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A comparison between flipped classroom, traditional, online and emergency response teaching in SARS COV2 Pandemic

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Abstract

In the last years, educational institutions all over the world has faced the need to give continuity to their academic activities while guaranteeing the compliance with health protocols required to control the SARS-COV-2 pandemic. Emergency Remote Teaching (ERT), has been the solution adopted by many institutions, changing the traditional classes to a synchronous videoconference scheme with the support of online learning platforms.

While ERT has been implemented as a temporary solution, from their application institutions can obtain valuable information about how to advance the digital transformation of the teaching and learning process after the pandemic ends. Some studies have found an increase in academic achievement in emergency remote teaching, partly explained by the combination of synchronous interaction with teachers and peers on videoconferences and chat rooms, and the benefits of asynchronous access to course materials that give the students the freedom to choose when to interact with the course material. Those findings suggests that further exploration of the benefits of this modality is needed. The evaluation of ERT characteristics and their comparison with traditional and blended models, may reveal insights about successful practices that can contribute to improve the learning experience and academic achievement of the students. In this study, we assess the learning experience of a sample of students from a first-year introductory programming course delivered using ERT modality using a validated learning experience instrument and analyze the data using factorial analysis to evaluate differences and similitudes on learning experience, academic achievement, and influence on first year student retention with similar courses delivered using other modalities.

Keywords

Flipped Classroom; Emergency Response Teaching; Learning Experience Assessment; Programming.

Introduction

Educational institutions all over the world has faced the need to give continuity to their academic activities while guaranteeing the compliance with health protocols and lock-downs required to control the SARS-COV-2 pandemic. The need to continue with teaching has been responsible that educational innovations with the potential to accelerate digital transformation in education, have an opportunity to be tested [1]. Emergency Remote Teaching (ERT) has been the solution adopted by many institutions [10], allowing to test the complete replacement of the traditional face to face lectures with a synchronous videoconference scheme with the support of online learning platforms.

One of the challenges of online learning is their applicability to the teaching of practical subjects in areas like engineering or medicine [1] [13], where many courses require laboratories to apply the knowledge in practical situations. In this study we analyze a programming course taught using emergency response teaching, to identify how this online modality affect the learning experience of the students with the purpose of identify features that could be helpful to the deployment of more effective online teaching practices on engineering from lessons learned during the pandemic.

The aim of this paper is to answer the following research questions:

- Which elements of student learning and motivation differ between an emergency remote teaching course and courses taught in online, flipped, and traditional modalities?
- Did emergency remote teaching influence student achievement or retention?

Methodology

Participants

The sample consisted of 197 students enrolled in a first-year introductory programming course taught using an implementation of emergency remote teaching (ERT) and 41 students of the same course but taught in a traditional online modality. The participation in the study was completely voluntary, representing a 14% of the 298 students enrolled in the online course and a 25% of the 798 students enrolled in the ERT course that semester.

To compliment the comparison of student experience, we used a dataset with the assessment of learning experience on an introductory programming class taught using traditional lecture based and flipped classroom methods, consisting of 620 students, with data gathered before the SARS COV-2 pandemic. Table 1 shows the composition of the sample.

Table 1: Composition of the sample

Modality	Sample Size (n)
Lecture based	211
Flipped	409
ERT	197
Online	41
Total	858

Procedure

To assess student experience, we used a modified version (Appendix, Table 6) of a previously validated learning experience assessment instrument [16] [17].

The introductory programming course subject of the study is an obligatory course for all first-year students of engineering programs at the university. When the social distancing measures made infeasible face to face classes, the university prepared for delivering courses using emergency remote teaching, selecting in-class activities that had proven to be useful to contribute to the learning of the students. These features were selected from modalities like flipped classroom because of their capacity to improve student satisfaction and learning of the students [14] [15] [4] [3] [16] and their blended nature, combining face-to-face with online learning activities.

Table 2 provides an overview of the activities included on each modality analyzed in the study. Face to face synchronous videoconference using the LMS Blackboard (https://www.blackboard.com) was used to deliver in-class activities to ERT and online students. The videoconference sessions were held twice a week for ERT students and once a month for online students.

Table 2: Activities in the courses included in the study.

Modality	Pre-class activities	In-class activities	Post-class activities
Lecture based	None	Concept Reviews Q/A Sessions Worked Examples Group Programming Assignments	Laboratory (each week) Three Graded Programming Assignments
Flipped	Videos with Lectures and	Concept Reviews	Laboratory (each week) Three Graded Programming

	worked examples. Closed-Ended Quizzes. Forum Participation.	Q/A Sessions Worked Examples Group Programming Assignments	Assignments Automatically graded online programming activities
ERT	None	Concept Reviews Q/A Sessions Worked Examples Group Programming Assignments	Two Graded Programming Assignments Automatically graded online programming activities
Online	Videos with Lectures Closed-Ended Quizzes Forum Participation	Concept Reviews Q/A Sessions Worked Examples	Two Graded Programming Assignments Automatically graded online programming activities

By the social distancing restrictions derived from the COVID-19 pandemic, ERT students had not face-to-face laboratory sessions, participating in more group programming assignments sessions on synchronic videoconferences instead. Flipped, Online and ERT courses used the opensource platform OpenEDX (https://open.edx.org/) to provide online automatically graded programming activities, using the python programming language.

Instruments and data collection

Data analysis was performed using python 3.7.9 using pandas, scipy, statsmodels, FactorAnalyzer and semopy [11] packages. The Kaiser-Meyer-Olkin was calculated to assess the adequacy of the data for exploratory factor analysis [9], obtaining a value of 0.86. Table 3 shows Cronbach's alpha values for each of the scales of the learning experience assessment instrument used for the study.

Table 3: Reliability of every dimension of the instrument.

Dimension	Cronbach's Alpha
Choice	0.88
Clear Goals	0.83
Challenge	0.79
Enjoyment	0.83
Peer Instruction	0.92

We conducted a confirmatory factor analysis using Structural Equation Modelling to validate factor structure of the assessment instrument, obtaining a model with a good fit (χ^2 (55) = 164.25, p=0.00; GFI=0.97, CFI=0.98, RMSEA=0.048). We extracted the factor scores for each of the dimensions evaluated and transformed them to T scores (0-100 range) for better interpretability.

Results

To answer the research question, which elements of student learning and motivation differ between an emergency remote teaching course and courses taught in online, flipped, and traditional modalities? the ERT group and control groups were compared doing ANOVAs on factor scores, and post-hoc Tukey tests when significant differences were found (Table 4).

Table 4: Comparison of mean factor scores for each modality.

	N	Clear Goals	Challenge	Peer Instruction	Enjoyment	Choice
ERT	197	48.77	50.02	48.70	48.98	47.11
Lecture	211	50.00	50.61	50.55	48.98	*49.94
Flipped	209	*51.41	50.57	51.00	*52.11	*52.54
Online	41	*41.77	*41.02	*43.38	*39.12	*38.83

In Table 4, significant differences (α=.05) with ERT modality are highlighted with *. We conducted ANOVAs to test for differences between each dimension of the learning experience instrument. The means of clear goals (p=0.001), challenge (p=0.001), peer instruction (p=0.0231), enjoyment (p=0.001) and choice (p=0.001) were significantly lower on each dimension for online learning compared with ERT. There was no difference between ERT and lecture-based learning except in the choice dimension, p=0.001. There were significant differences between flipped learning and ERT on clear goals (p=0.0019), enjoyment (p=0.003) and choice (p=0.001), but no differences were found on challenge (p=0.9) or peer instruction (p=0.071). We found a large correlation between choice and enjoyment, r=0.79, p<0.05, suggesting a relationship between these two variables.

To answer the research question: Did emergency remote teaching influence student achievement or retention? we collected the information of students admitted to the computer science engineering program of the university from years 2019 (before the pandemic) to 2021 (at the pandemic). Table 5 summarizes the GPA and academic status composition of each cohort.

Table 5: GPA and academic status of cohorts 2019, 2020 and 2021.

Cohort	N	GPA	Active	Temporary withdrawal	Definitive withdrawal
2019	111	5.08	85	7	19
2020	133	5.03	110	8	15
2021	161	5.19	141	5	15

To compare between cohorts, we conducted ANOVAs on GPA, and in academic status. There were no differences between cohorts, in GPA $F(2,402)=0.9928$, $p>0.05$, in active students $F(2,402)=2.8360$, $p>0.05$, and in withdrawal status, temporary $F(2,402)=0.9589$, $p>0.05$ or definitive $F(2,402)=1.9465$, $p>0.05$.

Discussion

The comparison of emergency remote teaching with lecture based, flipped and online modalities, shows that the learning experience of students was very similar to a traditional face-to-face modality with active learning. This result could be explained because the main change between the two modalities, in the case of our programming course, was the medium used to deliver the synchronic sessions. The significant difference in choice between ERT and face-to-face learning, could be explained by the lack of laboratory sessions in ERT, because of the social distance restrictions during the pandemic. Further studies are required to evaluate if the combination of synchronic videoconference sessions with face-to-face laboratories could improve learning experience or achievement at a level of the flipped classroom method, but without the costs of online course production. The lack of differences on learning experience between ERT and face-to-face teaching could explain that no differences were found on achievement or student retention among students of the different cohorts of the study.

Conclusions, Limitations and Future Work

In this study, we analyzed the influence of emergency remote teaching on learning experience, retention, and academic achievement. Concerning the research question: which elements of student learning and motivation differ between an emergency remote teaching course and courses taught in online, flipped, and traditional modalities? emergency remote teaching creates a learning experience very similar to face-to-face learning, better than the online delivery of the same course and below flipped classroom in terms of student experience. The enjoyment of ERT over online learning, could be explained by the preference for the inclusion of face-to-face interaction in online course delivery, in undergraduate and graduate students [2][6].

Concerning the research question: Did emergency remote teaching influence student achievement or retention? we did not find statistically significant differences between GPA or

retention between cohorts of students before or after the pandemic in our computing engineering program. Similar results had been obtained on higher education, for example, in achievement in economic courses [7]. The situation in schools is very different, where large achievement gaps are expected after the pandemic [5][12].

One of the principal limitations of the study is the small sample of online students, that reduces the generalizability of our conclusions about the performance of that modality. Our preliminary findings show that the implementation of emergency remote teaching did not affect the learning experience of the students and that their academic achievement at the end of the semester (represented by their GPA) were like students admitted before the pandemic. These results open an opportunity to further studies with the aim of evaluate the transition from face-to-face lectures to videoconference on some theory driven courses, preserving face to face interaction opportunities for active learning on laboratory sessions, that promote student learning and collaboration.

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Appendix:

Table 6: Learning Experience Assessment instrument.

Dimension	Question	
Choice	c1	I feel that the structure of the course allows me to choose the activities that I want to do to learn.
	c2	The course provides options for me to choose how I want to learn.
	c3	I have been able to choose the activities that I think will help me learn.
Clear Goals	f1	I am fully aware of what I must learn to pass this class.
	f2	I am fully aware of the activities that I must complete during the course to learn.
Challenge	b1	Understanding the content of this course is a challenge for me.
	b2	Applying the content of the course to develop a program is a challenge for me.
Enjoyment	e1	I have enjoyed the experience of taking this class.
	e2	I find it satisfying to apply what I have learnt in class to create my own programs.

	e3	One of my motivations for taking this class is seeing my programs work.
Peer Instruction	p1	I feel that the structure of the course allows me to interact with my peers and receive help from them.
	p2	I feel that the structure of the course favors a discussion and exchange of ideas with my peers.
	p3	I feel that the structure of the course allows me to learn from my peers.