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Face-to-Face or Online Learning in Applied Statistics in Health Sciences? Failed Experiment or Opportunity after COVID-19?

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Abstract: The rapid spread of the COVID-19 worldwide led to the migration of the traditional education system based on the face-to-face classroom into an improvised online system, among many other preventive measures. Thus, all teaching methods had to be adapted to this new modality. This work is aimed at studying the viability of the online teaching of the subject of Applied Statistics in Health Sciences in higher education based on the teaching experience lived during COVID-19. In addition to this, possible technological difficulties and COVID-19-derived problems were investigated. A retrospective observational cross-sectional study was performed to analyze the students' satisfaction according to the teaching methodologies in both face-to-face and online modalities. An exploratory and inferential analysis revealed that online teaching is feasible for the subject under study, although face-to-face learning still continues to significantly revert in favor of the quality of teaching. Therefore, further research is required to develop new online teaching methods given the feasibility of the proposal found in this research. Most of the students reported not having technological learning difficulties, whether related to their connectivity or technological resources, which did not have a significative impact on their teaching perception. Despite the psychological sequalae of COVID-19, this did not affect the students' teaching satisfaction.

Keywords: teaching methodologies; face-to-face teaching; online teaching; COVID-19; learning difficulties; statistics teaching; remote evaluation

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1. Introduction

Statistics is a field of knowledge which mainly comprises the collection, analysis, and interpretation of data. All evidence-based research needs to use its tools to obtain rigorous results on the raised research questions. Thus, Statistics is the basis of the scientific method and, consequently, it is the reason for being included in the study plans comprising all science degrees, whether exact, social, or health sciences in higher education. In particular, Statistics plays a crucial role in research planning and decision-making in the health sciences [1]. Among many other applications, it includes understanding the risk factors for communities, tracking and monitoring diseases, witnessing the impact of policy changes, and assessing the quality and safety of health care according to the National Library of Medicine [2]. This work focuses on the subject of Applied Statistics in Health Sciences which is part of the Nursing degree curriculum, as established in [3]. This subject takes place in the second semester of the first course of the nursing degree according to the study plan.

Following Greenberg [4], distance learning is defined as "a planned teaching/learning experience that uses a wide spectrum of technologies to reach learners at a distance and

is designed to encourage learner interaction and certification of learning". In this work, distance learning will be indifferently named virtual learning, online learning, or e-learning. Nowadays, there is a growing interest in distance education due to the numerous advantages that it offers. Among others, they highlight the fact that university education can be acceded at one's convenience at your own pace via the internet and the World Wide Web [5] and the possibility of offering educational opportunities to many people who would otherwise be excluded from the traditional higher education system [6]. Nevertheless, the so-named theory of online learning has been both celebrated and condemned in educational practice and research [7]. Motivated to clarify this issue, the main research question set out in this paper is whether it is feasible the online teaching of the subject of Applied Statistics in Health Sciences based on students' perception. Critics of online learning theory stated that too strict adherence to any theoretical viewpoint often filters our perceptions and thus blind us to important lessons of reality [8]. Thus, the present research aims to answer the previous research question by comparing teaching methodologies in the traditional face-to-face and emerging online modalities based on the teaching experience lived during the COVID-19 pandemic.

COVID-19 was declared a global public health emergency on 30 January 2020 and was later declared as a pandemic on 11 March 2020 by the World Health Organization [9]. Consequently, the Spanish population was confined to their homes without the possibility of leaving them except for exceptional reasons of force majeure [10]. This situation was extended until May, when the so-called "de-escalation" began which, although it allowed a progressive slow return to normality, it prevented the return to classrooms for the rest of the academic year. Among other precautions, the transition from face-to-face conservative teaching learning methods to remote instruction through online and hybrid learning was a major leap that the education sector took [11].

1.1. Learning Difficulties

In addition to the challenge of a rapid migration to the online learning system, other conditioning factors for student satisfaction must be considered for a fair comparison of the learning methods. Some pre-COVID-19 studies were aimed at analyzing the influence of the teacher on student satisfaction [12,13] or their personal preferences regarding the subject itself [14,15]. They could be classified as ''subjective" covariates influencing the student opinion, which are not the focus of this research. Others instead adopted a more economical approach, analyzing the interaction between student satisfaction and the information technology (IT) infrastructure that they had for monitoring online classes [16]. Since students did not have time to make a planned supply of IT infrastructures after the sudden outbreak of the pandemic, the secondary objectives of this research are to analyze the association between both technological resources and internet connectivity and student satisfaction. On the other hand, many works were dedicated to investigating the impact of COVID-19 on the psychological wellbeing (see [17,18]). Some of them were focused on higher education [19] and particularly on the nursing degree [20]. Therefore, it was also investigated whether the degree of the psychological impact of the pandemic affected in any way the students' perception.

1.2. Literature Review

Although there is a vast literature devoted to virtual learning which has experienced a substantial increase after the COVID-19 pandemic, few studies have focused on analyzing the virtual learning of the subject of Statistics. Most of these studies were performed before the outbreak of COVID-19 and were devoted to analyzing virtual learning environments (VLEs) mainly using a software as a complement to teaching [21–26] or as an enabling technology for Official Statistics [27]. The only existing work, as far as the authors' knowledge, focused on the impact of COVID-19 on the teaching of Statistics in higher education was conducted by Vega-Hernández et al. [28]. Nevertheless, it was stated from the teachers' point of view so that it is more oriented to their fast technological adaptation to learning and

their concern about virtual assessment fraud rather than the degree of student satisfaction. Leaving aside the field of Statistics, there are many teaching experiences reported after the outbreak of COVID-19 from other areas of higher education. It is noteworthy that there is no consensus regarding the efficiency of online teaching. Ramos-Pla et al. hold that online learning strategies in education faculties were successful, and some of them should be incorporated in face-to-face learning [29]. On the other hand, the authors analyzing online learning in engineering, technology, business management, and communication disciplines maintain that there is a pessimistic perception towards the transition to the completely online setting despite finding a significant student engagement in learning [11].

1.3. Objectives of the Study

Under this framework, the main objective of this work is to analyze the viability of online teaching in the subject of Applied Statistic in Health Sciences through the teaching experience lived during COVID-19. Particularly, we focused on: (i) comparing face-to-face and online teaching methodologies from the students' perspective; (ii) identifying the technological difficulties of e-learning; (iii) analyzing the psychological impact of COVID-19 on e-learning; and (iv) determining the students' satisfaction regarding distance evaluation.

2. Materials and Methods

2.1. Sampling and Instrumentation

A retrospective observational cross-sectional study was performed to analyze the viability of online learning in the subject of Applied Statistics in Health Sciences. The data were collected from 128 nursing students from the Faculty of Physiotherapy and Nursing of the University of Castilla-La Mancha (Toledo, Spain). The data were gathered in 2020 when the COVID-19 pandemic settled in Spain, causing a general confinement and forcing online teaching in the middle of the semester (see Figure 1). In particular, responses were collected from the 1st to 15th of June 2020 after having finished the final evaluation test of the ordinary call. The temporal sequence of the contents divided into units for the second semester of the academic course of 2019/2020 are also depicted in Figure 1. It is important to mention that all the units are independent without involving some of them more difficulty than others so that a fair comparison of teaching methodologies is possible. The inclusion criteria were: (1) to be enrolled in the subject of Applied Statistics in Health Science in the academic course of 2019/2020 (2) to have taken the subject in both modalities, face-to-face and online modalities, and (3) being willing to participate in the study and signed an informed consent form. The exclusion criteria were (1) not having attended classes regularly (at least once a week) and (2) not having attended classes in any of the modalities, face-to-face or online one.

January							
N	M	Tu	W	Th	F	Sa	Su
1			1	2	3	4	5
2	6	7	8	9	10	11	12
3	13	14	15	16	17	18	19
4	20	21	22	23	24	25	26
5	27^{0}	28^{0}	29^{0}	30^{0}	31^{0}		

February							
N	M	Tu	W	Th	F	Sa	Su
5						1^{0}	2^{0}
6	3^{1}	4^{1}	5^{1}	6^{1}	7^{1}	8^{1}	9^{1}
7	10^{1}	11^{1}	12^{1}	13^{1}	14^{1}	15^{1}	16^{1}
8	17^{1}	18^{1}	19^{1}	20^{1}	21^{1}	22^{1}	23^{1}
9	24^{2}	25^{2}	26^{2}	27^{2}	28^{2}	29^{2}	1^{2}

March							
N	M	Tu	W	Th	F	Sa	Su
10	2^{2}	3^{2}	4^{2}	5^{2}	6^{2}	7^{2}	8^{2}
11	9^{2}	10^{2}	11^{2}	12^{2}	13^{2}	14^{2}	15^{2}
12	16^{3}	17^{3}	18^{3}	19^{3}	20^{3}	21^{3}	22^{3}
13	23^{3}	24^{3}	25^{3}	26^{3}	27^{3}	28^{3}	29^{3}
14	30^{3}	31^{3}					

April							
N	M	Tu	W	Th	F	Sa	Su
14			1^{3}	2^{3}	3^{3}	4	5
15	6	7	8	9	10	11	12
16	13	14^{4}	15^{4}	16^{4}	17^{4}	18^{4}	19^{4}
17	20^{4}	21^{4}	22^{4}	23^{4}	24^{4}	25^{4}	26^{4}
18	27^{4}	28^{4}	29^{4}	30^{4}			

May							
N	M	Tu	W	Th	F	Sa	Su
18					1^{4}	2^{4}	3^{4}
19	4^{5}	5^{5}	6^{5}	7^{5}	8^{5}	9^{5}	10^{5}
20	11^{5}	12^{5}	13^{5}	14^{5}	15	16	17
21	18	19	20	21	22	23	24
22	25	26	27	28	29	30	31

June							
N	M	Tu	W	Th	F	Sa	Su
23	1	2	3	4	5	6	7
24	8	9	10	11	12	13	14
25	15	16	17	18	19	20	21
26	22	23	24	25	26	27	28
27	29	30					

Face-to-face teaching | Online teaching | Final exam (Ordinary call) | Data collection

Superscripts are referred to the unit of contents: [0] Introduction to biostatistics, [1] Descriptive statistic, [2] Probability and ROC curve, [3] Inferential statistic, [4] Relation/Association measures between variables, and [5] Linear Regression

Figure 1. Second semester of 2019/2020 calendar and temporalization of teaching modalities.

The data were collected through a self-administered anonymous online questionnaire. The used instrument was self-developed since, as far as the authors' knowledge, there is not a validated instrument in the literature to compare the face-to-face and virtual teaching methodologies and, at the same time, to collect some aspects of the extraordinary circumstances of COVID-19 at the time of the administration of the questionnaire. Table 1 collects the structure of the questionnaire, the questions, and the way in which the responses were operationalized. The questions asked in the questionnaire were divided into five blocks: (1) socio-demographic features, (2) evaluation of learning methodologies (face-to-face and virtual modality) and assessment of the subject, (3) learning difficulties due to information and communication technologies (ICTs), (4) the psychological impact of COVID-19, and (5) the assessment of the online evaluation. In block 2, all the methodologies were scored through a five-point Likert-type scale, which corresponded to a 1 = very poor, 2 = poor, 3 = normal, 4 = good, and 5 = excellent degree of satisfaction. A score of 0 was used for no answer/do not know responses. The remaining questions were qualitative response questions. Two constructs were measured through a Liker-type scale: 1. student satisfaction in face-to-face teaching and 2. student satisfaction in online teaching. Both scales are divided into two dimensions according to (a) the satisfaction relative to teaching methodologies (items 1–4, see Table 1) and (b) the satisfaction relative to the general aspects of the subject (items 5–7, see Table 1). A reliability analysis was conducted to analyze the internal consistency of both scales. The student satisfaction scales reported a Cronbach's alpha of 0.824 and 0.906 for the face-to-face and online teaching, respectively. Subscales (a) and (b) obtained a Cronbach's alpha of 0.738 and 0.710 for the face-to-face teaching scale, while they were 0.858 and 0.798 in the case of the online teaching scale. Since the values of this coefficient higher than 0.7 are considered acceptable [30], we can trust the psychometric properties of the scale used.

Table 1. Outline of the questionnaire.

	Block 1. Socio-Demographic Features
1.	Age
2.	Gender *(male, female)*
3.	Grade *(1, 2, 3, 4)*
4.	Residence before COVID-19 *(university residence, shared apartment, alone in an apartment, parents' residence, others).*
5.	Residence during COVID-19 *(university residence, shared apartment, alone in an apartment, parents' residence, others).*
	Block 2. Evaluation of learning methodologies and assessment of the subject
1.	Satisfaction degree *(1–5)* [1] about the face-to-face teaching: 1. magistral lessons, 2. practical classes, 3. computer classes, 4. tutorials, 5. follow-up, 6. timing, 7. overall.
2.	Satisfaction degree *(1–5)* [1] about the online teaching: 1. magistral lessons, 2. practical classes, 3. computer classes, 4. tutorials, 5. follow-up, 6. timing, 7. overall.
	Block 3. Learning difficulties due to ICTs
1.	Sufficient technological resources *(yes, no).*
2.	Sufficient internet connection *(yes, no).*
3.	Type of internet connection *(optical fiber, ADSL, mobile connection).*
	Block 4. Psychological impact of the COVID-19
1.	Psychological affectation *(nothing, something, severe).*
	Block 5. Assessment of the online evaluation
1.	Satisfied with the online evaluation *(yes, no).*

[1] five-point Likert-type scale: 1 = very poor, 2 = poor, 3 = normal, 4 = good and 5 = excellent degree of satisfaction.

2.2. Demograpich Features

Table 2 shows the socio-demographic variables of the sample. The final sample was integrated by 128 respondents comprising 75.7% of the students enrolled in the 2019/2020 academic year, which implies a high percentage of the response. The vast majority of the students were taking the course for the first time (90.6%). The average age was 19.5 years and 79% of the sample were female. One of the most important features of the present work is to analyze the interaction between the factors related to new technologies and others derived from COVID-19 and distance learning. In this regard, 75.8% of the students revealed to have sufficient technological resources to follow up on classes and 74.2% exhibited to have a sufficient internet connection for the same purpose. Approximately two in three students reported being somewhat psychologically affected by the COVID-19 pandemic, while 22.7% of them considered to be severely affected, and 8.6% were not affected at all. It is noteworthy that significative differences were found in the frequency distribution regarding the place of residence before and during the COVID-19 pandemic. In particular, living in their parental residence experienced an increase of 56.2% during the COVID-19 pandemic.

Table 2. Description of socio-demographic variables of the sample [1].

Variables	Statistics
Age Mean (*SD*)	19.5 (±2.7)
Gender	
Male	26 (20.3%)
Female	102 (79.3%)
Grade	
1	116 (90.6%)
2	8 (6.3%)
3	2 (1.6%)
4	2 (1.6%)
Sufficient technological resources	
Yes	97 (75.8%)
No	31 (24.2%)
Sufficient internet connection	
Yes	95 (74.2%)
No	33 (25.8%)
Type of internet connection	
Optical fiber	79 (61.7%)
ADSL	42 (32.8%)
Mobile connection	7 (5.5%)
Psychological affectation	
Nothing	11 (8.6%)
Something	88 (68.8%)
Severe	29 (22.7%)
Residence before COVID-19	
University residence	23 (18%)
Shared apartment	58 (45.3%)
Alone, in an apartment	2 (1.6%)
Parents' residence	43 (33.6%)
Others	2 (1.6%)
Residence during COVID-19	
University residence	0 (0%)
Shared apartment	4 (3.1%)
Alone, in an apartment	4 (3.1%)
Parents' residence	115 (89.8%)
Others	5 (3.9%)

[1] Categorical variables are reported by *n* (%), whereas numerical variables are reported by $\overline{x}$ ($\pm SD$)

2.3. Statistical Analysis

A descriptive and inferential analysis was performed to address the objectives of the present research. The Wilcoxon signed-rank test was used to determine the existence (or absence) of significant differences between the face-to-face and online median level of satisfaction. In order to find the possible associations between the methodology scores and the learning difficulties, whether technological or derived from the COVID-19 pandemic, Cramer's V test was applied for each pair of categorical variables. The significance level was set to 0.05 for all the statistical hypothesis tests. The IBM SPSS Statistics v. 28 software (Statistical Package for Social Science) was selected to perform the data processing and analysis. Wilcox_effsize function belonging to the rstatix R package was used to measure the effect size when there are significant differences between both modalities of teaching methodologies.

2.4. Description of the Learning Methodologies and Other Aspects of the Subject's Assessment

Four learning methods were used in this course to achieve the learning outcomes: magistral lessons, practical classes, computer practices, and tutorials. All these methodologies were migrated to the online modality when the lockdown started by using the ICTs similarly to the first virtual experiences [31]. The virtual platform used for online asynchronous learning was Moodle [32] to provide learning materials and general announcements. Microsoft Teams [33] was selected to deliver the course in real-time (the synchronous method), ensuring interactions between the students and their learning facilitators or instructors continued [34]. These were the virtual supports given by the institution. The teaching methodologies used in both versions, face-to-face and online, will be briefly described below.

2.4.1. Magistral Lessons

This is the most traditional teaching method in which the teacher conducts an expository lesson supported by some teaching material being, in the case of this course, a presentation with slides. In these classes, it is a mainly exposed theoretical content with some illustrative examples given the applied nature of the subject. The participation and interaction with students are not allowed except to ask questions. In the face-to-face modality, these classes were performed in a traditional classroom equipped with a projector to present the slides, whereas sharing the presentation from teacher's screen was the method used in the online version. In addition to this latter, the teacher was seen by students live by image and voice.

2.4.2. Practical Classes

This kind of methodology comprises two phases: (i) students are asked to solve themselves a set of study-case problems prior to class, and (ii) only those exercises in which they faced a greater difficulty or doubts are corrected and explained in class. The first phase of this methodology is independent of the teaching modality. In face-to-face classes, study-case problems are projected in class and some arguments are clarified using a traditional physical backboard, whereas they are supported in a virtual board in the online modality. This latter comprises the difficulties of writing mathematical notation and, if feasible, it is very time consuming to write.

2.4.3. Computer Classes

This is probably the methodology that experienced more severe changes when moving to the online modality. In these classes, a set of real data-based problems are stated that students must solve using the statistical software IBM SPSS Statistics v.28. In traditional face-to-face classes, the proposed problems are solved in situ and projected in class at the same time as the students reproduce the steps on their personal laptops or using classroom computers. We thought that it was unlikely that students would be able to properly follow such a class online, since they would need one computer to follow the teacher's explanation

and another one to reproduce the exercises (we thought that it was not feasible to properly visualize both on the same screen). Thus, in the online modality, practice manuals were provided in which the problem resolution was detailed step-by-step (using screenshots). This methodology changed, therefore, from being synchronous to asynchronous, this being a substantial change. In order to reinforce the asynchronous modality, the teacher was connected during the classes so that he/she could assist with any arisen doubt.

2.4.4. Tutorials

These are not regulated classes, but are agreed upon request by the students. They are particular sessions in which one or more students meet with the teacher to expose any arisen doubts or to reinforce the unclear parts of the subject. They took place in person in the professor's office in the face-to-face modality, whereas the meetings were virtual in the online modality. In both cases, the methodology consisted in a personal interview.

2.4.5. Other Aspects of the Subject's Assessment

In addition to know the degree of the students' satisfaction regarding the teaching methodologies, the general perception of the subject, the timing of the contents, and the follow-up of the subject are fundamental aspects for obtaining a good learning performance. Thus, the students were also asked by their perception of these three general subject aspects in both modalities, face-to-face and online.

3. Results

3.1. Face-to-Face vs. E-Learning

In order to establish fair comparisons between the teaching methods, only students who took the subject for the first time were considered hereafter. The satisfaction degree that students showed in relation to the different teaching methodologies is depicted in Figure 2. All methodologies (except to tutorials) exhibited different medians, being better valuated the methodologies in the face-to-face version. The largest discrepancies were shown in the practical lessons in which 25% of the students expressed a poor or very poor satisfaction using e-learning. It is also remarkable that the boxplots remain unchanged in face-to-face and distance tutorials, with 50% of the responses representing a good or excellent satisfaction. The outliers depicted in the graph were considered in the analysis since they were valid values for being withing the range.

Table 3 collects the statistics calculated for all the methodologies in the traditional classroom and online modalities. In addition to this, the results of the inferential analysis are shown through the *p*-values. Significant differences were found between the medians of the face-to-face and distance learning for all methodologies, except for tutorials and computer classes. In order to quantify the magnitude of the experimental effect, the effect size was calculated. According to [35], values lower 0.3 report a small effect, values between 0.3 and 0.5 reveal a moderate effect, while values above 0.5 exhibit a large effect. The obtained values were 0.62, 0.33, 0.39, 0.40, and 0.39 for the discrepancies found between face-to-face and online modalities of the theoretical, practical, follow-up, timing, and overall scores, respectively. Thus, all the categories reported a moderate effect except for the theoretical classes which exhibited a large effect. Regarding the averages, the best valuated face-to-face methodology was tutorials (4.04), followed by master classes (3.91). Nevertheless, although tutorials were also the best scored in e-learning (3.85), the next most appreciate one was computer classes (3.36). It may be related with the students' positive reception of the manuals elaborated for the resolution of the SPSS study cases step-by-step. The follow-up of the subject was better perceived in the face-to-face modality than in the online one. On the other hand, although the medians remained unchanged and the averages exhibited quite similar regarding timing in both modalities, significant differences were found. It could be due to the high variability of the scores found in the face-to-face modality (see Figure 2). It is noteworthy that the median general evaluation of the subject was "good" in the face-to-face modality, whereas it was "normal" in the online learning modality.

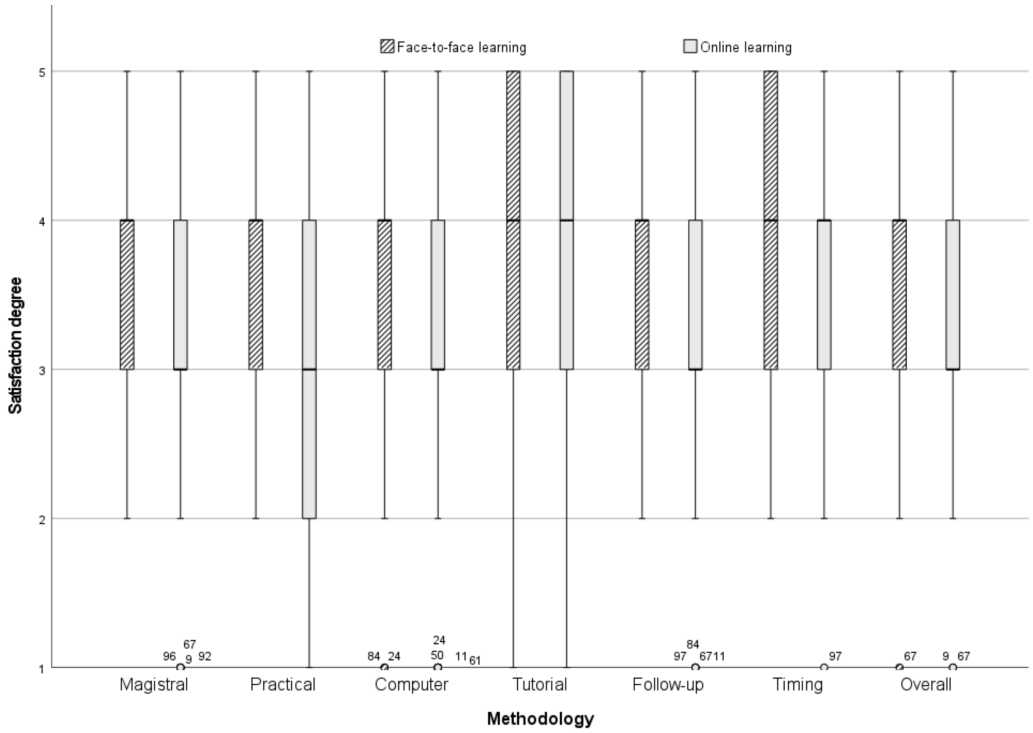

Figure 2. Satisfaction scores distribution for the different methodologies using face-to-face and distance learning.

Table 3. Scores of learning methodologies and assessment of the subject.

	Face-to-Face Learning		**Online Learning**		
Learning Methodologies and Valuation	**Mean (± SD [1])**	**Range**	**Mean (± SD)**	**Range**	***p* Value**
Master classes/theoretical ** [3]	3.19 (±0.72)	2–5	3.21 (±1.05)	1–5	<0.01
Practical classes/study-case resolution * [2]	3.46 (±0.83)	2–5	3.16 (±1.20)	1–5	0.03
Computer classes/SPSS software	3.63 (±0.96)	1–5	3.36 (±1.20)	1–5	0.08
Tutorials	4.04 (±0.97)	1–5	3.85 (±1.14)	1–5	0.13
Follow-up ** [3]	3.74 (±0.92)	2–5	3.40 (±1.05)	1–5	<0.01
Timing ** [3]	3.98 (±0.86)	2–5	3.63 (±1.03)	1–5	<0.01
Overall ** [3]	3.72 (±0.77)	1–5	3.42 (±0.99)	1–5	<0.01

[1] SD: standard deviation. [2,3] methodologies marked by * and ** correspond to those in which significant differences were found at 5% and 1%, respectively, between face-to-face and online modalities.

3.2. Technological Difficulties Found in E-Learning

In order to analyze the possible interactions between the low scores in the online modality and the difficulties encountered in the use of ICS, new variables named "differences" were created for the methodologies in which significant differences were found in the previous subsection. These new variables were defined as the scores' difference in the face-to-face modality minus the virtual one. Thus, positive differences corresponded to the responses underestimating e-learning. The associations between the scores' difference for each methodology and the sufficiency of the technological resources and internet connections were explored. The only pair which turned out to be significant was the scores' difference in practical classes and the sufficiency of the internet connection ($V = 0.39$, $p = 0.01$). In particular, students who disliked the online modality the most (difference +3) represent 8% of those that considered themselves as having an insufficient internet connection, whereas they are 4.7% of those with a good connection.

Since the internet connection turned out to be significant for the satisfaction degree of the practical classes, the relationship between the type of connection and the sufficiency of

the internet connection was investigated (Table 4). Nevertheless, no significant differences were found between the frequency's distribution of both variables ($V = 0.197$, $p = 0.113$).

Table 4. Table of contingency displaying the frequency distribution regarding type of connection and the sufficiency of internet connection.

Type of Connection/ Sufficient Internet Connection	Mobile Connection	ADSL	Optical Fiber	Total
No	3	11	11	25
Yes	4	26	57	87
Total	7	37	68	112

3.3. Psychological Difficulties Derived from COVID-19 in E-Learning

The existence of relationships between the scores' differences in both modalities for each methodology and the degree of the psychological impact of COVID-19 were explored. Even though 68.8% of the students stated that they were somewhat affected and 22.7% severely affected, as showed in Table 2, no significant differences were detected between the scores and the degree of psychological affectation.

3.4. Online Evaluation

Finally, the students were asked if they were satisfied with the system of online evaluation since the COVID-19 pandemic did not allow them to return to classes to take face-to-face exams. Most of them agreed with the evaluation system (68.8%), whereas 31.2% showed some disagreement.

4. Discussion

This research shows the results of a teaching experience in which face-to-face and online teaching methods coexist in the same academic course over the same student population. Due to the COVID-19 pandemic, teaching was forced to migrate to the online modality, thus offering the possibility of comparing both teaching methodologies. The main objective of this work was to investigate the feasibility of the online teaching of the subject of Applied Statistics in Health Sciences, which had not been considered until that moment. Online learning has been recognized as time saving and as a way of developing time management skills [11]. In addition to this, possible e-learning difficulties were explored relative to technological and COVID-19-derived problems.

It is noteworthy that all the methodologies (magistral lessons, practical classes, computer classes, and tutorials) exhibited a satisfaction degree median of normal or good in both modalities. Nevertheless, face-to-face methodologies were significantly higher scored than online ones (except to tutorials and computer classes). Based on previous results, it might be drawn that, although online teaching is viable in the subject of Applied Statistics in Health Sciences since a normal satisfaction is perceived, face-to-face learning significantly reverts in favor of the quality of teaching. This may be due to the fact that the teaching methodologies used in the online modality were somewhat improvised due to the sudden outbreak of the pandemic. In this vein, other authors state that careful planning is needed to lead to a true transformation which requires the modification of the learning strategies and the communication between the actors in the process and the evaluation strategies [29]. Consequently, since this teaching experience proved that online teaching is viable in Statistics, more sophisticated e-learning methodologies need to be performed to a correct digitalization in higher education after COVID-19.

Focusing on each teaching methodology separately, the worst rated online methodology was the practical classes. In this stream, Gamage et al. reported that learners are concerned about the missing or uncompleted practical component of their courses [11]. Then, in line with the conclusion drawn above, most of the efforts should be aimed at developing better practical teaching online methodologies. Tutorials were satisfactorily

performed in both modalities. This fact may be because communication with students is one of the most successful activities in teaching, having in mind that ICT facilitate communication, as Ramos-Pla et al. stated [29]. Therefore, this teaching experience was proposed to incorporate virtual tutorials as teaching methodology as a digitalization strategy after COVID-19. In addition, no significant differences were found between the scores of the face-to-face and online computer classes; in fact, they were the best valuated online methodology after tutorials since the elaborated manuals were well received by the students. From the view of the teacher, traditional computer classroom foments distractions that may lead to a loss of student attention. However, the use of offline manuals offers the advantage of being consulted at any time and as many times as necessary. Thus, this teaching experience proposes the use of manuals to conduct the teaching when the methodology involves the use and management of software.

Another important issue to consider in the present work is the exceptional circumstances derived from COVID-19 in which this study took place. Thus, technological difficulties due to the rapid migration to the online system as well as those derived from the psychological sequalae of COVID-19 were investigated. Approximately two-thirds of students reported having both a sufficient internet connection and enough technological resources. Then, as expected, no significant differences were found between technological difficulties and the difference in the scores given to the face-to-face and online modalities. The only distinguished result was that students with a poor internet connection reported a poorer satisfaction with the practical classes than those with a sufficient connection. On the other hand, uneasiness, fear, stress, and sadness were some of the psychological damages which derived from the COVID-19 pandemic, as reported in the literature [36,37]. Nevertheless, although two in three students exhibited to be somewhat psychologically affected by the COVID-19, this fact was not found to be associated with their perceptions about the teaching methodologies. On the other hand, most of the students agreed with the online evaluation system since the COVID-19 pandemic did not allow for the return to the classroom for the rest of the academic year.

Other methodological aspects should also be considered as the limitations of this work. The first is that the used instrument was self-developed. At the time of administering the questionnaire, there was no validated instrument in the literature to perform this comparison of teaching methodologies and consider, at the same time, the factors associated with the COVID-19 pandemic. On the other hand, the teachers' feelings should be also considered since they were manifested to be overwhelmed by the situation, not knowing how to adjust to the new normal [11]. Therefore, other conditioning factors for the students' satisfaction requires further research to assess the quality of online teaching.

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