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Article

Challenges and experiences of online evaluation in courses of Civil Engineering during the lockdown motivated by the Covid-19 crisis

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Abstract: As a consequence of the global sanitary crisis in early 2020, universities had to tackle with a sudden shift in their teaching-learning strategies so that the preset competences could be fulfilled. This study presents the learning outcomes of the tasks implemented, student experiences and feedback, as well as some reflections from the instructors with a holistic perspective of the courses due to the measures and adaptations adopted. Six courses taught at Civil Engineering degrees of three universities, two from Spain and one from Peru, are analyzed. The teaching and evaluation strategies are described and some reflections are made by comparing the student's performance with the previous course. Although the shift to online learning had to be made from day to day, with no time for preparation, the experience has proved that online learning can be beneficial in some aspects and have probably come to stay, although some others are difficult to replace with respect to face-to-face learning, especially students' engagement and motivation.

Keywords: COVID-19; online learning; higher education; evaluation

1. Introduction

In the first months of 2020, due to the sanitary crisis motivated by Covid-19 pandemic at a global level, most teaching centers around the world were forced to modify their teaching methodologies and turn them into new strategies compatible with online learning. Most universities scrambled to adjust and apply digital systems needed for remote learning. However, some recent studies seem to agree that the teaching institutions were not prepared for such a sudden shift to Emergency Remote Teaching (ERT) [1]. There is an increasing number of experiences shared around the world studying how this situation has affected teachers and students, especially focused on primary and secondary levels of education [1-4], but not so many at the higher education level [5, 6].

In these circumstances, each university adopted different solutions, usually including specific software for distance learning, such as video call applications, and giving general guidelines and instructions so that the lecturers knew how to adapt their teaching activities. Nevertheless, the lecturers were finally who had to take the decision on how to specifically implement online teaching, turning their traditional teaching strategies into online learning by incorporating new tools, such as video calls or screencast videos, and implementing new forms of interaction with the students by using virtual forums or online group tutorials. Thus, the digital tablet has proven to be a valuable tool for teaching and interacting with learners [7-9]. These decisions responded to many factors, such

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as their motivation, their digital skills or their family or personal circumstances, which could make conciliation harder.

Transforming traditional face-to-face teaching into distance teaching is not trivial, neither for the lecturers, nor the students. Some elements must be adapted, such as the teaching materials, the tools used for their production or the interaction mechanisms with the students. All this implies that both parts, students and lecturers, must adapt their daily work, since they must learn how to use new tools and the way they interact with each other.

As Singh et al. state, the use of the World Wide Web facilitates both types of online learning strategies, since it makes asynchronous teaching easier, allowing for an anytime and anywhere learning, and makes synchronous teaching easier by means of video call tools [10]. Many experiences show that online learning is possible, both using synchronous and asynchronous methodologies [11, 12]. In fact, Higher Education would be hard to imagine without it, since traditional methods, such as master and practical classes, are often combined with online resources. Nevertheless, evaluation is still not solved, since some disciplines, as is the case of many courses in engineering degrees, make use of problems solved in a specific time period as the most appropriate evaluation method, which is not easy to adapt in an online environment.

During the lockdown period, continuous evaluation techniques were highlighted and recommended. This is a clear trend in the last years, since ongoing evaluation methods are considered as highly important in order not to be late to implement corrective actions that help students during the learning process [13], but has become particularly emphasized in the period of online teaching due to the Covid-19 crisis. In this regard, some learning methods, such as those involving teamwork, should not be forgotten, since these competencies are some of the most demanded in recruitment processes [14-16]. On the one hand, online learning can make this easier, since there are now many collaborative tools that help students to work together but, on the other hand, due to the inherent nature of the traditional face-to-face teaching, the students are not used to them, which can be stressed by the lack of personal interaction in the campus, which may make involvement and commitment more difficult. In this field, it is interesting to distinguish between formative and summative assessment [17-19]. Formative assessment is more informal and its priority is to serve the purpose of promoting students' learning [20], complementing and helping the more traditional and formal summative assessment, based on essays, tests and exams. In spite of its informal nature, or maybe because of it, formative assessment has proved to increase students' achievement [21, 22], thus, it should not be disregarded, but boosted in online environments to promote engagement and involvement of students.

In this study, the evaluation systems adopted during the lockdown period in six courses taught in three schools of Civil Engineering are analyzed. These courses were taught by different lecturers, using their own strategies and under unequal circumstances. In some cases, the online evaluation was adopted earlier but in other cases almost at the end of the course, which clearly affected the evaluation methods eventually adopted. The evaluation strategies used to suddenly switch from face-to-face to online teaching are presented and discussed in each case.

In the first place, the study is presented, describing each of the analyzed courses. Then, the evaluation strategies adopted in each case are described and, finally, some results are discussed. Finally, in the view of the results, some final remarks and recommendations are given.

2. Description of the study

This study builds on the shift to remote teaching-learning and assessing in a set of modules taught at three universities under an internationalization scope driven by the Spanish Ministry of Education [23]. It forms part of a collaborative research work on the application of information and communication technologies (ICT) in innovation on Higher Education.

The shift to remote training was initiated by the closure of classrooms, what deprived both students and instructors from diverse rights and benefits. On the one hand, it had a negative impact

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on the inclusion process in Higher Education, understood as the ongoing and transformative process of improving education systems to meet all learners' needs, especially those in low-achieving students or with low-income families [24-26]. On the other hand, the change to remote teaching has implied a step forward to the so-called ubiquitous learning [27,28]. Another side effect is the advantage that the university system has taken from the rapid digital adaptation, the use of pervasive components, e-resources and wireless communications amidst the well-known physical constraints to deliver satisfactory and profitable teaching–learning experiences to the educational agents. However, this ubiquitous learning model is open for debate and demands further research in terms of both evaluation of knowledge and behaviour change measurement. In this regard, the authors consider that there is room for improving since a well-tailored integrated teaching-learning environment must comprise online activities, digital material and face-to-face interaction to yield satisfactory outcomes.

Table 1 shows the main features of the modules analysed in this study. All of them form part of curricula in Civil Engineering Schools.The subjects hereby mentioned are:

- Universidad Politécnica de Madrid (UPM, Spain): Strength of Materials, Construction Management and Dynamic and Seismic analysis of structures.
- Universidad de Jaén (UJA, Spain): Theory of structures,
- Universidad de Piura (UDEP, Peru): Research operations I and II, which are modules completed in consecutive semesters with continuously assessed assignments and exams.

All the courses were adapted to online teaching by means of either asynchronous or synchronous methods. Most classes were taught by means of online video calls. However, some classes for the first two weeks of the lockdown at the UPM and the whole UJA course consisted of screencast videos that could be watched by the students at their own pace.

Table 1. Main characteristics of the analyzed modules.

Course	University	Degree/Master	Year	Number of registered students	Teaching method	Examination method
Construction management	UPM	Degree	4th	65	Synchronous	Online
Strength of materials	UPM	Degree	2nd	215	Asynchronous & synchronous	Online
Dynamic and seismic analysis of structures	UPM	Master	2nd	15	Asynchronous & synchronous	Online
Theory of structures	UJA	Degree	2nd	42	Asynchronous	Online
Operations research I	UDEP	Degree	3rd	136	Synchronous	Online
Operations research II	UDEP	Degree	3rd	152	Synchronous	Online

3. Methodology

The closure of classrooms entailed sudden adjustments on teaching and evaluation so that the ongoing courses could end properly. Educational agents had to adapt their strategies to the new context, counting on the available resources in order to comply with the expected learning competencies. Such a big shift involved decisions at several levels, ranging from the Rectorate to the lecturers, most of which lacked digital competences and underwent those changes departing from a large variety of individual readiness and capabilities. No doubt those have implied a step forward in both the digital transformation of universities and the teaching of the future.

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The teaching methodologies adopted by the teaching units hereby considered are presented in this section. The initial strategies, planned before the lockdown, along with the adjustments performed to adapt them to the online learning environment are described.

Likewise, this study gathers the criteria used to assess the impact of this sudden shift on the learning outcomes as well as on both the instructors' and students' perceptions, which somehow have evolved since then.

3.1. Evaluation methodology of courses at UPM

The closure of classrooms occurred some eight weeks after the start of semester. It took between two and three weeks to reconsider and readjust the evaluation strategy since it was mandatory to rewrite such changes in the Academic Guide.

An important issue was the assessment design, whose impact on the learning process of students is significant [21, 22, 29]. Both formative and summative assessments were to be kept: the former as an essential part of the scaffolding structure as students can benefit from the discussion with and feedback from the teacher [30, 31], whereas the latter boosts quality assurance [31].

Two main lines of action were considered upon readjusting the evaluation strategy, tools and resources: 1) the follow-up of students through the continuous evaluation and 2) the preparation of exams.

Firstly, it was essential to keep the instructor's role not only as facilitator but also as activator of meaningful learning and help students to take ownership of their progress through ongoing assessment and reflection [32]. Thus, the teaching units approved an increase in the relative weight of the ongoing assessment in the final outcomes.

Class sessions were recorded so they could access them afterwards. Some supplementary material and e-resources were put available to students for autonomous learning. In order to ensure a suitable use of the former, diverse short questions were inserted in the pre-recorded videos (Edpuzzle) so that only students could continue watching them after answering. Indeed, this feature was highly valued by them.

In the Degree fundamental subjects, students were prompted to solve weekly exercises or problems at home. Also, at least once a week they should take short online quizzes (Kahoot, Socrative, Mentimeter) during class time.

As with most fourth-year engineering subjects, the Construction Management module is focused on practical application of engineering knowledge, through the relevance of assessments and self-directed inquiry-led learning which includes visits to work sites. However, during the lockdown, students were prompted to watch some specific documentaries and analyze the processes and workflows involved. The Edpuzzle has proven to be a valuable tool to insert some short questions at certain stages in order to follow up students' accomplishments.

As regards the Degree and Master technologically-oriented subjects, the instructors set several teamwork-based assignments focused on competence-based learning (CBL). In this sense, students should be capable of demonstrating some specific learning achievements after each stage and before shifting to the next one [33]. Each group should work on an ongoing set of assignments throughout the semester with online presentations on a two-week basis. Such assignments were tailored according to Vygotsky's principle of proximal development zone [31, 34-36], so some questions arose in this regard: what can they do individually on their own? What can they do with help as they continue to learn by interacting with others around them? The design criteria for such a teamwork ongoing plan built on these features [37]:

- To tailor the activity with a trade-off between engagement and personal work.
- To build on problem statements that pose relevant challenges.
- To realize that the activities are themselves learning strategies.

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- To highlight that the activities are focused on learning rather than on the work product.
- To promote tasks that require thinking and reasoning.
- To focus on the process through appropriate guidelines and instructions.
- To provide students with regular feedback from their progress.
- To assess their learning achievements rather than their work products.
- To empathize with learners when they encounter setbacks along their work.
- To promote a favorable environment, which fosters their effort rather than a single task or target.

ICT-based teamwork allows students to develop documentation, reporting and other transversal skills. Conversely, its implementation requires teachers and students to use a variety of digital tools, highlighting the importance of digital literacy [37-39].

Tutorials were another relevant task to follow up and accompany students during the remote learning stage. Those were increasingly given through the online platforms (BlackBoard Collaborate, Microsoft Teams and Zoom, among others), with noticeably good results, although the online tutorials remained. In this regard, the digital tablet emerged as a key tool to deliver the instructor explanations and responses to students' queries.

Secondly, the Civil Engineering School ruled that the Final Degree Projects were presented online and exams were held online as well, which entailed a challenge. This raised a set of obstacles and uncertainties for both instructors and learners: some students showed weak motivation to distance learning, some professors were either reluctant to adapt to distance learning or not convinced of its usefulness, lack of preparing the community to deal with distance learning, lack of clarity of the methods of remote evaluation, among others.

The instructors involved in this study carried out several online Likert-type surveys among the students to gather their perceptions on the deliveries, the evaluation process, the extent of success achieved from the sudden shift in teaching and evaluation as well as on their learning achievements [40]. The University also conducted end-of-semester surveys to perceive students' perceptions on teaching strategies, performance and usage of innovative tools in teaching.

Surveys were also intended for perceiving the degree of satisfaction with the teaching strategies implemented during the pandemic. The responses were classified according to a Likert scale, ranging from 5 (completely agree) to 1 (completely disagree).

3.2. Evaluation methodology of course at UJA

In order to understand why the teaching and evaluation methodology was converted to online teaching as described later, it must be clarified that the course of Theory of Structures comprises two main parts, one is an introduction to Elasticity, mainly describing strains, stresses, their tensorial expressions and their relationship through Lamé's and Hooke's equations, ant the other one is an introduction to Strength of Materials, presenting axial, shear and bending stresses, torque and how to solve stress diagrams in isostatic beams. Therefore, this is a course where solving problems has a paramount importance as a teaching tool.

Online teaching due to lockdown started after seven weeks after the start of the semester. From the very beginning, a big effort was made to proceed with the lectures in the most similar way as the classroom lectures. Since, due to family conciliation issues, lectures could not be given in a synchronous way, an asynchronous methodology was followed. Until then, classroom lectures had been given mainly using the blackboard, since, due to the great importance of problems in this course, this is considered as the most adequate method. Because of this, a great effort was made to adapt these lectures to online teaching, thus lectures were given by means of videos recorded using screencast tools, supported by handwritten solved problems and slides presentations. Problems were solved by hand by the lecturer, scanned and used to prepare a slides presentation. The progressive explanation that would take place using a blackboard in the classroom was simulated by recording the voice of the lecturer during the slides presentation using the open source software Kazam. Before the lecture, the students had access to the video and also the scanned solution of the exercise in PDF.

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This material was always available before the official time of the lectures and clear instructions were given to the students, so they could follow the course and use the material properly. Every two weeks a group video tutorial session was arranged via Google Meet in order to solve questions and clarify doubts about the lectures, which, together with the doubts solved by email, proved to be an efficient way of solving questions about the course.

Regarding the practical sessions, no big changes had to be made, since all of them consisted of solving given problems by using specific software (Matlab for Elasticity problems and Robot Structural Analysis for Strength of Materials problems), available by the students through academic license. Therefore, video tutorials were prepared for instructing the students on the usage of the software and short videos explained the problems to solve.

With regard to the evaluation of the course, following instructions received from the university, an alternative methodology had to be designed. Table 2 shows how the evaluation methodology was modified to an online final exam, comparing the evaluation items and their weights on the final mark.

Table 2. Modification of the evaluation methodology of the UJA course. The last column corresponds to the modified methodology to adapt evaluation to an online final exam. Items marked with an asterisk must be passed independently to pass the course.

Item	Criteria	Tool	Weight (original methodology)	Weight (modified methodology)
Lab practices and use of TIC tools	Participation and attendance, delivery of well solved reports, report structure and quality of the document.	Lecturer's observation and notes. Reports of the practical sessions	10%	30%
Theory and problems	Mastering of the theory and practical aspects of the course.	Final exam	90%	50%
Study of cases and exercises	Works and cases proposed in the practical sessions.	Deliverable problems	0%	20%

The original evaluation system consisted mainly of two items, lab practices that were assessed based on the students' participation and on reports prepared by the students in groups of two members, which had a weight of 10% on the final mark, and a final exam testing theoretical questions and practical problems, which had a weight of 90% on the final mark. Students must pass both items independently.

The University of Jáen (UJA) decided to switch from a traditional on-site final exam to an online final exam just three weeks before the end of the course and encouraged lecturers to implement ongoing assessment methods to reduce the weight of the final exam. Since this decision was made at the very last part of the course, drastically modifying the evaluation methodology was considered unfair for the students, who had been preparing the course based on the original evaluation methodology. In addition to this, including new items at the very last part of the course could increase their work load in excess. Finally, the assessment methods were adapted following these recommendations but trying to maintain the same general criteria of the original methodology.

It is important to highlight that this course is evaluated mainly using problems that must be solved in a final exam. It is a course in which theory supports the practical part, but the student must fundamentally learn how to solve problems in a given time. Thus, the evaluation methodology was modified in a way where the same premise was preponderant. A new evaluation item was included, "study of cases and exercises", which consisted in problems that were solved in class during the last week of the course. The weight of the lab practices were increased up to 30% to reduce the weight of

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the final exam, which had a weight of 50%, following the recommendations made by the university. The exam maintained the same structure as in a regular year, with a theory part with a weight of 20% and problems with a weight of 80%, but the theory was transformed into an online test and the problems were defined using parameters that had different values for each student, Figure 1 shows an example of one of the problems designed for this exam, therefore, each student had different results and copying was not easy. In addition to this, each problem had to be delivered before the next problem was presented, this reduced the chances of sharing results and consultation among peers. To guarantee that the students themselves were the authors of the submitted exercises, prior to the exam, the students were required to send a video writing by hand a specific text in order to serve for comparison.

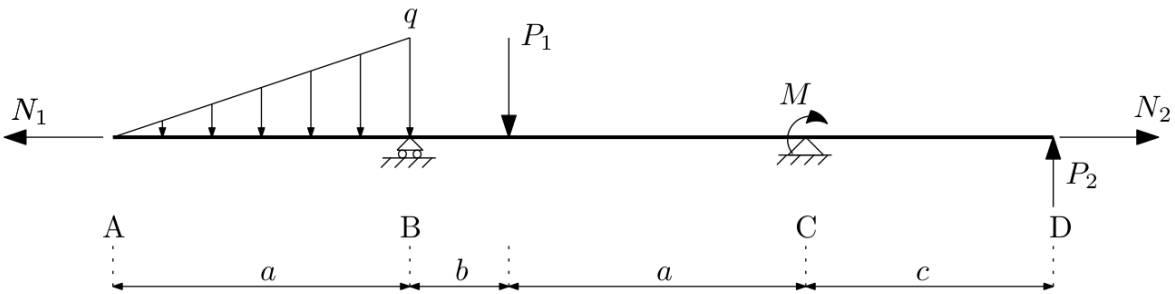

Figure 1. Example of one of the problems designed for the online exam. Each student had a different set of parameters.

Problems were published at the website of the course at a given time, should be solved in paper by hand, scanned with a smartphone and delivered online before the deadline. Since this procedure was new, the new item, "study of cases and exercises", was designed as preparatory exercises for the final exam, so the students got accustomed to it. In these exercises, the delivery process was more flexible, since the students were not used to the scanning and uploading procedure, and passing them was not mandatory for passing the course.

3.3. Evaluation methodology of course at UJA

The cohort comprised 136 and 152 registered students, respectively. Lessons were taught remotely, synchronously and simultaneously recorded. Extensive use was made of UDEP Virtual, the digital Learning Management System (LMS). This platform held a variety of e-resources, often known as e-textbooks, which go beyond electronic versions of printed material since are intended to support both self-paced and tutor-paced student learning [41, 42]: video conference classes, pre-recorded videos, individual and teamwork assignments, class notes and presentations, podcasts and tutorials.

Such a variety of digital resources was conceived for remote teaching, autonomous learning and assessment. The couple e-textbooks and digital media form a promising paradigm that spreads higher education in a variety of settings, so that students be involved in learning contexts with immersive experiences that help them to attain meaningful learning [43]. In this regard, many publishers have placed their e-resources free of charge during the confinement period.

Practical lessons consisted of two virtual laboratory sessions and four team workshops, drawing on collaborative work, by using the Excel Solver tool and focused on competence-based learning [33]. Workgroups were accompanied and supervised by the instructor on a weekly basis. In addition, students took four individual practical exercises as well as an end-of-semester exam for summative assessment issues.

In case students failed to take these exams due to technical, personal or health causes, UDEP set an extraordinary exams programme.

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This university also conducted end-of-semester Likert-type surveys to grasp students' perceptions on certain features of the course development regarding the impact of innovative tools in teaching and assessment.

4. Results

In order to measure the impact of the experiences hereby described, a set of indicators for both process and results has been applied, focusing on three areas of interest: 1) the impact of e-resources and e-textbooks on learning outcomes, 2) the benefits and drawbacks of online evaluation when compared with on-site sessions and 3) meaningful learning achievements.

The impact of the whole evaluation process has raised several reflections from both the instructors' and students' standpoints.

Most students expressed diverse concerns about the new constraints:

- Weak motivation for distance learning; the home environment was not suitable.
- A shortfall in their comprehension of some applied subjects in the absence of classroom interaction.
- Difficulties when performing remotely oriented work.
- Uncertainty about the lack of clarity of the methods of remote evaluation.

As regards the professors, the following reflections can be summarized:

- The need to overcome an initial resistance to adapt to remote education.
- Online teaching requires a big effort in preparing new material, although it can be used again in future courses.
- Lack of digital competences in professors.
- Lack of preparing the university educational agents to deal with distance evaluation.
- Lack of training in the use of technology and the absence of uniform controls among all exam takers.
- Some instructors are not convinced yet of the usefulness of distance learning and assessing.

Some difficulties and uncertainties drove the at-hand preparation of exams:

- To maintain the preset learning competences and outcomes.
- To ensure honesty, probity, confidentiality, authorship and equal opportunities of the exam takers.
- The possibility of designing exams while keeping the same structure as in the on-site ones.
- The online examination tool could not be a source of uncertainty nor conflict to students.
- It was mandatory to avoid third-party tools or resources by the exam takers.

Hence, the exams were designed so that the response times were very tight, questions and problems were precise and objective, so that the response resulted from reasoning, relating concepts, demonstrating, argumenting or deriving issues and expressions. Thus, the design of exams became a trade-off between keeping the classical structure as much as possible and ethical and ensuring the authorship issues. However, our ex-post analysis shows somehow that the instructors' effort focused primarily on avoiding cheating. As a consequence, low-achieving students have been especially affected by such measures. Nevertheless, the figures of both passing students and dropouts are similar to those of the previous year. Therefore, it cannot be concluded that the sudden shift to remote learning had an impact on the outcomes. Indeed, students' feedback subscribes to this feature.

Table 3 shows a comparison of both passing and dropout rates between 2019 and 2020 for the selected modules. As the differences are not significant, we cannot conclude any kind of impact in those outcomes from the change to remote teaching.

Table 3. Comparison of students' performance in each course in 2019 (face-to-face teaching) and 2020 (online teaching).

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	Registered students 2020	Passing rate 2020 %	Dropout rate 2020 %	Passing rate 2019 %	Dropout rate 2019 %
Strength of materials	215	42	27	60	22
Construction management	65	75	11	73	8
Dynamic and seismic analysis of structures	15	100	0	91	9
Theory of structures	42	50	19	44	22
Research operations I	136	97	5	84	16
Research operations II	152	98	1	84	12

In general, the response and attitude of students to online exams were notably positive and proactive. Most of them acted responsibly, eager to participate and reach their learning outcomes. However, around 10% of exam takers lack maturity as they tried to cheat and exchange information during the exams. Given that students are actually proficient in digital technologies, instructors struggled to monitor the exam sessions, even with online video surveillance albeit low success. Besides, students at home were prompted to write the responses to the question in their own hand and to scan their manuscripts and upload the resulting PDF files to the examination platform.

4.1. Results of courses at UPM

The previously described process and behaviour patterns apply to this case. With regard to the concern about security and confidentiality of data and information during exams, one noticeable proof of cheating is shown below. Three exam takers wrote the response to a given exercise in their own hand and uploaded the scanned versions to the platform. All three used the same alternate approach to address the solution. However, such a method neither belonged to the module syllabus nor was taught by instructors. Besides, all three students depicted the same charts and schemes with the same mistakes indeed at the same steps. Figure 1 shows the excerpts from the three individual responses.

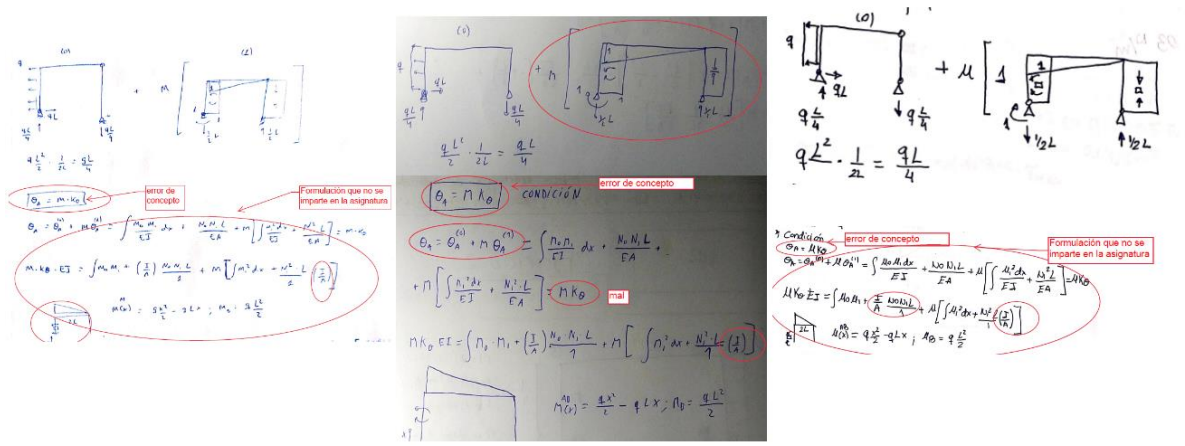

Figure 2. The same excerpts from three students' own manuscripts during a remote exam. The approach, notation and procedure is the same in all three cases, not taught in the course. Even the mistakes coincide and at identical places.

Student experiences and feedback reveal rather good acceptance and goal achievement, as shown below.

Strength of materials and Construction management

The items of interest were the following:

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1. Degree of satisfaction with online classes.
2. How do you value your learning of the subject when compared with face-to-face classes?
3. Have you studied autonomously the subject more than during in-person period?
4. Degree of satisfaction with individual time management and learning.
5. How could you study in online groups during the pandemic as compared with the on-site regime?
6. How do you value your learning achieved through studying in groups during the pandemic?
7. Degree of satisfaction with the e-resources delivered by the instructors of the subject during the lockdown period.
8. Certainty on having mastered the two key concepts taught in the subject.
9. Would you recommend applying the teaching method used in this subject to other modules?
10. Have you achieved the learning expectancies during this period?
11. Your degree of readiness to follow online classes at the beginning of the lockdown period.
12. Your current readiness to follow online classes at the end of the lockdown period.
13. Degree of mind shift with respect to online classes after this experience.
14. Open questions, suggestions, complaints, etc.

Table 4. Results from the survey on student perceptions and degree of fulfillment of expectancies. Courses of Strength of materials and Construction management, taught at UPM.

	Strongly agree	Agree	Neutral	Disagree	Completely disagree	Mean	Std. deviation
(1)	19.4%	19.4%	38.7%	21.0%	1.6%	3.34	1.06
(2)	3.2%	16.1%	45.2%	35.5%	0.0%	2.87	0.79
(3)	3.2%	22.6%	27.4%	27.4%	19.4%	2.63	1.12
(4)	1.6%	21.0%	38.7%	29.0%	9.7%	2.76	0.95
(5)	4.8%	22.6%	33.9%	19.4%	19.4%	2.74	1.15
(6)	3.3%	36.1%	44.3%	14.8%	1.6%	3.25	0.80
(7)	41.9%	40.3%	16.1%	1.6%	0.0%	4.23	0.77
(8)	16.1%	40.3%	41.9%	1.6%	0.0%	3.71	0.75
(9)	13.3%	23.3%	38.3%	18.3%	6.7%	3.18	1.09
(10)	8.2%	41.0%	32.8%	13.1%	4.9%	3.34	0.97
(11)	14.8%	41.0%	19.7%	18.0%	6.6%	3.39	1.13
(12)	3.3%	24.6%	50.8%	21.3%	0.0%	3.10	0.76
(13)	19.7%	37.7%	21.3%	16.4%	4.9%	3.51	1.13

Students expressed a fair acceptance of the digital resources involved during the distance learning stage, as well as a reasonably good achievement in their goals. Their suggestions helped to design future actions for the next course, regardless it is online or on-site.

Dynamic and seismic analysis of structures

The remotely oriented teamwork weighted one third of the final grade. It was conceived for competence-based learning focused on problem solving. Thus the survey included three main topics: fulfilment of learning achievements, perceptions on teamwork effectiveness and on team leadership. several items about the individual learning achievements within the group work method. The main questions included were:

1. I have mastered the core concepts application to the seismic design of a given simple structure.
2. Satisfaction level with individual learning from teamwork
3. Satisfaction level with autonomous learning and individual contribution to teamwork
4. Would you recommend applying competency-based learning through teamwork to other modules?
5. Have you achieved your learning expectancies during this period?

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6. Your readiness to do online teamwork in the beginning of the lockdown period.
7. Your readiness to do online teamwork at the end of the lockdown period.
8. Level of satisfaction with your own contribution to teamwork
9. Level of satisfaction with teammates' contribution to teamwork
10. Extent of mind shift with respect to teamwork benefits after this experience.
11. Own leadership skills for doing teamwork.
12. Own skills for overcoming setbacks collaboratively.
13. Team leader's skills for overcoming setbacks collaboratively.

Table 5. Students' perceptions on their goal achievements through the remotely oriented work. Course of Dynamic and seismic analysis of structures, taught at UPM.

	Strongly agree	Agree	Neutral	Disagree	Completely disagree	Mean	Std. deviation
(1)	40.9%	40.9%	15.2%	3.0%	0%	4.20	0.80
(2)	63.6%	27.3%	9.1%	0%	0%	4.55	0.66
(3)	27.3%	54.5%	18.2%	0%	0%	4.09	0.67
(4)	54.5%	9.1%	27.3%	9.1%	0%	4.09	1.08
(5)	45.5%	45.5%	9.1%	0%	0%	4.36	0.64
(6)	9.1%	63.6%	27.3%	0%	0%	3.82	0.57
(7)	2.3%	54.5%	9.1%	0%	9.1%	3.91	1.08
(8)	54.5%	45.5%	0%	0%	0%	4.55	0.50
(9)	54.5%	27.3%	0%	18.2%	0%	4.18	1.11
(10)	0%	36.4%	45.5%	18.2%	0%	3.18	0.72
(11)	9.1%	72.7%	18.2%	0%	0%	3.91	0.51
(12)	9.1%	72.7%	18.2%	0%	0%	3.91	0.51
(13)	45.5%	36.4%	18.2%	0%	0%	4.27	0.75

4.2. Results of course at UJA

Figure 3 shows a correlation between the final mark of a student and the average time he or she took to view the PDF files prepared for every lecture since they were available online. This graph intends to see if there is a connection between both values, since it is expected that a motivated student will visualize the available material earlier than a non-motivated student, since the former usually prepares the course at the same rhythm it is taught and the latter procrastinates and studies only during the last weeks before the final exam. Each mark represents a student and the dashed line shows the linear trend of this correlation. It shows a decreasing trend, as expected. Data is broadly spread around the first part of the graph, which groups those students that visualize the files earlier, which is logical, since not all the students have the same capacities and not all of them need the same time to comprehend the concepts. Nevertheless, it is clear that a significant delay in accessing the material is related to a lower final mark. .

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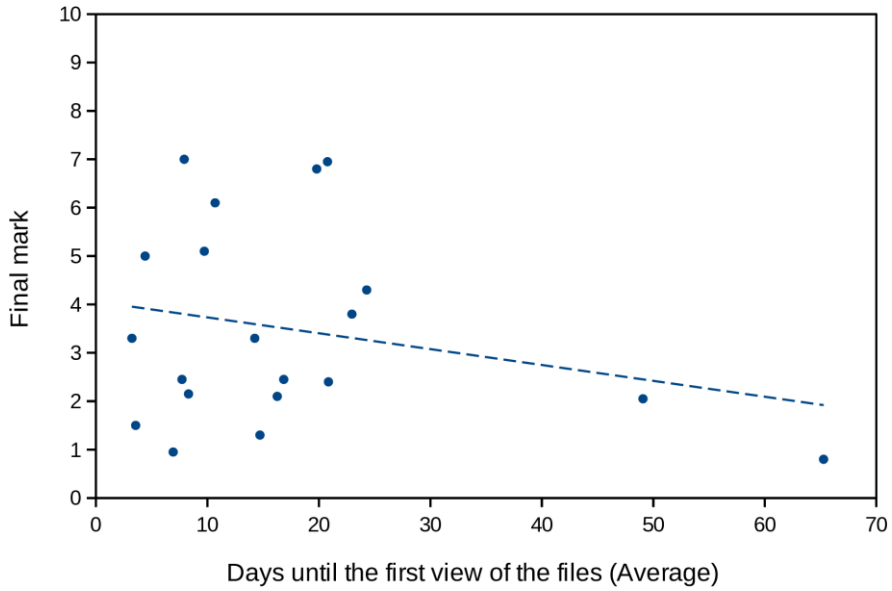

Figure 3. Correlation between the final mark of the students and the average time they took to access the PDF files available for each lecture. The dashed line represents the linear trend of this correlation.

In addition to this conclusion, it is interesting to analyse some aspects observed during the online teaching period. Since the students had access to the videos and the scanned solution of the problems at the same time, they could focus only on understanding the video and only taking notes of those issues that were of particular interest for them. Since the problems were solved by using a slide presentation, the explanation time was reduced (a traditional lecture of 50 minutes was reduced in average to 35 minutes), since no time for writing on a blackboard was required. This, in a traditional classroom teaching context, can be seen as a drawback, since a faster pace on teaching may become elusive for some students, but in this online context, it proved to be beneficial. Since lectures were recorded in videos, accessible by the students anytime and as many times as they wanted, those students who needed it could rewatch the whole video or only certain parts easily but those students who did not need it, had more time available for other subjects. In this regard, the students expressed their satisfaction with this teaching methodology during the group tutorial sessions, remarking the convenience of watching the lectures more than once if they needed. This supports, as already stated by Shahabadi and Uplane [44], that anywhere-anytime learning has clear benefits for the students, since they have control over their learning pace and can manage their time better.

Regarding the practical sessions, they seemed to be efficient and, compared with previous years, no big problems were encountered. By contrast, solving questions from the students became a much more time demanding task, since, due to the extraordinary situation motivated by lockdown, students were allowed to ask questions via email or ask for video calls with the lecturer. This led to a situation where the lecturer's availability was not limited to specific time periods during the week, but was extended to the whole week. This proved to be effective for solving questions but implied a high additional workload for the lecturer.

Figure 4 shows the students' performance compared with the previous year. It is interesting to observe that, although an online exam could imply higher rates of cheating leading to better marks, this was not the case. In general, no cheating was detected and the design of the online exam - setting different parameters for each student and a sequential solving of the problems - seemed as a successful alternative to the original classroom exam, with similar problems and difficulty.

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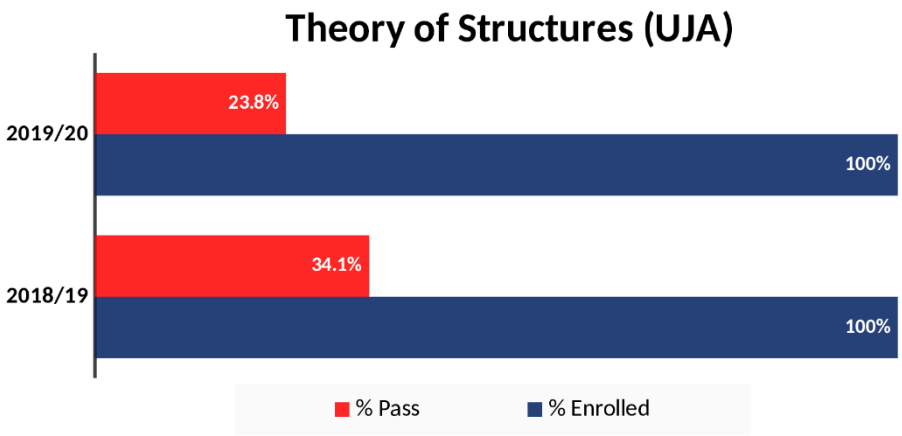

Figure 4. Comparison between the students' performance of courses 2018-19 and 2019-20 for Theory of Structures, taught at UJA.

It must be noted that the lower performance of the students with respect to the previous year cannot be attributed to the adopted online methodology, since the same methodology was used in another course taught in the Mechanical Engineering degree at UJA and the performance was higher (from 32.6% in 2018-19 to 59.4% in 2019-20). For some reason, the students of Theory of Structures were less motivated during the semester. Some of them mentioned that in other courses the workload of deliverable reports had remarkably increased, since shifting to online evaluation had encouraged other lecturers to reduce the weight of the final exam and increase the number of ongoing evaluation tasks.

4.3. Results of course at UDEP

In short, features inquired by the questionnaire were:

1. Degree of satisfaction with the implemented remote teaching model.
2. Degree of mind shift with respect to online classes after this experience.
3. Degree of accomplishment of the module syllabus.
4. Assessment of the implemented evaluation methodology.
5. Usefulness of the virtual lab & workshops.
6. Instructor availability.
7. Usage of innovative resources and e-textbooks in remote teaching.
8. Usage of digital resources and e-textbooks in assignments and exams.
9. Teacher-student interaction and availability to deal with unforeseen events.
10. Adequacy of elapsed time for grade publishing.

Research operations I

Pass rate was 97% of the 136 registered students. Their level of satisfaction with the implemented online teaching and assessing approaches suggests a line of action for next courses.

Table 6. Feedback from the survey on students' perceptions and degree of fulfilment of expectancies. Course of Research operations I, taught at UDEP.

	Strongly agree	Agree	Neutral	Disagree	Completely disagree	Mean	Std. deviation
(1)	13.7%	42.5%	39.7%	1.4%	2.7%	3.63	0.84
(2)	18.5%	54.0%	26.6%	0.8%	0%	3.90	0.69
(3)	57.5%	30.1%	2.7%	0%	9.6%	4.26	1.18
(4)	19.2%	31.5%	38.4%	6.8%	4.1%	3.55	1.01

Figure 5 shows the average level of learners' satisfaction about the module, whereas the red line shows those of the Engineering Faculty.

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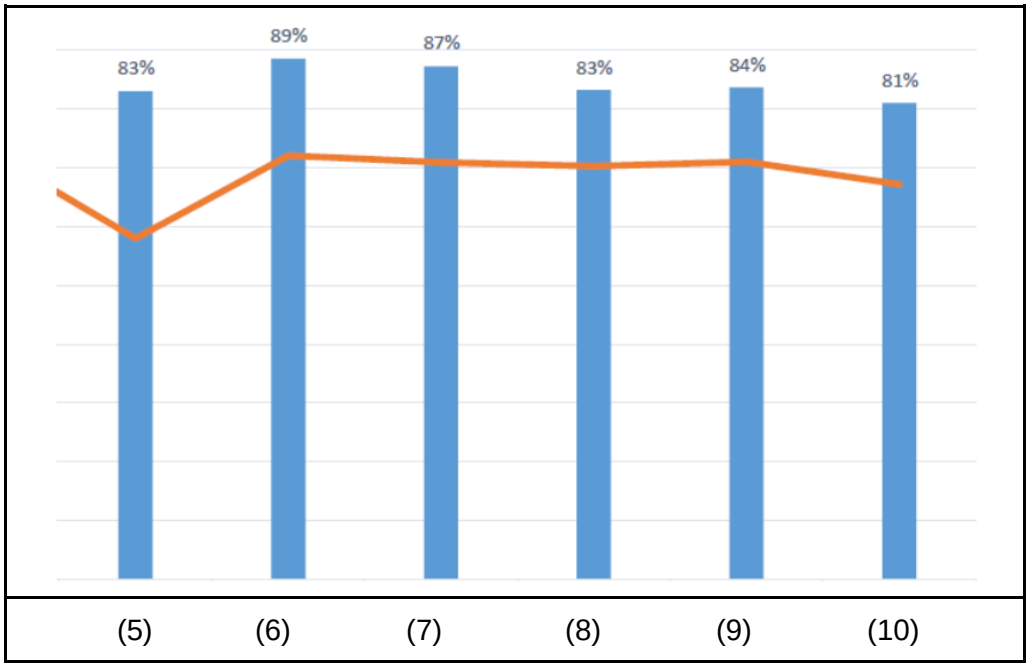

Figure 5. Average values of UDEP students' satisfaction degree on the teaching-learning and assessment processes in Research operations I.

Research operations II

The enrolled group comprised 152 attendees. The feedback from the survey on their perceptions and degree of fulfilment of expectancies is summarized below.

Table 7. Feedback from the survey on students' perceptions and degree of fulfilment of expectancies. Course of Research operations I, taught at UDEP.

	Strongly agree	Agree	Neutral	Disagree	Completely disagree	Mean	Std. deviation
(1)	17.1%	53.9%	25.0%	3.9%	0%	3.84	0.74
(2)	15.7%	57.9%	24.8%	1.7%	0%	3.88	0.68
(3)	33.8%	42.9%	20.8%	2.6%	0%	4.08	0.80
(4)	62.3%	31.2%	3.9%	2.6%	0%	4.53	0.69

Learners took individually four practical virtual lab exercises as well as an end-of-semester exam through Zoom. Instructors have faced analogous difficulties and issues as referred to probity, individuality and authorship. Around 6% of students failed to take the ordinary evaluation items and dates, mainly due to personal, health or technical reasons. So the university arranged an extra-ordinary call for the "Covid exam".

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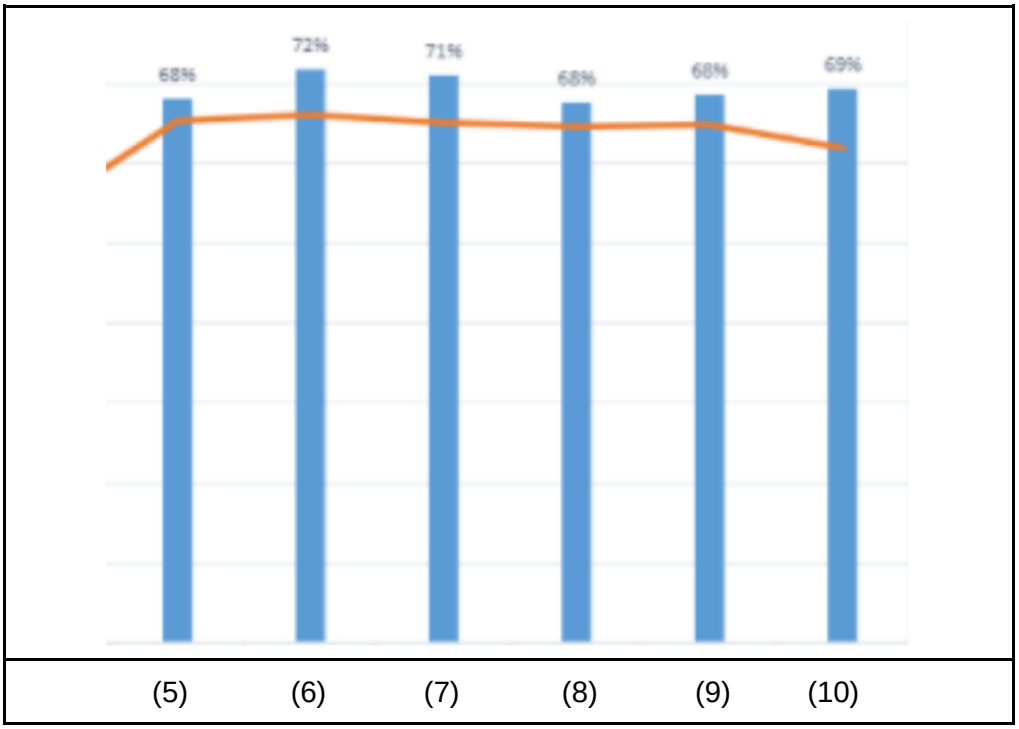

Figure 6. Average values of UDEP students' satisfaction degree about the teaching-learning and assessment processes in Research operations II.

5. Discussion

This recent crisis has shown that the current university learning system is remarkably digital and has just given a step forward to the design of the future Higher Education system. This passes through the use of active learning models and the development of digital competences for educational agents. Other features can be envisaged in this route: synchronous teaching, ubiquitous learning, active learning strategies such as synthesis capability, problem-based, project-based, service, competence-based and experiential learning, among others [38].

As regards both the virtual training and the ICT-mediated assessment processes, there is much room for improvement, especially when focusing on the formative assessment. It departs from revising their meaning in the future digital context, analyzing their limits and possibilities, determining which types of knowledge are adequate for being evaluated and identifying the drawbacks and capabilities of virtual tools [45, 46]. Indeed, the recent experience reveals that ICT-based evaluation shows a trend to summative and quantitative assessment, even more when inserted within Learning Management Systems (LMS). Besides, ensuring the effectiveness of the technical and digital layout of remote evaluation has become essential and is open for debate: the absence of uniform controls and the pervasive use of digital tools may lead to the loss of quality assurance and hence of the evaluation purpose.

Likewise, this recent experience has revealed two other challenges: to reduce the digital divide and the lack of inclusion in Higher Education. It may include facilitating the digital equipment loan service and the access to wireless technology to low-income families.

Furthermore, future Higher Education is digital, in which mobile devices play a paramount role as they have jumped to the spotlight and become a inseparable tool for university students, who lead technologically-focused lives. This issue demands a mind shift in educational agents. Likewise, this recent experience has also revealed diverse pending tasks about supporting distance learning students to overcome their lack of motivation and difficulty of understanding in some applied courses and remotely oriented work. Only then will they be able to succeed in their study, which could help to decrease the dropout rate. In this regard, the digital transformation strategies must also concern research and social service missions.

6. Final remarks

The closure of university classrooms caused by the advent of the recent global sanitary crisis has implied a handful of efforts, challenges and adaptations to the remote teaching-learning system. Undoubtedly, some measures, practises and changes have come to stay, namely, the use of the digital tablet in remote teaching, pre-recorded videos with inserted questions to ensure follow-up, preset questionnaires and quizzes for online use, the capability to meet with students and colleagues, among others.

The adaptability to the constraints imposed by remote teaching has emerged as a key feature: good-achieving students during the face-to-face stage of the semester performed well during the distance learning phase, whereas low-achieving students became more affected. The dropout rate in fundamental subjects reached 22%, notably higher than in technological modules, which was lower than 10%.

As regards the digital divide and the lack of inclusion as shortcomings, a deep reflection is required about setting policies to support and counsel students in order to foment their integration and adaptability so that they can meet better their learning outcomes.

Lastly, the impact of this sanitary crisis on Higher Education has shown the effectiveness of distance teaching, either synchronous or asynchronous. Conversely, the remote evaluation process still raises technical, functional and ontological controversies that need to be addressed and improved.

Author Contributions: For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used "Conceptualization, X.X. and Y.Y.; methodology, X.X.; software, X.X.; validation, X.X., Y.Y. and Z.Z.; formal analysis, X.X.; investigation, X.X.; resources, X.X.; data curation, X.X.; writing—original draft preparation, X.X.; writing—review and editing, X.X.; visualization, X.X.; supervision, X.X.; project administration, X.X.; funding acquisition, Y.Y. All authors have read and agreed to the published version of the manuscript.", please turn to the CRediT taxonomy for the term explanation. Authorship must be limited to those who have contributed substantially to the work reported.

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