same assessment criteria.

5 ANALYSIS AND DISCUSSION

In this section we detail how we approached each one of the research questions. We expose the data collected and show our analysis, followed by a discussion on each topic. Following open science principles, we made our raw data and analysis procedures available at: http://bit.ly/3BGKY9s.

RQ1. What is the impact on students dropout during the course?

There are mostly two ways of classifying students who dropped out of the course. These students can officially unroll from the

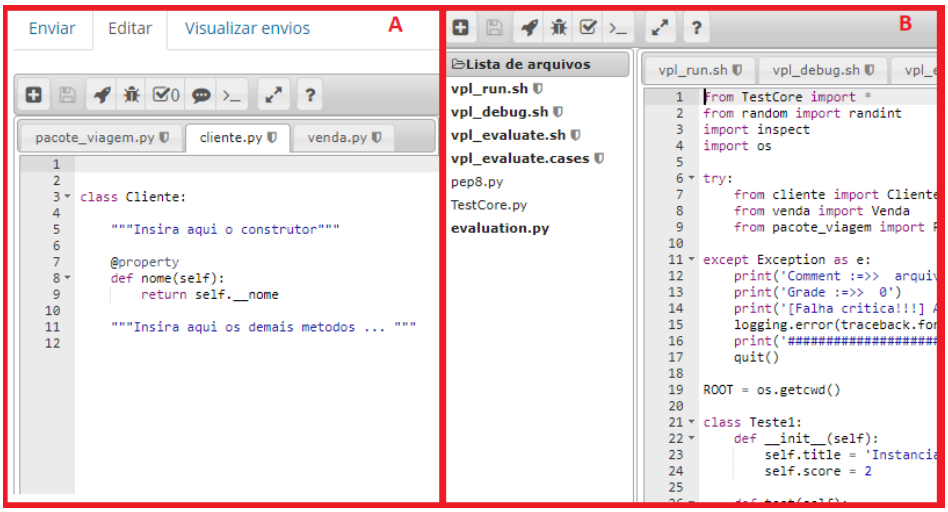

Figure 1: VPL. (A) Students coding view. (B) Instructors test code definition view.

Figure 2: Interactive exercises with H5P.

course (canceling their enrollment), or they can simply stop attending classes. To answer this research question, we took into consideration the number of students who stopped attending classes and consequently failed the course by *Insufficient Attendance* (denoted FI). If a student fails to attend at least 75% of the classes of a course, this student automatically fails the course with an "FI" label. This measure is used university-wide and was also considered in the OOP course of this study.

In Table 2 we compare the students in Face-to-Face Learning (FFL) and Emergency Remote Learning (ERL) regarding their dropout rates.

Table 2: Comparison of dropouts before and during ERL

	Total number of students	Total number of students with FI	Percentage of students with FI
FFL	**79**	**14**	**17.72%**
ERL	**80**	**11**	**13.75%**

When comparing the number of students who failed due to insufficient attendance, we noticed that ERL did not cause an increase in these numbers. In fact, the number of students who dropped out of the course during it reduced from 14 to 11 (-21.4%). It would also be interesting to consider the number of students who officially dropped out of the course, and consequently were removed from the list of students. Unfortunately, we did not have access to this data to include in this study, as they are automatically removed from the Moodle system.

RQ2. What is the impact on learning outcomes of practical activities?

In order to answer this question, we evaluate two different measures. The first one explores the grades of students who finished the practical activities. The second one analyses the amount of students who did not even attempt to answer the activities.

Table 3 shows the average grades for each one of the practical activities. In this table, only the grades of students who finished and submitted the activities were considered. We noticed that most of the activities performed during ERL had a small decrease of grades (-0.38 in average), while activity A4, A7 and project P2 had slightly higher grades during ERL. These assessment results indicate that the ERL scenario did not have a significant impact on the grades of students who took the time to do the activities.

Table 3: Average grades in practical activities (out of 10)

	A1	A2	A3	A4	A5	A6	A7	P1	P2
FFL	10	8.47	9.76	9.34	9.60	9.29	8.75	7.80	8.26
ERL	9.32	7.69	9.69	**9.37**	8.90	8.72	**8.80**	7.67	**8.37**

Now we analyse whether ERL has impacted the number of students who did not attempt to solve the activities. Figure 3 depicts the percentage of students who did not attempt the activities of the course. The horizontal axis represents the percentage of students (out of the total number of students in FFL and in ERL respectively); colours represent the activities; the top bars clustered together represent the data in FFL and the bottom ones represent data during ERL.

In normal situations (FFL), we usually observe that towards the end of the semester, students historically tend not to finish practical activities for various reasons.

In most activities the percentage of students who did not attempt the activities during ERL was smaller (P1, A1, A2, A3, A5, A6, A7). One possible reason is that with the COVID-19 pandemic, the university allowed students to officially drop out of a course (canceling their enrollment) much later in the semester than before, giving them the opportunity to be removed from the course without failing it. Another possibility is that instructors were more willing to extend deadlines during the pandemic, which, in fact, happened.

RQ3. What topics in the discipline's curriculum were most impacted?

To answer this RQ we analyse the outcomes of practical activities and consider the topics of the course related to each one of them. Here we consider the average grades of the activities related to each content topic. For instance, "*Principles and concepts of Object Oriented Programming*" was applied in practical activities A1, A2, and A3. Results are shown in Table 4.

The most relevant impacts were observed in "Principles and concepts of Object Oriented Programming" (0.51), "Abstract classes and polymorphism" (0.7), and "Object oriented systems design with MVC" (0.57). However, in the last two subjects, the average grades in ERL were slightly higher than in FFL, and here all content topics were considered in the development of the full projects.

RQ4. What is the impact on students failing the course?

Using the formula mentioned in section 4.1 for calculating the final grade, students are considered to have been successful in the course when their final grade is above 6.0 and they had sufficient attendance (i.e. must have attended at least 75% of the classes, denoted FS). To assess the impact on students failing the course, we compare the number of failures before and after the ERL and highlight the number of students who got a negative outcome even though they had enough attendance. We consider this last situation more serious than failing by insufficient attendance, because it possibly highlights difficulties in understanding the contents of the course. Table 5 shows the results of students' failures found in this study.

The results found complement RQ1, where we evaluate the number of students who dropped out of the course by not attending enough classes. By analysing the table we see that the total number of students who failed the course even though they had enough attendance (FS) was slightly larger during ERL, with an increase of only 3.7 percentage points, but representing a variation of 42%.

However, a reflection is needed about this variation in relation to the final grades. As paper-based tests were removed from the assessment, this may have changed the behaviour of students in relation to practical activities, or even in relation to dropping out of the course. Students who, for instance, received a lower rating on the paper-based tests could apply more or less effort in carrying out the practical activities. This possible influence was not analyzed in this study. Furthermore, to overcome this limitation, other assessment strategies could have been applied to replace paper-based tests, such as oral exams [13].

RQ5. What is the student's evaluation regarding the adaptation to the ERL?

This research question aims to understand the students' point of view regarding the adaptation to the ERL model. In order to answer this research question, we explore three different dimensions of adaptation to the ERL: (i) evaluation of the new online teaching resources; (ii) evaluation of the live synchronous classes and; (iii) evaluation of the students' own engagement (self-assessment).

For data collection, an online questionnaire was created using Google Forms (https://forms.google.com/). For each of the dimensions, affirmative sentences were elaborated with answers in a four-point Likert scale. In addition, a question was added seeking to identify the main causes of possible difficulties for students to participate in the ERL. The themes of each statement are presented in Table 6. As the objective was to collect the evaluations of the students who participated in the ERL, the questionnaire was applied to the 80 students at the end of each of the two semesters after the beginning of the application of the ERL. Of these 80 forms submitted, 30 students responded, representing a response rate of 37.5%. This response rate is possibly explained by the fact that the questionnaire was applied at the end of the semester, when several

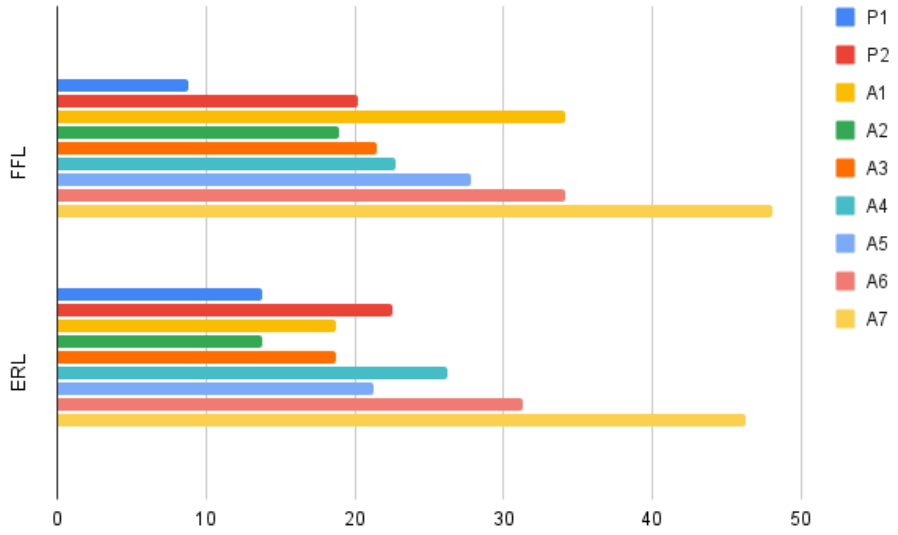

Figure 3: Percentage of students who did not attempt the activities.

Table 4: Impact on topics of the course

Content topics	Activities		Projects	
	FFL	ERL	FFL	ERL
Principles and concepts of Object-Oriented Programming	9.41	8.90		
Relationships between objects	9.19	8.92		
Abstract classes and polymorphism	9.6	8.90		
Object oriented systems design with MVC	9.29	8.72		
Exceptions Treatment	8.75	8.79		
Graphical User Interface			8.26	8.37
Data persistence and object serialization			8.26	8.37

Table 5: Comparison of course failures before and during ERL

	Total number of students	Total number of students who failed	Total number of students who failed with FS
FFL	79	21 (26.5 %)	7 (8.8 %)
ERL	80	21 (26.2 %)	10 (12.5 %)

students may no longer be following the course emails or even no longer have the same interest in participating.

The analysis of the responses presented in Table 6 for each dimension is presented below.

Dimension 1: Educational Resources For this dimension, three questions were applied. Regarding the students' perception of the **quality of educational resources**, 23 (77%) students strongly agreed and 7 (23%) agreed that the educational resources made available online are of sufficient quality. Although the term "quality" is vague and was not explicitly defined in the questionnaire, the fact that all students agreed indicates that educational resources met students' quality expectations. It was not the intention of this question to assess in detail all possible aspects of the quality of educational resources, but only to collect a subjective impression of students if quality expectations regarding the materials were met.

Regarding the **interactivity of the content** made available online, 19 (63%) students strongly agreed and 11 (37%) agree that the materials made available online have good interactivity. No students disagreed. As interactivity was focused on the adaptation of educational materials, especially using H5P, the responses indicate that the adaptation of the material brought enough interactivity to the ERL.

The learning support of the **activities** made available online were also evaluated, with 20 (67%) students strongly agreeing and 9 (30%) agreeing that the activities facilitated their learning. Only 1 (3%) student disagreed that the activities aided in learning. As most

Table 6: Perceptions of students regarding adaptation to the ERL

		Strongly Agree	Agree	Disagree	Strongly Disagree
Dimension 1	Quality of online resources	23	7	0	0
	Content Interactivity	19	11	0	0
	Activities	20	9	1	0
Dimension 2	Interactivity of synchronous classes	17	11	2	0
	Live classes complement online content	19	11	0	0
Dimension 3	Dedication	16	10	4	0
	Participation	9	14	7	0
	Adaptation to ERL	8	13	6	3

of the activities were already available online using VPL before the ERL and were complemented with other exercises, questionnaires etc., the results indicate that the addition of new activities apparently favoured learning in the participants' opinion.

Dimension 2: Live synchronous classes Two questions addressed this dimension. In the first, the **interactivity of the synchronous live classes** was also evaluated, with 17 (57%) agreeing strongly and 11 (36%) agreeing that the live classes were sufficiently interactive. Among the students, 2 (7%) disagreed about the interactivity of the classes. The questionnaire did not ask for details, but by observing the participation of students during classes, it is possible to say that much of the interactivity of live classes was provided by the use of interactive quizzes performed using the Kahoot tool (https://kahoot.com/).

Regarding whether **live classes complement online content**, 19 (63%) students strongly agreed and 11 (37%) agreed. No students disagreed. These responses indicate that the strategy of making content available online for the asynchronous class and the subsequent synchronous live class approaching the same content in a more practical way, seems to have pleased the participants.

Dimension 3: Self-assessment of student engagement In this dimension, students were asked to self-assess their engagement through three questions. A fourth question allowed students to detail the possible difficulties faced by students to participate in the ERL.

Regarding **personal dedication** to the course, 16 (54%) students strongly agreed and 10 (33%) agreed that they have dedicated to the course. However, 4 (13%) students disagreed. This indicates a good rate of personal dedication to the course of 87%, especially when it comes to an evening course.

About the **participation in the live classes**, 9 (30%) students strongly agreed and 14 (47%) agreed that they actively participated in the live classes. Among the participants, 7 (23%) disagreed that they had actively participated in live classes. As the term "actively" was not explicitly defined in the questionnaire, it is possible that some students interpreted this active participation as opening the camera, audio or participating in the chat. Our observation of student behaviour in live classes reinforces this suspicion, as most did not participate through audio or video.

About the **adaptation to the ERL** in general, 8 (27%) students strongly agreed and 13 (43%) agreed that they had a good adaptation to the ERL. However, 6 (20%) students disagreed and 3 (10%) students strongly disagreed regarding this personal adaptation to the ERL. Students indicated that the greatest difficulties in this adaptation were professional difficulties (13 - 43%), pointing out difficulties such as overwork, job searching or incompatible schedules; personal difficulties (10 - 30%), pointing to family difficulties, distractions, inadequate space for studies, and personal motivation, and; technical difficulties (4 - 13%), indicating difficulties such as internet instability, problems with laptop or mobile phone or electricity instability. The students were able to point out more than one difficulty.

It is possible to observe that, in general, the students' evaluation was quite positive in relation to the adaptation of the discipline to ERL. It is possible to highlight the evaluation of the online learning materials, the interactivity of the online content and the complementarity of synchronous and asynchronous contents. However, it is also possible to observe a large set of difficulties in the students' personal adaptation to the ERL. This came with no surprise, at a time of so many personal difficulties faced by everyone.

5.1 Hypothesis Validation

Using the same formula for calculating the final grade of the course, to compute the learning outcomes, we consider that each project is worth 40% of the final grade while the average of marks of practical activities is worth 20%. Using this measure, we computed the average final grades for both groups of students, the ones who did the course during FFL and during ERL.

As we noticed that the average of learning outcomes of students during FFL was 6.63 out of 10, while the average grades of students during the ERL was 6.54 out of 10, we decided to perform t-tests [10] to do a deeper analysis, in order to confirm or refute our initial hypothesis. Here we considered all samples for FFL and ERL and the following hypotheses:

- *Null hypothesis*: FFL and ERL have the same mean of learning outcomes,
- *Alternative hypothesis (H1)*: one mean is greater than the other.

By assuming a one-tailed test with a two-sample equal variance, and considering p = 0.05, we obtain a t-value of 0.36 > p, which indicates that the null hypothesis is confirmed and there is no significant difference between learning outcomes of FFL and ERL. These results reinforce the ones observed on Table 3, which show minimal differences on students' average grades in practical activities. In other words, there was no statistically significant negative impact on student learning outcomes.

It is difficult to clearly identify the reasons why students' outcomes have not changed significantly, given the multiple variables involved in such an unstable scenario as the COVID-19 pandemic. Such a rapid and radical shift from face-to-face learning to ERL was expected to have negative impacts over students' performance.

It is possible that the strategies adopted in this course migration to ERL contributed positively to this result, but many other changes were carried out by the entire university and by the students themselves which may have contributed to these results. Another aspect to take into account is that the Projects developed by students count much more in the final grade than other practical activities. As the Projects evaluation rubric remained the same and the grades had better results in the ERL, a possible reflection would be if the students applied more dedication to the Projects than before. Thus, deeper analyses, seeking the students' opinion through surveys and interviews, are necessary in order to expand these reflections and better identify the causes of these results.

5.2 Threats to Validity

Some threats to validity were observed in carrying out this research and strategies were adopted to mitigate their possible impact. In assessing impacts from the students' point of view, the questionnaires were applied at the end of the two ERL semesters. This can be a possible threat to the validity of these analyzes, since some students had already dropped out of the course, leading to a positive assessment trend, as students with the greatest difficulties in adapting, or who had not liked the content, were no longer enrolled. Another possible threat refers to the response rate of 37.5%, which, despite being relevant, may not adequately represent the opinion of non-responding students, since the sample was not randomized. To minimize these possible threats, we try to involve as many students as possible, carrying out assessments at the end of the last classes of each semester and sending messages to those who did not participate in those classes.

Another possible threat to validity refers to the possibility of generalizability of the research results regarding the sample size (only one subject, with the participation of 159 students) and the sample selection strategy. However, small sample sizes are expected in case studies, which typically are not that very generalizable. Furthermore, to minimize the impact of sample size, we tried to distribute students as best as possible, with 79 students from two different semesters with FFL and 80 students from two different semesters with ERL.

6 CONCLUSION

The impacts of the new coronavirus pandemic on education are possibly incalculable. Universities needed to migrate to Emergency Remote Teaching quickly, leading to several adaptations in teaching. This article presents the analysis of the ERL impacts on the learning outcomes of an Object-Oriented Programming course through a case study. We analyze the learning results of all students from three classes of this course before the beginning of the ERL and three classes after the ERL. From the analysis of these data, it is observed that there was no significant impact on the students' assessment results, rejecting the initial hypothesis.

However, although the adopted educational strategies seem to have contributed to the fact that the learning outcomes were not worse in the ERL, it is not possible to state that they were the only cause. It is expected, as future work, to study whether the return to in-person classes will have an impact on learning outcomes, maintaining the didactic strategies adopted to ERL.

REFERENCES

[1] Stephen Adam. 2006. An introduction to learning outcomes A consideration of the nature , function and position of learning outcomes in the creation of the European Higher Education Area.

[2] Michael K. Barbour, Randy LaBonte, Charles B. Hodges, Stephanie Moore, Barbara B. Lockee, Torrey Trust, Mark Aaron Bond, Phil Hill, and Kevin Kelly. 2020. Understanding pandemic pedagogy: differences between emergency remote, remote, and online teaching. In *State of the Nation: K-12 e-Learning in Canada.*

[3] L. Bickman and D. J. Rog. 1997. *Handbook of applied social research methods.* Thousand Oaks, Sage.

[4] J. A. Castro Filho, R. S. Freire, and D. L. Maia. 2021. Estudo de Caso como método de pesquisa em Informática na Educação. In *Metodologia de pesquisa científica em Informática na Educação: abordagem qualitativa*, E. O. Pimentel, M.; Santos (Ed.). SBC, Porto Alegre.

[5] Tom Crick, Cathryn Knight, Richard Watermeyer, and Janet Goodall. 2020. The Impact of COVID-19 and "Emergency Remote Teaching" on the UK Computer Science Education Community. In *United Kingdom Ireland Computing Education Research Conference.* (Glasgow, United Kingdom) *(UKICER '20).* Association for Computing Machinery, New York, NY, USA, 31–37.

[6] UFSC Universidade Federal de Santa Catarina. 2020. *Diagnóstico Institucional UFSC - Junho 2020.* https://coronavirus.paginas.ufsc.br/files/2020/06/15_06_20_DIAGNOSTICO_INSTITUCIONAL_1.pdf

[7] Yogesh Kumar Dwivedi, D. Laurie Hughes, Crispin Coombs, Ioanna Constantiou, Yanqing Duan, John S. Edwards, Babita Gupta, Banita Lal, Santosh Misra, Prakhar Prashant, Ramakrishnan Raman, Nripendra P. Rana, Sujeet Kumar Sharma, and Nitin Upadhyay. 2020. Impact of COVID-19 pandemic on information management research and practice: transforming education, work and life. *International Journal of Information Management.*

[8] Chuck Hodges and Denver Fowler. 2021. COVID-19 Crisis and Faculty Members in Higher Education: From Emergency Remote Teaching to Better Teaching through Reflection. *International Journal of Multidisciplinary Perspectives in Higher Education* 5, 1, 118–122.

[9] Santiago Iglesias-Pradas, Ángel Hernández-García, Julián Chaparro-Peláez, and José Luis Prieto. 2021. Emergency remote teaching and students' academic performance in higher education during the COVID-19 pandemic: A case study. *Computers in Human Behavior* 119, 106713.

[10] Edward H Livingston. 2004. Who was student and why do we care so much about his t-test? *The Journal of surgical research* 118, 1.

[11] WHO World Health Organization. [n.d.]. Rolling updates on coronavirus disease (CODIV-19). https://www.who.int/emergencies/diseases/novel-coronavirus-2019/events-as-they-happen Last accessed 18 October 2021.

[12] F. M. Reimers and A. Schleicher. 2020. A framework to guide an education response to the COVID-19 Pandemic of 2020. https://www.oecd-ilibrary.org/content/paper/6ae21003-en

[13] Mihaela Sabin, Karen H. Jin, and Adrienne Smith. 2021. Oral Exams in Shift to Remote Learning. In *Proceedings of the 52nd ACM Technical Symposium on Computer Science Education.* Association for Computing Machinery, New York, NY, USA, 666–672.

[14] Sidnei Renato Silveira, Cristiano Bertolini, Fábio José Parreira, Guilherme Bernardino da Cunha, and Nara Martini Bigolin. 2021. Impactos do Ensino Remoto na disciplina de paradigmas de programação durante o isolamento social devido à pandemia de COVID-19. *Revista Gestão E Desenvolvimento* 18, 2, 200–213.

[15] Simone Souza, João Choma Neto, Leo Paschoal, and Elis Hernandes. 2021. Ensino Remoto Emergencial de Engenharia de Software com PBL: um relato de experiência. In *Anais do XXIX Workshop sobre Educação em Computação.* SBC, Porto Alegre, RS, Brasil, 31–40.