CIVIL ENGINEERING POSTGRADUATE STUDENTS' PERCEPTION ON SYNCHRONOUS VIRTUAL VERSUS FACE-TO-FACE TEACHING DURING COVID-19

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Abstract

This study examines the perception that postgraduate civil engineering students at the Universitat Politècnica de València have about virtual and face-to-face sessions. For this purpose, a nine-item Likert-scale questionnaire was used. Fifty-one students, representing more than 77% of those enrolled, answered the survey. They correspond to students of two master's degrees related to civil engineering in blended learning (virtual and face-to-face teaching simultaneously). The main result shows that slightly less than 69% of the respondents strongly agree or somewhat agree with the following statement: "With the information I have now, I would enroll again in this master's degree in blended mode." Only slightly more than 7.8% would strongly disagree or somewhat disagree with the following statement: "In the absence of a pandemic, I would like this master's degree to be offered in a blended mode in the future." From the multivariate analysis of the survey, it is clear that blended learning is here to stay even after the pandemic problem is resolved. Contributing to this is that a large proportion of the students are of Latin American origin, and this mixed modality facilitates their access to graduate studies. These results imply a future in-depth review of how master's education is delivered.

Keywords: Civil engineering, virtual teaching, COVID-19, Likert-scale, postgraduate education.

1 INTRODUCTION

Full-time traditional teaching in universities is usually focused on face-to-face teaching through lectures that complement the more practical classes. However, this way of teaching changed radically in just a few days, when the COVID-19 pandemic broke out. This situation brought about a change and opportunities in higher education. We attempt to analyze this paper focusing on the perception of blended learning by students of graduate courses related to civil engineering.

The population was confined in most European states because of the coronavirus pandemic in March 2020. The quarantine and containment measures adopted to mitigate the virus were in effect until May, when a gradual descaling occurred. In this short period, education changed abruptly to a virtual modality, as schools, colleges, and universities were no longer allowed access [1]. Subjects designed for face-to-face teaching required urgent modification and additional requirements. At the Universitat Politècnica de València (UPV), these new methods have focused on teaching through lectures and practical classes using the Microsoft Teams platform and recorded videos illustrating the subjects' contents. This rapid transition to virtual teaching occurred regardless of the preparation of teachers [2]. At the UPV, students began to attend theory and practical classes from their homes via online platforms. Student evaluations had to be done remotely, as this confinement lasted longer than desired. This situation has continued during the 2021-2022 academic year at the UPV. The teaching has been hybrid, with part of the students present and others following the class online synchronously or attending the recorded classes.

Virtual teaching has already been possible for some years, as described, for example, in the work of Singh and Thurman [3]. However, its application depends on institutions, degrees, and programs [4]. The learning achieved with this teaching modality involves a shift in learning efficacy that depends on many factors [5]. In engineering studies at the UPV, most of the subjects did not have virtual teaching implemented. Consequently, students, teachers, and infrastructures were not ready for this rapid transformation, as claimed in some studies [6]. Moreover, what seems evident is that this pandemic presents itself as an event that will have a structuring and lasting impact on university distance education [7].

Therefore, it is essential to know students' perceptions when managing the face-to-face to remote teaching transition. Several studies affirm that students willingly accept virtual learning, but it is not the same thing to freely choose this teaching modality as to apply it compulsorily [8], [9]. Another added aspect is that virtual teaching allows access to international students or others who want to combine

their work with the study of a postgraduate course. These circumstances are of vital importance, as it is possible that blended learning has been left behind in this type of university education related to civil engineering. In this professional field, we must not forget the importance of quality education in the employability of graduates [10].

Our research group lectures on subjects in the field of civil engineering and its management and has conducted numerous investigations in this area [11]-[14]. Our courses have two main parts: a theoretical part in which professors present the concepts of construction procedures and management of civil engineering works and a second part in which students solve practical problems. The theoretical and practical parts are graded to determine the evaluation at the end of the course. In addition, our teaching unit has another postgraduate course more closely connected with optimizing structures where the same methods have been implemented. These topics are directly involved in research in the field of optimization [15]-[18], multi-criteria decision-making [19], [20], and life cycle assessment [21], [22]. This study evaluates different issues related to virtual teaching in graduate civil engineering courses. For this purpose, an anonymous questionnaire was provided to undergraduate civil engineering students at the UPV.

The ultimate goal of the research was to test whether what had been a pandemic requirement, i.e., blended teaching, was an innovation that could be sustained in the future. This hybrid teaching-learning system model contributes to the continuation of the educational process in our universities. In addition, this model combines face-to-face and virtual modalities and adapts to the characteristics of each subject or teaching activity. This aspect is essential since the number of students enrolled in these post-degree courses increased with virtual teaching. This possibility would allow international students with difficulties to physically travel to our university and professionals who combine their work with their studies to attend our classes.

2 METHODOLOGY

The methodology of the present study consisted of a questionnaire based on a Likert scale to find out the students' opinions about the virtual or face-to-face teaching modality. After describing the questionnaire, the sample is characterized. The results are then examined using descriptive statistics and multivariate analysis.

2.1 Likert-scale questionnaire

A set of questions for the anonymous survey is prepared to know the undergraduate students' perception regarding the significance of critical thinking as transverse competence. The questionnaire consists of two parts: the first leads to characterize the population, by inquiry of the personal data of the individual (i.e., course inscription, sex, age, marks on the previous semester course, the second part queries 11 questions about the respondent's opinion regarding the significance of the critical thinking. The Likert scale used here is a five-point scale used for the individual to express to what extent he/she agrees or disagrees with a given statement. These are scaled-based answers 1 to 5 as described next: 1) strongly disagree, 2) disagree, 3) undecided, 4) agree, 5) strongly agree. Several studies systematically demonstrate that parametric statistics are robust concerning Likert scales [23]. The data mining and statistical analysis tool is SPSS 17. The variables are examined, and multivariate analysis is applied to interpret the results.

2.2 Characterization of the survey conducted

A non-probabilistic convenience sample was taken from the Master's Degree in Civil Engineering Planning and Management (MAPGIC) and the Master's Degree in Concrete Engineering (MUIH) students. MAPGIC aims to create a management knowledge base that will enable an analysis of infrastructure and utilities, accelerate adaptation to new environments, provide leadership and human resource management skills, and enable optimal decision-making in the construction industry. The primary purpose of the MUIH is to promote a thorough knowledge of concrete as a structural material and the expertise required for the design and analysis of concrete structures.

The sample comprises 51 participants representing more than 77% of those enrolled answered the survey. 49% of the participants belong to MUIH, 43% belong to MAPGIC, and the rest belong to other studies. The confidence interval is 95%, with p=q=0.5, which implies a sampling error of 13.7%, considering that the sample characterizes an infinite population. Additionally, Cronbach's alpha coefficient checks the reliability, a measure of internal consistency of the items' scale (P1 to P9). The value obtained is α=0.508, a moderately low value, although acceptable for a preliminary analysis.

However, if item P6 (face-to-face students learn more than those attending online classes) is eliminated from the questionnaire, the value obtained rises significantly to α=0.668.

60.8% of the students sampled are male. In terms of nationality, the vast majority were international students (mainly from Latin America); 21.6% of respondents were from Colombia, 19.6% from Peru, and 11.8% from Ecuador. Almost half (49%) of the respondents are between 25 and 30 years old. In addition, nearly half of the students surveyed work and study simultaneously, with only 37.3% studying for a master's degree full-time. It is also interesting to know the percentage of responses according to the education received by the students. Thus, 52.9% of students attend classes face-to-face, 35.3% attend classes synchronously, and 11.8% follow recorded classes.

3 RESULTS

This section provides the results obtained from the questionnaire. After descriptive statistical analysis, the means of the items were compared through ANOVA, and multivariate analysis was applied to the data for interpretation.

3.1 Descriptive statistical analysis

Table 1 shows the average and standard deviation values of each of the nine questions in the survey. It is noted that the greater the agreement with the issues raised, the minor disagreement there is between opinions. The issues with which respondents agreed most strongly are as follows: (P5) as a student, I have sufficient resources to follow the mixed-mode classes without any problem; (P9) in the absence of a pandemic, I would like to see this Master's degree taught on a blended basis in the future; and (P2) the resources made available by the university are sufficient to provide blended teaching. On the other hand, the items with higher variability are (P8) I would re-enroll in this Master's degree under blended learning with the information I have now, and (P6) face-to-face students learn more than those attending online classes.

Table 1. Mean and standard deviation of item responses.

No	*Item*	*Average*	*Stdev.*
P5	As a student, I have sufficient resources (my own or provided by the university) to follow the mixed-mode classes without any problem	4.55	.673
P9	In the absence of a pandemic, I would like to see this master's degree taught on a blended basis in the future	4.35	.996
P2	The resources made available by the university are sufficient to provide blended teaching	4.35	.996
P4	In general, the materials provided by the lecturers in all the subjects of the Master are suitable for blended teaching	4.31	.969
P3	In general, the Master's lecturers have adapted to blended teaching without any problems	3.92	.977
P1	I am following the classes without significant problems in this blended learning	3.90	1.063
P8	I would re-enroll in this master's degree under blended learning with the information I have now	3.88	1.478
P7	If it were possible and there was no pandemic, I would want teaching always to be face-to-face	3.55	1.189
P6	Face-to-face students learn more than those attending online classes	3.49	1.475

After the analysis of correlations of the questions, the strongest correlation (Pearson 0.628, with pairwise significance 0.000) corresponds to (P2) the resources made available by the university are sufficient to provide blended teaching with (P4) in general, the materials provided by the lecturers in all the subjects of the Master are suitable for blended teaching. Following, the subsequent strongest Pearson correlation, -0.459 (with pairwise significance 0.001), corresponds to (P6), face-to-face students learn more than those attending online classes with (P8) I would re-enroll in this master's degree under blended learning with the information I have now. Finally, the research question (P9) in the absence of a pandemic, I would like to see this Master's degree taught on a blended basis in the future has the

highest correlation with the item (P1) I am following the classes without significant problems in this blended learning (Pearson correlation 0.354, with pairwise significance at 0.011 level).

The fundamental research question of this survey was to ascertain the perceptions of current students regarding the permanence of blended teaching in the future (item P9). The response has been affirmative in a high percentage. Only four students (7.8%) would strongly disagree or somewhat disagree with item P9, as is shown in Fig. 1. On the other hand, the main result shows that 68.6% of the respondents strongly agree or somewhat agree with item P8: “With the information I have now, I would enroll again in this master's degree in blended mode." This result is exciting since it reaffirms the idea of maintaining mixed teaching in these postgraduate courses in the future.

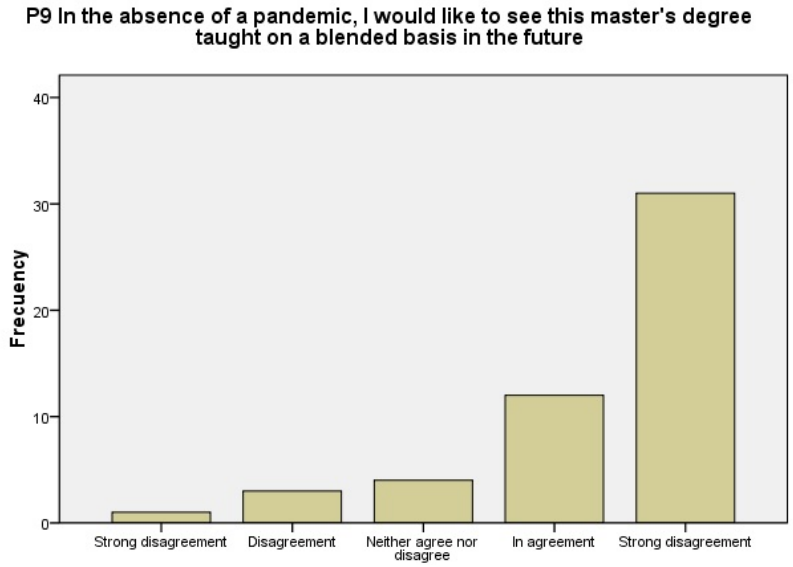

Figure 1. Histogram of frequencies for item P9.

3.2 Analysis of variance to compare multiple means

The analysis of variance (ANOVA) technique is the primary tool for studying the effect of one or more factors (each with two or more levels) on the mean of a continuous variable. It is, therefore, the statistical test to be used when one wishes to compare the means of two or more groups. The null hypothesis underlying the different types of ANOVA is that the mean of the variable under study is the same in the different groups, as opposed to the alternative hypothesis that at least two means differ significantly. ANOVA compares multiple means, but it does so by examining variances.

ANOVA computes the mean of each of the groups and compares the variance of these means against the mean within-group variance. Assuming the null hypothesis that the data for the different groups are all from the same population, the weighted between-group variance will be the same as the mean within-group variance. As the means of the groups move away from each other, the variance between the means will increase and move away from the mean within-group variance.

The objective of using ANOVA is to test whether there are significant differences concerning students who follow face-to-face classes versus those who follow online classes synchronously or asynchronously. The research question of interest is the one reflected in item P9 (In the absence of a pandemic, I would like to see this master's degree taught on a blended basis in the future).

According to Table 2, students agree or strongly agree that classes could be taught in a blended learning mode in the future. However, this opinion is slightly more pronounced in the case of students who receive classes synchronously and slightly less in the case of those who receive them asynchronously. However, there are no significant differences between the means, as shown in Table 3, where the significance of the ANOVA does not permit to discard the null hypothesis of equality of the means.

Table 2. ANOVA for item P9

Modality	*P9 In the absence of a pandemic, I would like to see this master's degree taught on a blended basis in the future*
Face-to-face learning	4.26
Synchronous virtual learning	4.56
Asynchronous virtual learning	4.17
Total	4.35

Table 3. ANOVA for item P9

	Source of variation	*Sum of squares*	*Degrees of freedom*	*Mean squares*	*F*	*Sig.*
P9 In the absence of a pandemic, I would like to see this master's degree taught on a blended basis in the future	Between	1.184	2	.592	.586	.560
	Within	48.463	48	1,010		
	Total	49.647	50			

The same analysis was carried out concerning the master's degree. No significant differences were found among the means, although MAPGIC students have a slightly more favorable opinion (4.45) than MUIH students (4.28). There are also no significant differences between students who study full-time (4.32) and those who study and work simultaneously (4.75). However, part-time students are more favorable to blended teaching. Interestingly, women are somewhat more favorable (4.45) than men (4.29), although without significant differences.

3.3 Application of multivariate data analysis

After analyzing the correlations, a factor analysis (FA) is performed using principal components to determine the variables explaining the configuration of correlations within the group of variables of the study. Ultimately, we seek to identify the 'constructs' or underlying variables that explain the observed variables. In addition, a multiple linear regression analysis will be performed to model the research question (P9) with the rest of the items.

3.3.1 Principal components analysis

Principal component analysis (PCA) is a multivariate method that analyses a data set in which several interrelated quantitative dependent variables describe observations. PCA reduces the dimension of an original group of variables to a new subgroup consisting of unobserved variables. Briefly, PCA computes factors that are a linear combination of the original variables and independent of each other. The PCA method thus allows the information provided by multiple variables to be "condensed" into a few components. Therefore, it is advantageous to apply before using other statistical techniques such as regression. We choose the first principal component to explain most of the possible variance of the original variables, and so on. Thus, no a priori dependence between the variables is assumed, so PCA is applied prior to multiple regression [24]. The correlations matrix is used instead of the covariance to avoid affecting the results' unit of measure. In this manner, the average value of the principal components is zero, and its standard deviation is 1.00. Furthermore, a criterion to identify the number of principal components is deemed (the eigenvalue of the PC is more significant than 1.00). Likewise, the Varimax method is used for ease of understanding, as it assumes an orthogonal rotation that minimizes the number of variables that present severe saturation in each factor [25].

Before extracting principal components (PC), each variable becomes explained 100% by itself. However, the principal components do not explain all the variability. Table 4 shows the proportion of each variable's variance that the factors can explain after the extraction, i.e., the communalities that measure the level of information available after such extraction. Item P7 is the one that best explains the model (if it were possible and there was no pandemic, I would want teaching always to be face-to-face). On the other hand, item P1 (I am following the classes without significant problems in this blended learning) explains less the model.

Table 4. Communalities.

No	Item	Extraction
P1	I am following the classes without significant problems in this blended learning	.463
P2	The resources made available by the university are sufficient to provide blended teaching	.577
P3	In general, the Master's lecturers have adapted to blended teaching without any problems	.587
P4	In general, the materials provided by the lecturers in all the subjects of the Master are suitable for blended teaching	.678
P5	As a student, I have sufficient resources (my own or provided by the university) to follow the mixed-mode classes without any problem	.553
P6	Face-to-face students learn more than those attending online classes	.678
P7	If it were possible and there was no pandemic, I would want teaching always to be face-to-face	.829
P8	I would re-enroll in this master's degree under blended learning with the information I have now	.694
P9	In the absence of a pandemic, I would like to see this master's degree taught on a blended basis in the future	.515

Table 4 shows that items P1 and P9 have a communality lower or close to 0.50. This low communality means that these items do not share relevant information concerning the rest of the variables. Therefore, we discard them in the PCA. With the exposed criteria, three underlying principal components explain 69.729% of the variance (Table 5) of the seven items of the survey. The components are associated with the following underlying features:

- Component 1: It is related to adapting lessons and teaching materials to blended learning.
- Component 2: It is concerned with the perception of blended learning and the willingness to re-enroll in blended learning.
- Component 3: It is linked to the willingness of face-to-face classes in the absence of the pandemic and the technological resources provided by the university to deliver blended learning.

It is worth mentioning that the first principal component explains the most variability in the data set. In this case, it seems that students have answered based on the availability of teaching materials and the means provided by the University. It should be taken into account that the UPV has made a great effort to ensure that the classrooms have quality audiovisual means to follow the distance classes and record these classes. In addition, professors have had to make an effort to provide material (notes, videos, or exercises) so that blended teaching is possible. These resources made available to students in virtual teaching have also benefited face-to-face students.

Table 5. Matrix of rotated components.

		Components		
No	Item	1	2	3
P2	The resources made available by the university are sufficient to provide blended teaching	,827		
P4	In general, the materials provided by the lecturers in all the subjects of the Master are suitable for blended teaching	,806		
P3	In general, the Master's lecturers have adapted to blended teaching without any problems	,737		
P6	Face-to-face students learn more than those attending online classes		-,853	
P8	I would re-enroll in this master's degree under blended learning with the information I have now		,781	
P7	If it were possible and there was no pandemic, I would want teaching always to be face-to-face			,872
P5	As a student, I have sufficient resources (my own or provided by the university) to follow the mixed-mode classes without any problem			,605
	Extraction method: Principal components analysis. Rotation method: Kaiser Varimax Normalisation. Values lower than 0.5 were removed.			

3.3.2 Multiple regression models

This section performs a multiple linear regression analysis to establish models that explain the chosen dependent variables. For this purpose, inferences are drawn on single or multiple linear models. The *R* coefficient quantitatively quantifies the variables' correlation levels. Linear models are adjusted by least squares so that the independent variables explain the dependent or response variables. The coefficient of determination R^2 assesses the fitness and is calculated as the fraction of the variation in the response variables that the linear regression model explains [26].

First, an adjustment is made to explain each response variable in its most correlated explanatory variable. The purpose is to increase *R* by adding independent explanatory variables. To do so, the stepwise method introduces the variables together and checks whether each of them remains or drops out of the model. A significant increase in explained variance to 5% (*F*=0.050) is considered an inclusion criterion, while a 10% drop (*F*=0.100) is taken to exclude a variable. The first variable to be included is the highest *R*. All correlations are recalculated by removing the effect of the variable in the model. Then, the following variable with the highest *R* is entered into the model to obtain the independent variables that enter the model.

The first thing that can be observed from the different regression models is that, although there are correlations between different items, the linear models obtained explain little of the variability of the response variables. Thus, for example, the research question, summarised in item P9, can only very slightly explain (10.8%) the variability with item P1 (Table 6). Note that both items had meager communality. It can be interpreted that students following the classes without problems could explain the willingness to re-enroll in the same postgraduate course in the absence of a pandemic.

The explanation (variability explained by 25.3%) for students re-enrolling in this master's degree with blended learning is that they do not believe that face-to-face students learn more than those who attend non-face-to-face classes and have sufficient resources to follow blended classes (Table 7).

These results imply the need to delve deeper into the causes that explain the students' favorable opinion of blended learning. It is possible that, should the circumstances of the pandemic change, the results could change. Therefore, this study should be considered preliminary and should be continued in successive courses to verify the students' opinions.

Table 6. Multiple regression models. Response variables: P9 In the absence of a pandemic, I would like to see this master's degree taught on a blended basis in the future.

Model		***Coef.***	***Revised R^2***
1	(Constant)	3.057	.108
	P1 I am following the classes without significant problems in this mixed model	.332	

Table 7. Multiple regression models. Response variables: P8 I would re-enroll in this master's degree under blended learning with the information I have now.

Model		***Coef.***	***Revised R^2***
1	(Constant)	5.489	.195
	P6 Face-to-face students learn more than those attending online classes	-.460	
2	(Constant)	2.658	.253
	P6 Face-to-face students learn more than those attending online classes	-.424	
	As a student, I have sufficient resources (my own or provided by the university) to follow the mixed-mode classes without any problem	.594	

4 CONCLUSIONS

The present work has tried to find civil engineering post-degree students' opinions about hybrid face-to-face and virtual teaching. The aim is to determine the feasibility of continuing with this type of mixed teaching in the future to facilitate access to international students and professionals who wish to combine work and studies. For this purpose, a questionnaire was developed based on a five-point Likert scale. Fifty-one students, mainly from Latin America, responded to the survey. The students' assessment of

the hybrid teaching was very high. In general, the average opinion of the students does not show significant differences, although MAPGIC students have a slightly more favorable opinion (4.45) than MUIH students (4.28). There are also no significant differences between students who study full-time (4.32) and those who study and work simultaneously (4.75). However, part-time students are more favorable to blended teaching. Interestingly, women are somewhat more favorable (4.45) than men (4.29), although without significant differences. The general perception is that they have sufficient resources to follow the mixed classes. In addition, in the absence of a pandemic, they would like to see graduate courses taught in hybrid mode. However, even though no significant differences between the means were detected, students who follow virtual classes synchronously perceive the benefits of mixed classes to a greater extent than those who follow them asynchronously. Only four students (7.8%) strongly disagree or somewhat disagree with this perception.

Multiple regression models explain a low percentage of the variability in the data. Nevertheless, they point out that students following classes without problems could explain their willingness to re-enroll in the same graduate course in the absence of a pandemic. In addition, the multivariate regression explains that students re-enroll in this master's degree with blended learning because they do not believe that face-to-face students learn more than those who attend non-face-to-face classes and have sufficient resources to follow the blended classes.

The above data indicate the excellent prospects that university graduate courses have for maintaining mixed face-to-face and distance teaching in the future. This possibility would allow international students and those who combine work with their studies to attend these postgraduate courses. However, this work should be considered preliminary. As future lines of research, it is proposed to improve the questionnaire to increase its reliability and survey other students in other university contexts to check whether the observed trends can be extrapolated and are maintained over time. This unexpected COVID-19 consequence allows us to find future opportunities based on new technologies and the adaptation of professors and students to new teaching and learning methods.

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