The Impact of Emergency Remote Teaching on Students' Stress and Satisfaction in Project-Based Learning Experiences*

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COVID-19 has caused and continues to cause many changes in the way people around the world live. This study analyzes how COVID-19 and the adopted emergency remote teaching (ERT) methods have influenced university education, focusing on their impacts on project-based learning (PBL) methods. For this purpose, a comparative study is made between students' stress and satisfaction levels in a PBL course, before and during the COVID-19 pandemic. The results reveal that the emergency remote teaching methods do not necessarily affect the levels of stress and satisfaction of students, as compared to the usual face-to-face teaching, if adequate measures and monitoring are undertaken. Our results also show that, in face-to-face teaching, professors have a leading role for balancing the stress and satisfaction variables. However, in emergency remote teaching, students themselves assume a higher degree of responsibility for balancing such variables, which can constitute an interesting complement to other strategies for the promotion of soft skills.

Keywords: COVID-19; higher education; Project-Based Learning; workload stress; students' satisfaction

1. Introduction

According to the Organization of Economic Cooperation for Development (OECD), "the global spread of the COVID-19 pandemic severely affected higher education" [1]. The lockdown implied that higher education institutions (HEI) had to close their doors to students and academics, and distant online-supported teaching was established, with all its difficulties, to give continuity to ongoing courses, forcing institutions and professors to digitalize at high speeds, facing several challenges.

Although the direct relationship between HEI and technology, and previous experiences with elearning and b-learning methods have facilitated in many cases the transition to online education, the truth is that no institution based on face-to-face methods was prepared for such an abrupt change. More than conventional online education, planned from the beginning, the situation lived in most cases along 2020 can be seen as a shift to an emergency remote teaching (ERT) model. This has been reflected in many of the current publications which point out the challenges and lessons learned from this fast digitalization [2, 3]. Some research even focused on the stress the students might be suffering during lockdown [4–6]. In fact, the effects of COVID-19 on education have become a topic of interest in the research literature [7–11].

In the author's opinion, it is necessary to further analyze how the pandemic is influencing higher education, so as to incorporate into post-pandemic education the key learnings and most beneficial strategies and methods. To this end, this research compares the levels of stress and satisfaction of the students of the Bioengineering Design and Medtech course of two academic years, 2019/2020, with conventional face-to-face lessons, and 2020/2021, with online lessons, implemented as an emergency remote alternative. The statistical analysis of the results of both courses and their subsequent comparison leads to interesting results and can be useful in adopting the best aspects of each type of teaching methodology for project-based learning (PBL) courses.

For ease of reading, the article is structured as follows. It begins by providing an overview on how the pandemic situation is affecting higher education, especially in engineering, and analyzing why it is important to maintain a balance between stress and satisfaction in universities, an equilibrium that may have been affected by COVID-19. The next section shows how the research conducted, to which courses it is applied, and previous studies and methods inspiring it. Then, the results obtained in both situations, face-to-face ("pre-COVID-19") and emergency remote situations, are analyzed

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and compared. Finally, the conclusions thus obtained are presented, with the purpose of supporting future courses employing PBL methodology in similar ERT situations.

2. Literature Review

2.1 Education in Times of COVID-19

Online university education is becoming more and more available and is of special interest to professionals for lifelong learning purposes, to people living in remote places, and in low- and middleincome settings, and in general to anyone with limitations to attend face-to-face lessons. There are different types of advantages related to online education, such as lower operational costs, flexibility, and scalability of e-learning systems [12, 13]. Indeed, the massive open online courses (MOOCs) have proven to be a very attractive option for HEI [14]. However, this study deals with a special type of online education, adopted as an emergency alternative due to the 2019-2020 pandemic, normally without specific training or resources, which arguably has affected the stress levels of professors and students [5, 6, 15]. Therefore, in this study, online teaching and emergency remote education, are used as synonyms.

On most occasions, online teaching has been able to maintain practically the same scope, in terms of contents. However, university life brings students worldwide much more than just knowledge. University must be a source of networking and relationships, which have been dramatically limited by the pandemic and related educational methods. Furthermore, what began as a temporary solution for the 2019/2020 academic year, has been established as a norm for the 2020/2021 academic year in most universities around the world, which barely implemented any face-to-face courses. It seems necessary, as already suggested in the OECD report [1], to develop new strategies and techniques for online teaching-learning experiences that allow improved interaction.

In Spain, the study of Romero-Rodríguez et al. [3], in which 1544 university professors from different institutions took part, identified how to properly apply mobile devices to learning in higher education. Their results demonstrate that mobile learning is a useful method to develop active learning in exceptional situations.

In other countries, like Ecuador, social isolation was detected as one of the main problems during the lockdown between students, identifying that 16% of the students consulted had mental health scores that reflected depression [16].

Another challenge that this emergency online teaching has faced is linked to the inherent problems of remote assessment, with studies pointing to academic dishonesty as one of the most frequent problems in higher education in the Middle East [17].

Adaptation to the new situation of online education and blended learning is more than ever necessary, as Bolumole (2020) states, and professors need to adapt their pedagogies for online teaching, and students must deal with the lack of physical interaction [18].

The current pandemic has forced universities to adapt to online teaching at an extremely rapid pace. However, once this adaptation has been experienced and if all students count with some basic boundary conditions, such as home internet access, computer or even just a smartphone, universities may be well prepared for future emergencies even shift to online and blended learning strategies with benefits [12, 13]. In fact, the study of Bojović et al. (2020) [2] in Serbia shows that online teaching is more challenging for professors than for students, who are satisfied with the process.

2.2 The Balance Between Stress and Satisfaction in Higher Education Institutions

The increased stress and decreased satisfaction that online education can generate have already been reflected in some recent studies. For example, the work of Kee (2021) [19], through qualitative analysis, pointed to two main concerns in graduate students: the effectiveness of online teaching and the impossibility of seeing their colleagues in the classroom.

But beyond the stress caused by online teaching and, above all, by the situation of uncertainty that surrounds the world today, PBL places students on many occasions in a professional-like role that can cause stress, since working with engineering projects involves dealing with uncertainty and some degree of anxiety [20, 21]. In addition, the PBL format involves teamwork, which can also be a source of stress, as some studies have shown, even demonstrating that students feel more comfortable with individual assessment within the group [22].

Another reason for stress in contemporary education, especially mainly in master's degrees, is the large number of assignments for different courses that students have to complete. This usually is accompanied by the low satisfaction they feel, when they find that they have limited connection with the world of work [23].

Regarding stress' impact, some studies have demonstrated the negative effects of stress on students' academic performance [24], health, and even their behaviors [25]. From the satisfaction perspective, studies such as the one conducted by Karakas et al. (2015) [26], on the millennial generation, show that it is important to promote methodologies that (normally through challenges), boost motivation, creativity, and teamwork. PBL seems to fit this definition, probably it is only a matter of finding the right balance between stress and satisfaction levels. Precisely, one of the major generators of stress in adults is the imbalance between work and life [27], which has been widely studied in recent years in the field of healthcare [28, 29]. However, in the higher education environment only a few studies can be found [30, 31].

3. Method

The method consisted of the design and distribution of a questionnaire about stress and satisfaction to know the opinion of the master's students of the Bioengineering Design and Medtech course, in two different courses, 2019/2020 under a face-to-face model, and 2020/2021 under an emergency remote model.

It is necessary to mention that the Bioengineering Design and Medtech course is an eminently practical subject, in which work is done in teams. Seven teams were formed in the course 2019/2020, and six in the 2020/2021 course. In both academic years, the number of members in each team varies between six and eight. The teamwork follows a PBL methodology inspired by the Conceive-Desing-Implement-Operate (CDIO) model [32], particularized to the "Industriales-INGENIA initiative" [33]. Therefore, in principle, it could be greatly affected by the change to online learning. The Bioengineering Design and Medtech course is an annual course, with a total number of 28 sessions (14 in each semester), with a duration of 4 hours per session. The usual methodology during these sessions involves a first part is dedicated to a theoretical lecture by the professors, which is then addressed in practice by the teams, under the supervision of the professors. This was followed during the first semester of the 2019/2020 academic year. During the first semester of the 2020/2021 academic year, which was entirely virtual, two tutoring sessions with each team were held, outside scheduled class time, in order to have a better follow-up due to the circumstances.

It should also be noted that this course is taught in the first year of two master's degrees, which means that students of the 2020/2021 academic year do not know each other beforehand, and their first contact has been, in most cases, by computer means.

To be able to compare properly, this study uses a questionnaire to consult students at the same time of the course, just after finishing the first semester. The questionnaire had already been tested in the 2019/2020 academic year to find out the stress and satisfaction of the students [34].

The questionnaire had three sections. The first section was devoted to collect information about gender, country, current program, and previous formation. The second section was based on the level of agreement with the causes of the stress level. This section partially followed the items designed by Spielberger in his Job Stress Survey [35], adapting the stressors to the academic environment. The third section focused on satisfaction levels and was also measured through an agreement scale. This section was based on Kekana et al. (2007) [36] research on nurses' job satisfaction and was also adapted to the academic context. The description of the stress level variables (SS) and satisfaction level variables (ST) is shown in Table 1. The level of agreement in both variables was assessed by a 1-7 Likert-scale.

The number of students who responded during the 2019/2020 academic year was 18 out of a total of 44, while in the 2020/2021 academic year it was 40 out of 47. The main difference in the number of responses lies in the fact that in the 2019/2020 course the request was made during the holiday period, before exams, and the course 2020/2021 it was made during the last day of the course, leaving a specific time for this purpose.

The course has students from two different master's degrees, Industrial Engineering and Organizational Engineering. Table 2 shows the main characteristics of the sample.

The statistical analysis of the responses has been made with the R free software, including descriptive and correlation analysis.

4. Results and Discussion

4.1 General Analysis

Analyzing all the data for both years together, it can be seen in Table 3 that satisfaction throughout the course is much higher than stress, with total values of 5.1/7 and 2.1/7 respectively. Among the most satisfying factors are, with the same score (5.8/7), the fact that the students feel that their opinions are considered (ST17) and the good attitude of their teammates (ST18). This last variable is precisely the one that causes the least stress (SS7), with a minimum value of 1.1/7, thus proving the consistency of the responses. On the other hand, what causes the most stress is the assignment of new tasks that they are not used to facing (SS18), although its value is in the middle range of stress (3.6/7).

The low level of stress and the high level of satisfaction perceived by the students may result from several reasons, but perhaps the main one is the moment at which the analysis is carried out, at the end of the first semester in a one-year course. At

	Stress level variables		Satisfaction level variables
SS1	Team members not doing their job	ST1	Previous university studies
SS2	Inadequate support by professors	ST2	University contributing to my life
SS3	Insufficient team members to handle an assignment	ST3	Mission and vision of this university
SS4	Lack of recognition for good work	ST4	The opportunity to have a wide variety of topics
SS5	Frequent Interruptions in the course development	ST5	The workload of this Master's first year
SS6	Dealing with crises within the team	ST6	The workload of this course
SS7	Inappropriate behavior by my team colleagues	ST7	The help of the professors
SS8	Inappropriate behavior by professors	ST8	The help of the team colleagues
SS9	Poorly motivated other teams in the course	ST9	The sense of belonging to a team
SS10	Poorly motivated team colleagues	ST10	The materials/equipment available in the course
SS11	Lack of participation in the course decisions	ST11	The option of doing my favorite tasks in the team
SS12	Difficulty getting along with professors	ST12	The cooperation within the team
SS13	Assignment of disagreeable duties	ST13	The professional ethics perceived in the course
SS14	Inadequate quality equipment for doing the duties	ST14	The interest in the projects developed
SS15	Excessive paperwork of the assignments	ST15	The ability to improve the methods used
SS16	Very tight delivery times	ST16	The possibility to discuss the assignments
SS17	Assignment of increased responsibility	ST17	My opinion is considered
SS18	Assignment of new or unfamiliar duties	ST18	The attitudes of my team colleagues
SS19	Frequent changes in the assignments	ST19	The interaction with healthcare professionals
SS20	Periods of inactivity	ST20	The commitment to the quality in the course
SS21	Working overtime	ST21	Self-motivation for the good work
		ST22	The support of the professors
		ST23	The possibility of helping other colleagues

Table 1. Stress and satisfaction level variables

Table 2. Sample features

	Gender		Master		Country of previous studies			
Course	Male	Female	Industrial Engineering	Engineering Management	Spain	France	Perú	Italy
2019/2020	15	3	14	4	16	1	1	0
2020/2021	21	19	27	13	37	1	1	1

Table 3. Descriptive analysis

Stress level variables				Satisfaction level variables			
	Mean	Standard deviation	Median		Mean	Standard deviation	Median
SS1	1.6	1.06	1.0	ST1	5.1	1.3	5
SS2	1.8	0.96	2.0	ST2	4.8	1.2	5
SS3	1.9	1.10	2.0	ST3	4.1	1.3	4
SS4	1.5	0.78	1.0	ST4	5.4	1.5	6
SS5	2.1	1.17	2.0	ST5	3.6	1.8	4
SS6	1.4	0.68	1.0	ST6	4.3	1.2	4
SS7	1.1	0.44	1.0	ST7	5.2	1.6	6
SS8	1.2	0.59	1.0	ST8	5.7	1.4	6
SS9	1.9	0.99	2.0	ST9	5.4	1.4	6
SS10	2.1	1.16	2.0	ST10	4.5	1.5	5
SS11	2.2	1.17	2.0	ST11	5.2	1.3	5
SS12	1.5	0.71	1.0	ST12	5.7	1.2	6
SS13	2.3	1.52	2.0	ST13	5.6	1.3	6
SS14	2.3	1.42	2.0	ST14	5.2	1.6	5
SS15	2.5	1.71	2.0	ST15	5.0	1.4	5
SS16	2.4	1.48	2.0	ST16	5.1	1.4	5
SS17	2.3	1.33	2.0	ST17	5.8	1.3	6
SS18	3.6	1.84	4.0	ST18	5.8	1.3	6
SS19	2.3	1.48	2.0	ST19	4.6	1.6	5
SS20	2.5	1.52	2.0	ST20	5.2	1.3	5
SS21	3.0	1.86	2.5	ST21	5.5	1.3	6
Total	2.1			ST22	5.7	1.4	6
				ST23	5.2	1.4	5
				Total	5.1		



that time, they have not yet begun to make prototypes, which usually generates more stress, and a very creative and collaborative process has taken place, which students tend to like, confirming what research conducted by Karakas et al. (2015) [16] established about Millenials.

To identify whether there are differences in the perception of stress and satisfaction, according to gender, a gender analysis of the sample was carried out. The sample includes 36 men and 22 women. The results obtained show that the means for men and women are almost identical for both stress variables (2.1/7 for men and 2.0/7 for women) and satisfaction variables (5.1/7 for men and 5.2/7 for women). Moreover, no differences between the values obtained for the stress and satisfaction variables were found to be statistically significant. Unless otherwise indicated, in all contrasts we use in the text a significance level alpha equal to 0.05. Figs. 1 and 2 show the values obtained for men and women for the stress and satisfaction variables, respectively.

To conclude the general analysis, a study of the correlations between stress and satisfaction variables is carried out using Pearson's correlation coefficient. Fig. 3 shows that there is a positive correlation within the stress variables and within the satisfaction variables, and a negative correlation between the two variables, which confirms that the analysis used is consistent. Fig. 3 shows the

values of the correlation coefficients graphically with a color scale. The size and intensity of the color visually indicate the value of the coefficient. Red color corresponds to negative coefficients and blue to positive coefficients. The image is very useful to understand the structure of the correlation matrix, where the two blocks of questions can be seen in a differentiated way. The numerical values are not included to save space.

The correlation matrix shows the consistency of the results obtained, with the highest and statistically significant correlations being those between the stress caused by team members not doing their work (SS1) and the satisfaction produced by a good attitude of the team members (ST18) and cooperation (ST12). Similarly, the correlation between the stress of working with a poorly motivated team (SS19) and the satisfaction with the interest shown in the project developed is also very high and statistically significant, given that a motivated team will have a great interest in the success of its project. Finally, and also with very high and statistically significant values is the correlation between the stress produced by the lack of participation in decision making (SS11) and the satisfaction generated by the professionalism perceived in the course (ST13). It encourages students to feel part of the project, empowering them to make their own decisions, but accompanying them in the process.





Fig. 3. Correlation analysis.

4.2 Effects of the Emergency-remote Teaching

By comparing the 2019/2020 and 2020/2021 academic years at the same time, it is possible to assess the effects of emergency teaching on stress and satisfaction levels of students.

Starting with the stress variables, it is observed that, against all predictions, remote teaching did not cause the students more stress, but less, with the average stress during the face-to-face course being 2.4/7, compared to 1.9/7 during the emergencyremote course. It is possible that this can be explained precisely by the fact of being immersed in an environment of maximum uncertainty, which has led the students to relativize the stress that a subject can cause in their lives. Fig. 4 shows the values obtained in both courses for stress variables. Among the most significant differences, we can find SS5, SS6, SS8, SS9, SS10, SS11and SS20, being in all cases lower stress for the remote course. Because of these significant differences, it can be demonstrated that students who have undergone remote teaching can deal better with crises, interruptions, or periods of inactivity, and are also highly motivated to participate actively in the development of the course.

Analyzing now the satisfaction variables, the averages obtained are practically the same, 5.2/7 for the face-to-face course and 5.1/7 for the remote course. On this occasion, the only significant difference is found in variable ST19, on the satisfaction produced by interacting with professionals in the health sector. At this point, it should be noted that

while in the face-to-face course in the first semester there was the presence of health professionals in the classroom, in the 2020/2021 course, for scheduling reasons, the appointment was postponed to the second semester through an online round table, and therefore, at the time of this questionnaire, they had not yet had the opportunity to maintain this interaction. Fig. 5 shows the values obtained in both courses for the satisfaction variables.

According to the analysis performed, it could be said that, as already stated by Bojovic et al. (2020) [2] findings, students are satisfied with the emergency-remote teaching process, and there are hardly any differences concerning face-to-face teaching in the case of this course. This may be since this study is conducted after both students and professors have been using the emergency-remote teaching format for more than six months. This has allowed the professors to adapt their teaching methods to the situation, and the students to learn to interact virtually with each other. Bolumole (2020) [18] already pointed out both factors as necessary to achieve satisfactory processes.

The adaptation to the situation is probably the reason why the students are not already stressed by the remote teaching or by not being able to see their classmates, which according to Kee's studies (2021) [19] were the main concerns of the students in these online processes.

To explore the influence of stress variables and satisfaction variables in more detail a correlation analysis was also performed for each year sepa-







2019/2020 Face-to-face teaching		2020/2021 Emergency re	2020/2021 Emergency remote teaching					
	ST22		ST5	ST17	ST18			
SS11	-0.842**	SS1		-0.537**	-0.566**			
SS12	-0.860**	SS18	-0.515**					
		SS21	-0.500**					

Table 4. Higher correlations between stress (SS) and satisfaction (ST) variables

Note: ** means statistically significant at the 0.01 (bilateral) level.

rately, to see if there were differences between the variables that balanced stress and satisfaction depending on the type of teaching.

Table 4 shows that in the face-to-face year the correlations were higher and put the weight on the professors' support (ST22) to compensate for the stress involved in the initial interaction and decision making.

On the other hand, in the emergency-remote course, feeling valued and knowing that their opinion is taken into account (ST17), as well as the good attitude of the team members (ST18) have compensated for the stress caused by the fact that some colleagues were not fulfilling their assigned work (SS1). This has a considerable connection with the results of Backlund and Garvare (2019) [22], which pointed that teamwork can be a source of stress, but also of great satisfaction if the team works in coordination and harmony.

The correlation analysis also stands out that in the emergency-remote course they find that the tolerable workload of the master's degree (ST5), manages to compensate for the stress produced by facing new tasks in this subject (SS18) and the excess of work (SS21). This may be due precisely to the flexibility offered by having all the courses online. It should be noted that the professor plays a less prominent role in the emergency-remote model, with the team and the student's time management becoming more relevant.

5. Conclusions

The first finding is that the levels of stress and satisfaction have hardly changed in both years despite the different teaching methods. The second finding is that the influence of some factors in increasing satisfaction and decreasing stress has changed with the teaching methods. While in faceto-face teaching the figure of the professors gained special prominence, in online teaching it is the members of the team themselves who act to find the right balance.

The lessons learned from the exhaustive analysis

of the data in this research can be of great value in adopting the best aspects of each type of teaching methodology to PBL courses. It seems that giving the team a more central role and giving them confidence in their autonomy, while progressing on the role of professors as mentors and facilitators, can be the way forward, especially in master's degree courses.

Analyzing the stress and satisfaction of students during learning experiences is a key element to improve teaching methodologies. When the right knowledge, experience, and competencies of students are developed aligned with their satisfaction, without suffering too much demanding and stressing conditions, the quality of education consequently improves. The impact of learning activities affects students' aspirations, feelings, confidence, and lifelong learning attitude, necessary to build future better professionals.

In the authors' opinion, the study is innovative in a double way. On the one hand, it highlights the interest of measuring both stress and satisfaction, as a way for monitoring the evolution of engineering courses and for understanding how the innovations added to engineering courses or the change of boundary conditions affect students' emotions, which are clearly connected to their motivations and learning outcomes. On the other hand, although previous studies have dealt with students' stress and satisfaction in different programmes and courses, this study presents, to the authors' knowledge for the first time, a comparative situation before and after a dramatic event that has radically impacted the educational methods and environment.

Being true that the satisfaction levels are quite similar in both situations, authors' would like to stress that such maintained satisfaction levels have been enabled by a significant increase in professors' dedication (around a 25%-35% according to authors' measurements), which have led to some good practices including: (1) increasing the mentoring role and the synchronous presence, with at least three professors in the virtual classroom during all sessions of the course; (2) reducing the time dedicated to lectures and increasing dedication to tasks within working groups and role plays in the virtual sessions; (3) planning face-to-face virtual meetings with students' teams, doubling their frequency in the COVID-19 times, with respect to the original situation, among others. The sustainability of such extra efforts and the stress and satisfaction levels of professors will be analyzed in future studies, which will complement the presented findings for making them more universally applicable.

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