International Journal of Engineering Education Vol. 37, No. 6, pp. 1567–1581, 2021
Printed in Great Britain

0949-149X/91 $3.00+0.00

Perceptions of Engineering Faculty Members of Online Teaching Due to COVID-19*

SUSANA SASTRE-MERINO, Mª CRISTINA NÚÑEZ-DEL-RÍO, ARTURO CARAVANTES and JUAN LUIS BRAVO-RAMOS
Instituto de Ciencias de la Educación, Universidad Politécnica de Madrid. C/ Profesor Aranguren, 28040 Madrid, Spain.
E-mail: susana.sastre@upm.es, mc.nunez@upm.es, arturo.caravantes@upm.es, juanluis.bravo@upm.es

The global pandemic situation posed the challenge of modifying teaching at all educational levels. Higher education also had to transform its face-to-face learning, to distance teaching. This paper focuses on the faculty members' perception about the sudden change that they had to make to maintain a high-quality teaching in the context of a Spanish technical university. An ad-hoc survey was responded by 577 faculty members. It analyzed the effort and time spent compared to their previous teaching, the use of different ICTs, the difficulties perceived and their preferences of future teaching and training modalities. The faculty show that it has been much costlier than usual, regardless of their age or seniority. There has been progress in ICT knowledge and use, especially for faculty members who have not received prior training, and 57% of faculty members intend to incorporate modifications in their future teaching, such as new resources and materials, after-class questionnaires and distance mentoring. In any case, the older and with higher category faculty are inclined towards the face-to-face format for future teaching, while the younger ones and from initial professional categories bet on digitization to some extent. The online assessment stands out as a great difficulty. Also, the students' low participation, the greater workload and time spent and the inability to receive feedback from students due to lack of eye or personal contact have been pointed out as the difficulties to carry out adequate monitoring. In short, the digital divide in university teaching has found in the emergency remote teaching an opportunity to promote the improvement of learning, facilitating the revision of pedagogical approaches, updating methodologies and evaluation strategies that will promote the digital transformation of university education.

Keywords: ICT skills; engineer education; faculty training

1. Introduction

March 2020 has been a turning point in teaching worldwide. The health emergency caused by COVID-19, with the application of confinement measures, involved the closure of education centres and the forced transition to distance learning. That has led many institutions to abruptly abandon face-to-face classes and replace them with online instruction [1]. As a consequence, many challenges were posed, such a lack of ''home office'' infrastructure both for teachers and students, like computers, internet availability, enough available bandwidth, time and effort needed to adapt the classes [2–4], and also lack of ICT and pedagogical skills to professionally design and deliver virtual education online [5]. But also, a window of opportunity was opened to include different options and resources to continue offering education for the students despite the pandemic. Teaching in this emergency situation made it possible to bring ICT use in the classes closer to teachers who, until now, had not considered it [2]. It has promoted reflection on their contribution to the learning process, reviewing the functions of teachers and faculty, [1] who, on the other hand, are key agents for the introduction of ICTs in teaching-learning processes [6].

Higher Education (HE) was no exception. The irruption of COVID-19 at the planetary level has posed the greatest challenge to education since World War II [7]. In fact, within a maximum period of one week, it had to take on the challenge of transforming itself and maintaining quality standards in teaching. The agility of many university organizations, focused on the transmission of face-to-face content was put to test, to move to an online environment and not always with an online pedagogy [5]. This has implied a significant effort on the part of different HE agents, like ICT support units, faculty training services and faculty members. Both ICT support units and faculty training services offered their professors a plethora of lectures, training sessions and even private tutorials to help them learn to use these tools and even how to use them effectively in their courses [4, 8]. There were numerous virtual courses and webinars with experts who shared their technological or techno-pedagogical knowledge with their peers.

Regarding faculty, they have had to move from being face-to-face teachers to distance teachers, without an adaptation period, or prior training and using means that educational institutions put at their disposal, and that were designed to complement face-to-face teaching [9]. According to

* Accepted 14 July 2021.

Donitsa-Schmidt & Ramot [4], the first confinement weeks could be described as hectic, frantic, and full of confusion, without visual feedback of the students' reactions, and without contact with other faculty members, to feel part of a socio-professional group that shared their problems and concerns. Therefore, teachers had to be deeply involved in the new teaching scenario, to help their students not to waste time with a failure or a decrease in their knowledge of the subject. And this commitment required working harder than ever before [8]. Additional hours were used to individually verify student attention and return feedback, which is one of the ways to increase effectiveness in group teaching [10].

In this line, different studies [11–13] point out that migrating from traditional or blended learning to a fully virtual and online strategy cannot be done overnight and is associated with many challenges. Because of the absence of a cautious design and development of the online strategies during this pandemic, this online experience should be considered rather as emergency remote teaching (ERT) than as effective online education.

This situation, common to all educational levels, has its specific connotations in HE and, specifically, in engineering studies, characterized by the high demand and difficulty of the content taught, the demands of reaching professional skills with a high level of social responsibility, together with the need of hands-on practical experiences that cannot always be substituted by online alternatives [11]. Faculty doubted if the enormous effort and dedication invested in adapting to online teaching would be rewarded with the students' acceptance of the new methodology and, above all, with their academic results in the medium and long term. Especially in these contexts, such as engineering and architecture studies, which in addition to being complex, are based on cumulative knowledge, so that if certain competencies have not been achieved, it is hard to tackle further steps within those contents. Hence new teaching models are needed, as well as learning new educational ICT, which requires a process [2]. In fact, for Cabero and Barroso [14], the management and incorporation of ICTs in the teaching-learning processes have revealed two great significant realities: the low or scarce technological-instrumental training of teachers, on the one hand; and on the other, the little didactic use made of the technological resources that teachers have at their disposal.

However, despite acknowledging the limitations of this ERT, the great number of experiences worldwide offer a high number of good teaching practices that should be taken into account. Not only for future well designed online programs but also to improve face-to-face strategies and blended learning [2]. The huge advancement in ICT use and the use of alternate resources and strategies will let many teachers incorporate practices to their classes. In fact, as Trujillo et al. [15] point out in a study with secondary education teachers, after the experience acquired in the pandemic, their preferred option for the course 2020-21, was a combination of face-to-face and distance teaching.

In this context, some studies around the use of ICT in HE have been published in which the centre of attention has been the student [3, 16, 17] and on the impact of COVID-19 restriction measures at different educational levels and different contexts. Most of these studies focus on specific countries, on technical aspects of e-learning or on the psychological or communication impact. [18]. They conclude that the use of technology in education provides benefits to students, although the training of teachers in this field is considered insufficient, as it was already described by Liu [19]. In fact, despite being less frequent, in those studies in which the teacher has been the focus of attention, the need for better initial and continuous faculty training in the educative use of ICTs is highlighted, with more emphasis on the most veteran staff [2]. The teacher is responsible for the integration of technology in educational programs that allow the modification of the learning process to place the student at the centre of the training process [6]. But, in most cases, teachers have not received specific training in the use of ICT [1]. Although younger faculty members, especially those who teach engineering content, are considered digital natives, this does not mean that they are trained in its active, critical and educational application as they need to be able to select and apply the range of its pedagogical possibilities [20].

In this study, the research focus has been the opinions and experiences of the teaching staff dedicated, for the most part, to the training of engineers. It has been carried out in the context of a Spanish polytechnic university that mainly trains engineers and architects. Their point of view about the change that, due to COVID-19, they have had to make to maintain a high-quality teaching has been analysed, in terms of the effort and time spent compared to their previous teaching, the use of different ICT, the difficulties and opportunities perceived and their preferences of future teaching and training modalities. The article also offers some opportunities and recommendations to move from the ERT caused by the pandemic to future effective online teaching in HE.

2. Faculty Training in ICT

The training of university faculty is a service,

generally, entrusted to the Departments and to senior professors who guide junior ones in their early years. This training is completed by attending courses, seminars, conferences or meetings between teachers. But, in general, there is no specific training to be a university professor as is required at other educational levels. In the case of the Universidad Politécnica de Madrid and other Spanish universities, there are centers specialized in faculty training[1] where the new lecturers receive voluntary initial pedagogical training. In addition, these same centers organize training activities aimed at lecturers who want to update their teaching methods and learn about the possibilities that ICTs put at their disposal.

Faculty training covers a wide scope of skills like planning, methodology, technology, tutoring, assessment, psychology, sociology and innovation. According to the historical data from the Institute of Educational Sciences of the Universidad Politécnica de Madrid (UPM), from 2000 to 2018 a considerable training investment was technology-focused [21]. However, most of the topics were related to face-to-face teaching and complementary tools for mathematics, simulation, and design. Specific training for distance teaching, like videoconference, eLearning planning or distance assessment, was secondarily requested. Nevertheless, these knowledge and technologies have proven to be of vital importance in the pandemic situation, due to the change in the traditional face-to-face educational model. The teacher must be a good communicator in the classroom, both online and also in a mixed model with part of the students at home and the other part in the classroom.

In this regard, García-Peñalvo et al. [22] reflect on what tools can be used in the shift to online training. Among the different types of online learning (knowledge base, online support, asynchronous, synchronous and hybrid training), which allow interaction, simulation and collaboration in an interactive environment, they propose a PLE (Personal Learning Environment) understood as a collection of tools that students use according to their personal needs. The difference between the LMS (Learning Management Systems) as learning managers and the PLE is that the former are institutional environments designed by the teachers and the PLEs are personally established by students, although both can be combined. However, regardless of the environment used, its integration can present barriers and difficulties for teachers such as time constraints, pressure from imposed guidelines, and lack of sufficient knowledge. Therefore, they need to acquire skills in the management of these electronic media to plan, implement and effectively evaluate the performance of their students [23].

These circumstances also imply a different methodological approach that will require adaptations on the part of students and teachers. As for the students, a greater involvement and autonomy is required [24]. Knowledge is not transmitted; it is acquired in an individual process that encourages self-criticism and responsibility and initiates students in reflecting on their learning. Distance training involves a transfer of learning control to students and the teacher's work is limited to accompanying and monitoring their actions. Students prepare study strategies, having a varied learning material that does not come from a single source. They become active actors in their own learning process, and they come to have a formative identity that goes beyond traditional learning contexts [14, 25]. Co-evaluation and self-evaluation actions play an important role in this aspect. Not forgetting that the problem of grading is real when students are not in the classroom and technology must be used to combat students from copying and avoid cheating [10].

As for teachers, the use of active methodologies is required: practical cases, teamwork, tutorships, seminars, discussion boards for interaction, multimedia technologies, etc., becoming agents that create learning environments that stimulate students, as pointed out by Crawford et al. [5]. But all this forces the teachers to be more dedicated as all this requires and allows a closer treatment, sometimes individual, of the student with closer and well-argued mentoring and a careful teaching guide. The direct contribution of the teacher will be specified in providing the specific contents of the subject, that is, what the student has to know, together with information, resources or actions aimed at making students aware of their situation and the need to develop and apply skills and strategies for their online learning. In addition, the teacher must plan virtuality, through different didactics than those of the conventional class. The contents are supplied gradually, allowing time for students to organize their work system, both individually and in teams. The communicational needs between participants and the management of cultural diversity must be considered. Distance training integrates physically, and culturally dispersed students and the teacher's voice should not be the only one heard in the classes.

[1] Among others. For example ICE-UPM (Instituto de Ciencias de la Educación, Universidad Politécnica de Madrid), ICE-UPV (Instituto de Ciencias de la Educación, Universidad Politécnica de Valencia), CUFIE (Centro Universitario de Formación e Innovación Educativa, Universidad da Coruña), Escuela de Formación – ULe (Universidad de León), ICE-UPC (Institut de Ciències de l'Educació, Universitat Politècnica de Catalunya), IUCE-USAL (Instituto Universitario de Ciencias de la Educación, Universidad de Salamanca).

Regarding the teaching competences for the switch to ERT, according to Tejedor et al. [18] students perceive the situation, when changing classes to distance mode, with too many negative aspects, such as online lessons being too similar to face-to-face classes and not being adapted correctly to online philosophy. In the case of Spain, these results are reinforced by the fact that students felt that faculty members did not have the appropriate skills to manage this mode of teaching. Their classes were of poorer quality, with less challenging and more boring lessons, and with more homework to do. Hence, the challenge now is to move from ERT to effective online teaching, and faculty training will play a significant role in the process.

Thus, the strengthening of educational planning and health measures in universities can give students and other actors the opportunity to continue learning and prevent the spread of the virus [23]. Not losing sight of the fact that the online education format can be helpful in the post-pandemic period, especially for students with special needs [10]. But this will require an important update in faculty training. Ultimately, higher education professors, researchers, and professionals should participate in and support research, evaluation, and strategic planning efforts to document best processes, increase evidence-based practices, and improve student learning in higher education. in the midst of COVID-19, thinking about future pandemics or the possible spread of other viruses in the coming years [23].

3. Method

3.1 Purpose of the Study and Objectives

The study presented in this paper is part of a broader study to understand faculty members' perceptions of teaching in COVID-19 times which also includes a section regarding emotional support and management. The results of that section are not analyzed here.

The study aims at answering the following questions:

1. What has been the advance in the management of technological tools?
2. What have been the barriers or difficulties encountered?
3. What have been the opportunities generated?

3.2 Design and Sample

A mixed design (quantitative and qualitative) was considered to carry out a descriptive analysis of the impact of distance teaching on the activity of the Universidad Politécnica de Madrid (UPM)' teaching staff.

Out of a total of 2892 faculty members who make up the UPM teaching staff [26], a convenient sample of 577 faculty members answered the questionnaire (almost 20%). The distribution in gender is 67% male and 33% female. As regards age, the mean in the sample is 51.93 (s = 9.52). The average teaching seniority is 19.88 years (s = 12.26). Faculty from all UPM centres and from different professional categories responded, with the participation of tenured faculty being more numerous. The distribution of professional categories in the sample is similar to the UPM population [26]. The different areas of knowledge that make up the educational community are also represented. Table 1 shows the principal distribution of the participants according to: gender, age, UPM seniority, current professional category.

Regarding the faculty teaching situation during confinement, 98% of respondents have taught courses. The most common level has been master courses. Size of groups has also been considered:

Table 1. Distribution of gender, age, UPM seniority, current professional category and teaching area

	Frequency	**Percentage**
Gender		
Female	187	32.4
Male	379	65.7
Missing data	11	1.9
Age		
≤30	10	2
31–40	71	12
41–50	145	25
51–60	231	40
≥61	106	18
Missing data	14	2.4
UPM seniority		
≤10	171	30
11–20	124	21
21–30	155	27
31–40	109	19
≥41	18	3
Professional category		
Professor	91	15.8
Associate Professor	205	35.5
Assistant Professor	196	34.0
Graduate Teaching Assistant	12	2.1
Adjunct Professor	69	12.0
Teaching area		
Forestry & Agronomy	113	19.7
Telecommunications & Computing	114	19.9
Civil engineering & architecture	165	28.7
Industrial technologies	158	27.5
Social Sciences	24	4.2

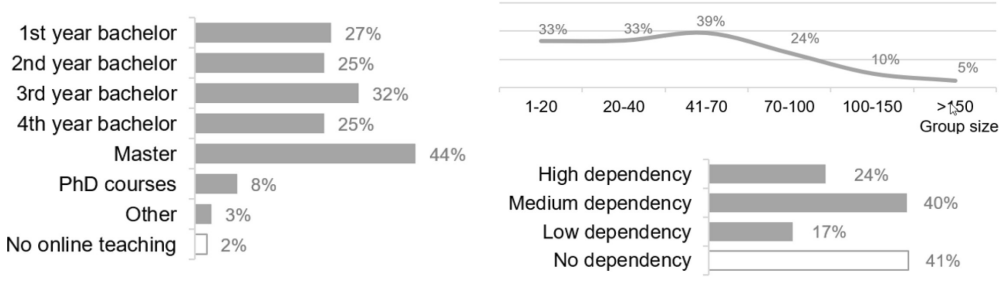

Fig. 1. Description of faculty situation regarding course years, group size and dependent people. High dependency: babies, elders and disabled people. Medium dependency: children and adolescents. Low dependency: adult children.

39% of faculty members had groups of 40 to 70 students, 33% of 20 to 40; 33% had less than 20 students per group and having more than 100 students per group was less frequent. Finally, 41% of faculty members did not have anyone in charge at home but the rest presented different situations of dependents: 40% of faculty members had a medium dependency situation, 24% high dependency and 17% low dependency (Fig. 1).

3.3 Instrument

An ad-hoc survey [27], elaborated and validated by experts in teacher training, collects the personal perceptions of teachers in different aspects through a 4 or 5-point Likert scale, together with demographic and personal information related to their professional career (seniority, category, among others). The survey comprises three sections: online teaching characterization (including types of activities and resources used: online classes, video recording for students, external videos, documents for autonomous reading, exercises with feedback, exercises for self-correction, online mentoring and email mentoring; exams organization and comparison with face-to face teaching in terms of time and effort); training and use of ICT (before, and during the confinement); and emotional management (which has not been analyzed in this study). The study is completed with several open questions, focused on the barriers and opportunities that have arisen with the change in teaching modality.

3.4 Procedure

The survey was sent by e-mail to all the faculty in the university. It consists of 35 questions, including demographic and professional profile items, and quantitative and qualitative items related with the study focus. The duration estimated to complete the survey was around 15 minutes. Data collection was accomplished from July to August 2020.

3.5 Data Analysis

The analysis of quantitative data was carried out with non-parametric tests, given the ordinal nature of most of the measurements obtained with the survey. Kruskal-Wallis and Wilcoxon tests are used for ranges differences and Spearman's coefficient for correlations. Specifically, Kruskal-Wallis test was used with independent variables with more than two categories (i.e., previous ICT training), to ascertain possible differences between independent groups. Wilcoxon test was used to check significant differences for paired groups. In the case of correlations of interval level variables (i.e., time, effort, increase in ICT knowledge), Pearson's test was performed. The statistical software SPSS/PC+, 26.0 was used to analyze data.

The analysis of qualitative data was carried out by the research team. The responses were coded and categorized. The type of categorization carried out was open or ad hoc, typical of the first phase of grounded theory. That is, it was inductive, since the categories were constructed from the data collected [28].

4. Results

The data analysis is structured in three main sections. First, the Advance in ICT use section reviews the quantitative results of the study, through non-parametric contrast tests of ranges averages and correlations. Then, the Difficulties and Opportunities sections review from a qualitative perspective the answers to open questions in which faculty present and explain, in personal terms, different aspects related to the change in teaching modality.

4.1 Advance in ICT use

Different aspects related to the impact of the pandemic on faculty are analyzed. First of all, the differences in relation to ICT knowledge and use are studied, before and after the change of teaching modality, as well as in relation to previous training to address them. The time invested in adjusting the teaching, as well as the effort spent, have been reviewed in relation to previous training, the increase in ICT knowledge, the variety of teaching activities carried out, and other variables such as faculty age, seniority and professional category and

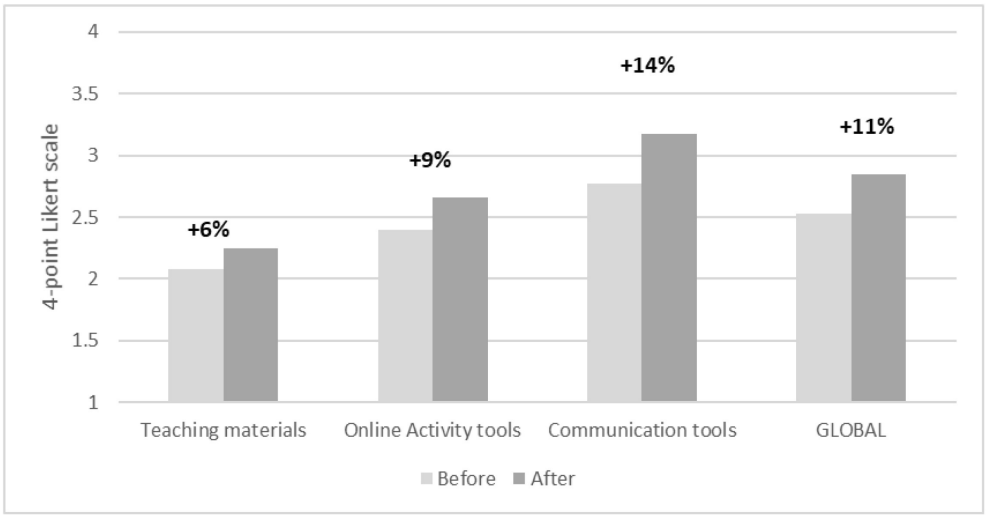

Fig. 2. Advancement in ICT knowledge and use. Comparison of faculty ICT knowledge and use before and after confinement (4-point Likert scale).

teaching areas, as well as courses years, gender and group sizes. Finally, faculty preferences for training (online, face-to-face and self-training) and teaching (face-to-face and online) have been explored.

ICT knowledge and use advancement due to the change to distance teaching was assessed through three variables: Communication tools -CT (including: C1: videoconferences, C2: surveys, C3: queries, C4 online classroom response systems, C5: chats, C6: collaborative tasks and C7: storage); Online activity tools – AT (A1: tasks, A2: discussions, A3: questionnaires, A4: co-evaluation, A5: glossaries and A6: video-lessons); and Teaching materials – M (M1: videos, M2: blogs and webs). The results show a general progress in the knowledge of ICT tools (Fig. 2). In fact, the increase is statistically significant in almost all of the items (Wilcoxon Z-test, with p-value = 0.000), except for online classroom response systems (C4) and Webs and blogs (M2) as it is shown in Table 2.

Regarding the advancement in ICT use and knowledge in relation to faculty ICT previous training, it is shown that the greatest increase corresponds to faculty members who had not received prior training, with significant differences in the use of communication tools (C-Total), and specifically, in videoconference, collaborative tasks and storage tools (Table 3).

The values shown by the indicators referring to the cost of changing the teaching modality (i.e., time and effort), from face-to-face to online, stand out. In fact, the faculty show that it has been much more costly than usual (in terms of time, $\bar{x}$ =4.68; s = 0.62 and effort $\bar{x}$ = 4.63; s = 0.59; 1 to 5 scale). The significant correlations obtained highlight the direct relationship between time and effort ($r_{(t\text{-}e)}$ = 0.62, p = 0.000), as well as between both of them and the increase in ICT knowledge, although these are much lower ($r_{(t\text{-}i)}$ = 0.14, p = 0.001; ($r_{(e\text{-}i)}$ = 0.16, p = 0.000). Concerning the analysis of time and effort perception in relation with faculty previous training, Kruskal-Wallis test reflects that they have not invested more time (H = 0.86, p = 0.836), but it has cost them more effort (H = 8.31, p = 0.040), especially for those who had no previous training in ICT (Table 4).

Considering the relationship of time and effort with the faculty' variety of teaching activities organized, age, university seniority, professional category, teaching area, and number of course years taught, the Kruskal-Wallis H-tests offer non-significant differences. However, gender does show significant results in both variables, with women reporting higher cost (time, H = 8.30, p = 0.004; effort: H = 10.14, p = 0.001). The size of the teaching group only shows significant differences in time spent, with H = 11.84, p = 0.037, which shows an increasing and constant dedication trend related to increase in group size.

The analysis is completed with the study of the correlation (Spearman's rho) between the time and effort spent in the change in teaching modality and other variables. Results indicate no relationship with the age, professional category or seniority of the faculty members. On the contrary, the variety of learning activities (type and number of task proposals) used in this period by faculty members shows a significant correlation with the time spent (rho = 0.12, p = 0.005), but not with effort (rho = 0.07, p = 0.122).

Finally, the faculty training preferences (face-to-face, online, self-training) are analyzed. In general, lecturers do not show a clear preference, with very close average values (face-to-face: $\bar{x}$ = 2.19, s = 0.82;

Table 2. Advancement in ICT knowledge and use. Increments' averages and Z-Wilcoxon tests for the differences before and after teaching modality

	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**CT**	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**AT**	**M1**	**M2**	**M**	**ICT**
$\bar{x}$	1.12	0.38	0.23	0.02	0.04	0.86	0.19	0.41	0.36	0.18	0.63	0.24	0.03	0.13	0.26	0.33	0.01	0.17	0.32
s	0.93	0.73	0.63	0.42	0.23	1.04	0.54	0.36	0.67	0.50	0.91	0.70	0.34	0.47	0.33	0.76	0.39	0.46	0.28
Z	–18.03	–11.07	–8.18	–1.20	–3.87	–14.90	–7.80	–18.44	–11.30	–8.11	–13.43	–7.57	–2.18	–6.55	–15.50	–9.52	–0.33	–8.47	–18.90
p(Z)	**0.000**	**0.000**	**0.000**	0.229	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	0.743	**0.000**	**0.000**

Significant differences are marked in **bold**

Table 3. Advancement in ICT knowledge and use in relation to previous ICT training. Ranges Averages (1: None, N = 57; 2: Self-training, N = 351; Training courses, N = 55; 4: Self-training & courses, N = 111). H-Kruskal-Wallis test

Ranges averages	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**CT**	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**AT**	**M1**	**M2**	**M**	**ICT**
1	348.50	314.80	292.40	293.80	296.54	377.79	323.54	384.02	316.37	303.27	306.67	306.49	290.54	263.23	329.66	283.86	290.85	287.86	368.69
2	275.70	279.50	287.90	284.20	287.10	287.18	283.45	277.64	287.26	283.59	290.74	286.42	286.26	283.61	284.68	287.00	283.72	284.81	279.95
3	302.90	284.40	284.30	298.50	287.10	243.29	293.61	274.48	293.73	307.66	244.05	257.35	285.71	299.98	267.47	306.60	286.08	302.91	276.22
4	285.90	300.30	285.30	289.30	284.32	264.05	278.78	275.55	270.33	281.77	288.95	296.09	290.73	306.08	284.69	281.49	298.43	288.18	275.28
H	11.14	4.36	0.17	1.54	1.64	26.03	8.30	21.86	4.69	3.67	5.85	5.51	0.41	9.56	4.91	1.49	2.65	0.84	15.35
df	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
p(H)	**0.000**	0.225	0.982	0.673	0.651	**0.000**	**0.040**	**0.000**	0.196	0.300	0.119	0.138	0.938	**0.023**	0.179	0.686	0.448	0.841	**0.002**

Significant differences are marked in **bold**.

Table 4. Cost of changing to online teaching, in terms of time and effort, in relation to previous training. Ranges averages (1: None, N = 57; 2: Self-training, N = 351, Training courses, N = 55; 4: Self-training & courses, N = 111). H-Kruskal-Wallis test

Range averages	Time	Effort
1	294.55	333.73
2	289.82	286.54
3	278.34	272.99
4	281.08	273.98
H	0.86	8.31
df	3	3
p(H)	0.836	**0.040**

Significant differences are marked in **bold**.

online: $\bar{x} = 2.44$, s = 0.80 and self-training: $\bar{x} = 2.41$, s = 0.76). Considering the preferences of future teaching modality (out of 100), a greater commitment to face-to-face is expressed ($\bar{x} = 58.67$, s = 28.59), followed by online-synchronous ($\bar{x} = 23.02$, s = 21.81), and online-asynchronous ($\bar{x} = 18.07$, s = 15.79). The older and with higher professional category are inclined towards the face-to-face format, while the younger and from initial professional categories bet on digitization to some extent ($r_{(age)} = -0.14$, p = 0.001; $r_{(UPM\ seniority)} = -0.14$, p = 0.001; $r_{(professional\ category)} = -0.10$, p = 0.015).

4.2 Difficulties

This section shows the results around three open questions that offer a global perspective of the problems found during confinement: the greatest costs in terms of teaching, the difficulties associated with assessment and evaluation and continuous monitoring.

Faculty members indicated numerous and varied aspects when asked about the greatest cost of online teaching for them (Fig. 3).

In the first place, and putting the focus on the students, the absence of communication stands out (almost 20%): faculty members miss not "seeing students' faces", feeling that they are speaking to no-one, since in general there is no teaching system in which to keep all students on screen at the same time; few teachers indicate that the higher cost has to do with the unfavorable disposition of the students (3%), their lack of commitment and involvement in their learning process. Very few indicate that monitoring their students has been the most difficult task for them (1%).

If we consider the teaching work itself, the responses indicate different aspects related to the change in teaching modality: adapting to online teaching (16%), which implies re-planning content, learning activities and tasks; distance evaluation (15%), including its preparation, its validity, and its meaning; and preparing teaching material adapted to the new circumstance (8%). Immediate update and without much support in the use of digital tools has also been costly (6%). Some indicate that the cost has been to "start" online teaching and very few point out that the shift to online teaching did not cost them additional effort.

Finally, there are other aspects that are not related to teaching but that affect it: the reconciliation with family life (9%) and the increase in work that it has entailed (11%). In addition, they also report the lack of resources: unstable internet connections, equipment, materials (7%). Finally, another 7% indicate as the costliest aspects, the

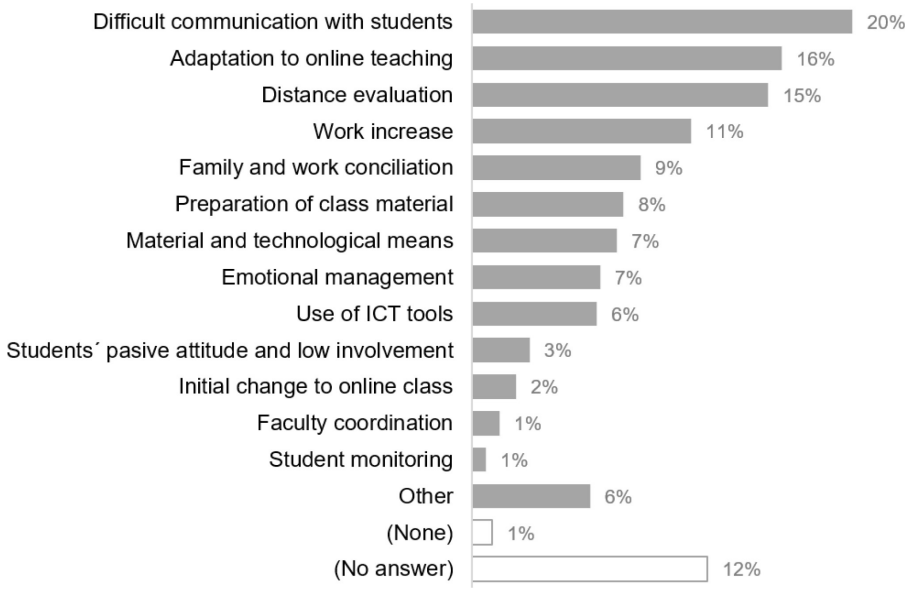

Fig. 3. Greatest costs in switching to online teaching.

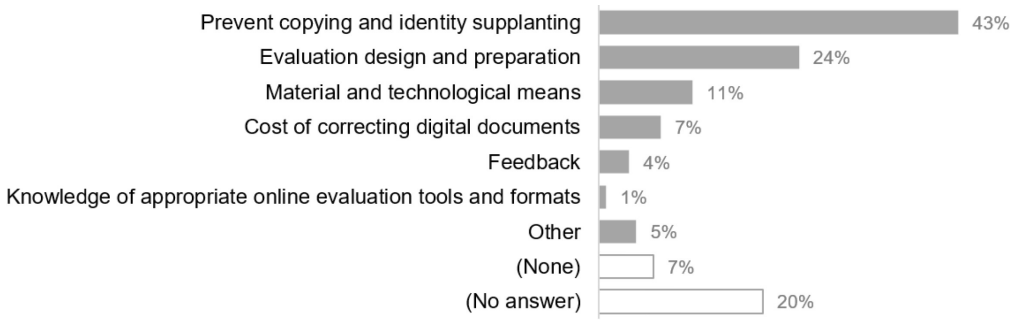

Fig. 4. Difficulties in planning, conducting and correcting distance exams.

lack of support and emotional aspects, such as isolation, anxiety, fatigue and assimilation of terrible news.

The online evaluation stands out as a great difficulty: especially due to the identification of the students and the need to guarantee their ethical behaviour (avoid copying; 43%), but its meaning is also questioned, as an accreditation of competences achieved. The effort required to design and prepare exams and evaluation tests (24%) and the increased cost of correction (7%) stand out. Some technical problems derived from the instability of internet connections have also been indicated (Fig. 4).

In relation to the difficulties found to carry out adequate monitoring of students (Fig. 5), faculty indicate as the most frequent: the low participation of the students (14.4%), the greater workload and time spent (10.9%), and the inability to receive feedback from students due to lack of eye or personal contact (10.9%).

4.3 Opportunities

The faculty have assessed whether they would like to maintain the modifications they have made in the way they teach for the coming year. It is interesting to note that 57% of the teachers consider that some resources and methodologies they have used in distance teaching can be useful in face-to-face or blended learning. On the other hand, 25% confess that they do not intend to incorporate anything used during ERT into face-to-face classes. This indicates that these teachers clearly separate the two teaching models (face-to-face and online) and what they consider useful in distance training has no place in face-to-face classes. The rest either do not answer (15%) or are undecided (3%).

Among the modifications to be maintained (Fig. 6), the most noted are the use of new resources and materials (12%), after-class online questionnaires (5%) and the incorporation of a new model of tutoring, via online that can be effective for students (7%). From a methodological point of view, it can be seen that some teachers point out the need to restructure their classes (4%), others opt to move to blended learning (3%), use flipped classroom (3%) or switch to online teaching (2%). Other opinions (4%) opt for different aspects: autonomous work, oral exams, more tasks, distance exams, team assessment, project-based learning, introduction of games, collaborative work or other forms of evaluation. Some simply consider that this situation that forced them to develop their classes online is going to influence their daily work, but they do not know very well how.

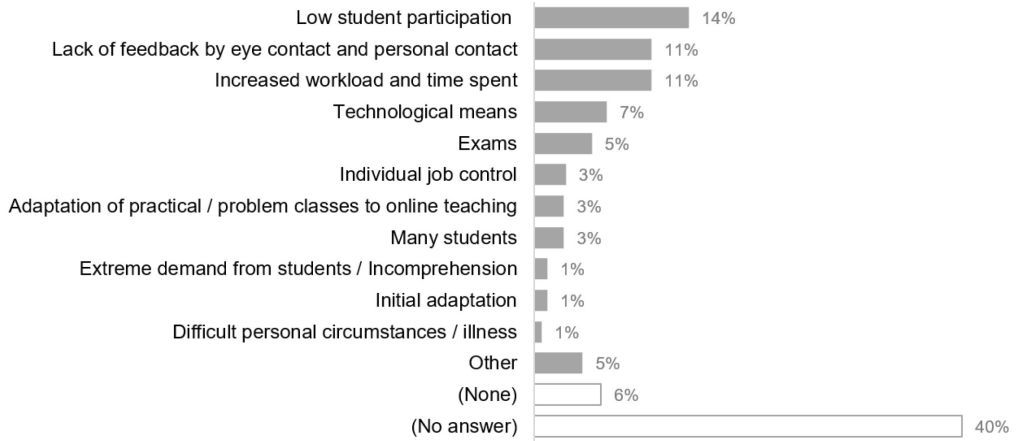

Fig. 5. Difficulties in monitoring students.

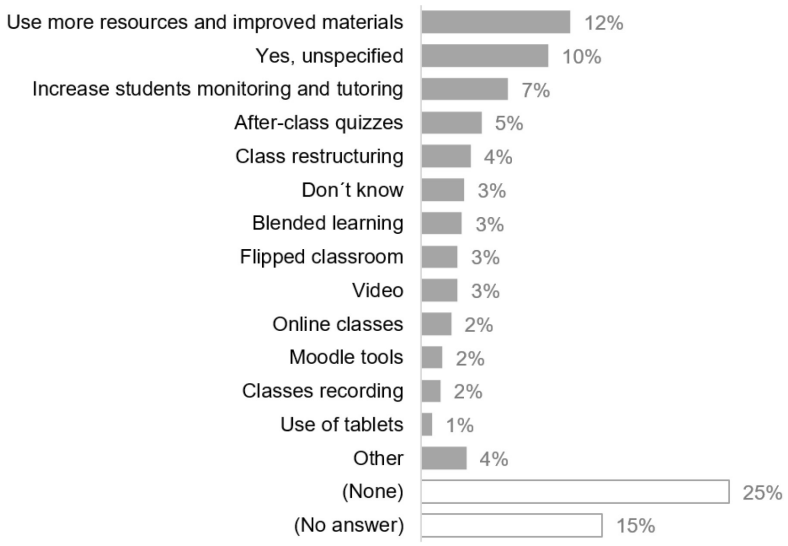

Fig. 6. Modifications made in pandemic teaching and to be incorporated.

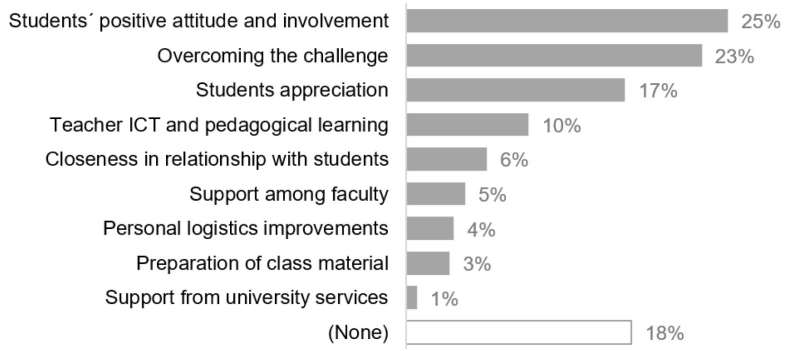

Fig. 7. The most satisfactory aspects about distance teaching work.

Regarding the most satisfactory things about distance teaching (Fig. 7), many of the respondents show surprise and satisfaction, basically for the students' attitude and gratitude and the relationship established with them. They highlight that the proper use of telematic means improves emotional closeness and more personalized relationships, which leads to greater participation during classes and a more relaxed atmosphere. Students are more aware of the effort and personal involvement of the teacher with learning, and they often appreciate it, even at the end of each class.

On the other hand, the satisfaction with the effort made to overcome the challenge of distance teaching stands out, which has resulted, in many cases, in better academic results. Some of them highlight the importance of teamwork among teachers to face the challenge and satisfaction with the feeling of unity. The learning and application of new methodologies and technologies, and the preparation or updating of materials has been a turning point that will facilitate the future work of faculty members.

Finally, in a less prominent way, reference is made to the logistical improvements that the use of teaching from home entails: reducing travel, losing less time, comfort and increasing family treatment.

5. Discussion

5.1 Challenges

Many studies at the international level have pointed out technology as one of the greatest difficulties of online university teaching in COVID-19 times (for example: [3, 11, 29]). This study has also evidenced through the responses of faculty members, that the digital divide is present and that it has affected both teachers and students. This has been observed not only in access (pointed by 11% of the respondents, and mainly related to slow connections and shared by several people, outdated computers for teaching requirements), but also, in the use and digital skills (6%), as remarked by Fernández Enguita [30]. The UPM, like the rest of Spanish universities, started

the confinement within an institutional scenario in which LMS and other technologies were already available to the educational community for 15–20 years, as indicated by García Peñalvo and Corell [31]. Despite this, its use still was, in most cases, as a repository of materials within courses designed under traditional schemes, with great weight of the teacher's role, as it has been highlighted by other studies in different contexts, such as the Argentinian [32]. This is especially remarkable in the case of the Spanish public universities, with a long tradition of face-to-face classes. From the 50 public universities, only 13 offer some blended degrees. The exception is the Universidad Nacional de Educación a distancia (UNED), which has offered online degrees for decades. Its proposal is based on a tutoring scheme, with few synchronous activities and the evaluation is carried out face-to-face. The online offer in Spain has therefore been covered by private universities, among which the following stand out: Universidad Nacional Internacional de la Rioja (UNIR), Universidad a Distancia de Madrid (UDIMA), Universidad Internacional de Valencia, Universidad Internacional Isabel I de Castilla and Universitat Oberta de Cataluña [33]. Interestingly, their expertise and possible natural leading role in the pandemic circumstances has not been reflected clearly in the Spanish HE scope.

Accordingly, in many cases, the master class remains the main teaching strategy, with few online interaction tools to adequately monitor progress. Hence it is not strange that two of the main difficulties pointed out by a relevant part of the respondents, are the lack of communication with the students (around 20%) and not perceiving their degree of understanding of the matter explained (11%). This lack of resources to closely monitor students generates in many lecturers a feeling of depersonalization of the teaching-learning process, as other studies also point out [24, 29].

Consequently, it seems logical that one of the greatest difficulties encountered was the assessment. Far from being done under the continuous assessment schemes promulgated by the European Higher Education Area (EHEA), it often continues to place great weight on the final knowledge test. De los Ríos et al. [33] described the inertia of the university to maintain traditional evaluation models. Thus, the greatest concern for many of the faculty members in this period (43%) has been the design of tests that could avoid copying and cheating, with the final feeling of not being able to achieve it and of being detrimental with honest students, which is consistent with other studies [11, 29]. On the contrary, another group of teachers has indicated that the appropriate use of ICTs has allowed them to have a closer relationship with the students (6%), greater emotional closeness (17%), a more relaxed environment and greater participation (25%). These two visions of the ERT may in turn be a reflection of the two great teaching models that coexist in the university, with a greater weight in the role of the teacher or the student.

The aforementioned results point out some areas of university teaching that require further transformation to adapt to the new educational horizon. While the faculty members' greatest advance in ICT use is manifested in communication tools (14%), the impact is less visible on their use for designing activities (9%) or creating materials (6%). So, the need to update teaching methodologies, especially evaluation systems, to give the student an active role in the teaching-learning process is highlighted, and also the digital transformation to support this methodological change. Not only for a possible online teaching scenario, but also to adapt the university to the new teaching-learning demands under face-to-face and blended schemes. Considerations for designing distance activities should establish the objectives and competencies that students must achieve, select the contents, indicate the available resources, establish the process' timing, expose the conditions for students grouping in collaborative tasks, control and follow the students' actions and decide and communicate the evaluation strategy. It must be considered, as Tejedor et al. and Crawford et al. indicate [5, 18] that although the resources used by the teachers during the confinement were mainly texts, these are not the ones that students prefer as digital sources for learning. They value more videos and other audio-visual and interactive materials, as well as activities that allow communication and interaction between peers and with the teacher. According to Moralista and Oducado [29], there are certain dynamics that suit best in face-to-face instruction and others in online learning, so faculty must be trained on how to promote student engagement in different scenarios.

All this approach will force the lecturer to master the virtual learning environment (VLE), to take advantage of its benefits and compensate for its weaknesses. It is urgent to adapt the subjects' teaching guides to distance training, to propose a variety of strategies and activities in a reasonable number (between compulsory and optional), and that cover the competences described in the syllabus. Faculty should include, among others: discussion panels, tasks included in the VLE (assignments, databases, reading documents, enquiries, questionnaires, glossaries, lessons, debates, forums, workshops); WebQuests development, creation of infographics and concept maps on

virtual contents, project-based learning, problem-based learning, case studies, research or exploration activities, role-playing games, simulations, virtual labs, flip-classroom, videoconferences, with all their possibilities and models (classes, proofs, debates, individual and collective mentoring, invitation to external experts, masterclasses). In the initial process phase, a welcome session with specific information is very important to clarify the subject rules, as well as activities to promote team building and communication between all those involved (teacher – student – student) and detect the group's previous knowledge and expectations. Additionally, in relation to the evaluation, it will be necessary to incorporate different strategies, beyond the classic models of multiple-choice exams, that manage to assess the work done by the student and the achievement of the competencies associated with the subject [35]. Realistic learning and assessment proposals will need to be carefully planned [36].

Regarding the specificity of some engineering subjects that require hands-on practical experiences, online alternatives, like virtual laboratories and simulators are presented as good options to complement practical education, or in case of a compulsory shift to online education [37]. But they cannot completely replace face-to-face training, as expressed by some faculty members (3%). Other studies have also gathered researcher's doubts for a full compatibility of online education with engineering, medical sciences or sport sciences [11].

In order to advance in the methodological change supported by ICT that the university requires, faculty training, supported by a determined institutional commitment, is shown as a fundamental tool and catalyst for change, both in teaching methodologies and in ICT skills that support them. This will enable to design the actions needed to achieve the learning objectives, and the evaluation methods in accordance with the EHEA to verify their degree of achievement. While these training programs already existed (many of them for more than 20 years [31]), their demand has increased significantly due to the need to compulsorily adapt to distance education and incorporate technology into teaching, although, as this study shows, no longer necessarily with the previous short and face-to-face scheme. Thus, faculty consider face-to-face and online training in the same way for future training, with very close averages (face-to-face: $\bar{x} = 2.19$, s = 0.82; online: $\bar{x} = 2.44$, s = 0.80). In line with what García Peñalvo and Corell [31] point out, it is evident that new approaches are necessary in this training, more flexible, open and inclusive, which include different online formats to the previous existing offer. While these formats already existed, the pandemic has managed to bring them closer to many teachers who were unaware of them and now consider them appropriate for their training. In fact, during the 2020–2021 academic year, the full program of the UPM faculty training service is being carried out completely online for the first time, with adaptations to online format. This is having an impact both in the number of participants in the courses and in the demand to participate in them. The increase in both variables has been estimated until June 2020–2021, taking into account that the training program ends in July. The distance training program has allowed to increase the number of participants in each course (65% higher) and the demand has increased around 12%. Regarding the courses related to digital teaching competences, offered in coordination with the UPM Tele-education Service (GATE), the number of participants has also increased, approximately by 30%. And the demand for this kind of course has risen by around 57%. Hence, the European Framework for the Digital Competence of Educators [38] will probably have to be revised to adapt to the new reality.

On the other hand, the evidence on the teaching model that still prevails in the university, very focused on the role of the teacher and with a predominance of summative evaluation, indicates the need to train new generations of lecturers with greater pedagogical and ICT skills. In Spain, initial training for university teaching is not a mandatory requirement, something that has been claimed by experts for decades [31, 39, 40]. At the UPM, there is an initial training program for university teachers, which until now is voluntary, offered since 1992 (even a previous version was offered since 1976), and which should take on greater relevance for the training of future teaching staff. In short, both for lecturers who join the university and for the rest, it is considered important to have a strategic training plan, preferably no longer based on willingness but on the HE institutional vision.

5.2 Opportunities

Despite the aforementioned challenges, it cannot be ignored that the ERT experienced in the months of confinement has meant a relevant advance in the digital transformation of the university. The data has shown the increase in the use of different ICTs in this period (Fig. 2) and around 60% of the teachers affirm that they will incorporate modifications in their face-to-face and distance teaching based on this experience. This advance has been possible due to the high efforts on their part and the institution to maintain quality teaching, as indicated by the data on the perception of extra time and effort invested in this study (($\bar{x}_t = 4.68$, $s_t = 0.62$

and $\bar{x}_e = 4.63$, $s_e = 0.59$; 1 to 5 scale) and in others [11].

In fact, as García Peñalvo and Corell [31] point out, the university community assumes that the supervening teaching model, supported in a relevant way by technology, will not disappear after the pandemic. This is in line with the results of the preference of the future teaching model of this study, which reaches 41.09% for the online modality, although more than half of the teaching staff's inclination is still to face-to-face classes. Analyzing this preference in relation to the age and professional category of the faculty members, significant differences have been observed. Older lecturers and lecturers with higher professional categories prefer face-to-face teaching. This result is contrary to the study by Moralista and Oducado [29], who point out the preference of the online modality for older teachers and those of a higher professional category, which they associate with a greater fear due to that age range of suffering the consequences of contagion. In this case, the concern of the necessary updating for the transformation of modality seems to predominate in the mentioned groups.

Finally, some positive aspects to maintain that have been highlighted by faculty members include the possibility of using from now on more resources and improved materials (24%), which partly have been developed during confinement. For example, the use of the LMS as a support for the subject learning activities, not only as document repository, multimedia materials for self-study of theoretical content, classroom response systems to encourage participation, attention and follow-up in online classes, and also the inclusion of online activities that promote learning and assessment by competencies, reducing memory requirements. Faculty members have also stated that they are now more eager to use other interactive tools specific to each discipline: simulators, compilers and virtual laboratories. Regarding monitoring and tutoring, 7% of respondents indicate that ICT use has allowed to increase it, mainly through self-assessment questionnaires with immediate feedback and videoconference systems.

Considering other aspects related to work and time organization, it has been pointed out that ICT use, especially videoconference and collaborative work systems have improved communication proximity, time flexibility and reduced travel. Interestingly, 5% of faculty members point out support and teamwork with colleagues as one of the most satisfactory aspects about distance work, which has increased despite social distance, as Donitsa-Schmidt and Ramot [4] also point out for the case of Israel (although a study on the perception of Spanish students in this period indicates the lack of coordination between teachers and the contradictory information as one of their complaints [18]). Continuous faculty training, pedagogical updating, revision and reflection have also been highlighted to support all the changes that faculty members are suggested to implement in the near future.

Further research is suggested to deepen the results of this study. A longitudinal approach which enables comparing faculty changes in perception after a new academic year would enrich the study. And also, the changes in faculty training and institutional support would complete the analysis of the change from ERT to effective strategies to effectively adapt to uncertain situations.

6. Conclusions

The increase in the use of ICTs due to COVID-19 has highlighted the digital divide for university faculty. The technologies were available, but a large part of the teaching staff did not know or use them. They maintained the inertia of traditional teaching with master classes and evaluation based on final tests with a great memory load.

Undoubtedly, the crisis has reduced this digital divide and has made many faculty members aware of the advantages and difficulties of using ICTs in education. Thus, the digital transformation has reached university teaching and offers a framework full of options that requires rethinking the teaching profession. The need to find activities, tasks and resources for different teaching scenarios (face-to-face and distance training) that guarantee the achievement of the professional competences of the graduates implies a work of reflection and important pedagogical updating. Some aspects that can be easily incorporated into any kind of university teaching are highlighted, such as new forms of multimedia and interactive materials, automatic questionnaires and distance mentoring. But the focus and cornerstone will be on the review of the processes and evaluation mechanisms that facilitate the monitoring of student progress, as well as the final grade of their achievements.

Hence, the responsibility of the teacher begins to evolve from a fulfilment of class hours and some evaluation tests to a focus on organizing learning and effective monitoring of students. For this, it is necessary to invest in faculty training in pedagogical methodologies and ICT use, and in the improvement of available technologies that reduce the feeling of isolation and increase the monitoring capacities of students. This leads to the need to rethink continuous and up-to-date training actions aimed at these faculty members. Until now, academic tasks had never been so complex and, at the same time, presented so many challenges and opportunities.

This paper has focused on the immediate impact of COVID-19 crisis on the teaching of a technological university. Further research in the medium and long term will enable to assess if the incorporation of ICT has supposed a real pedagogical change, posing the student at the center of the learning process.

References

1. J. Zimmerman, Coronavirus and the great online-learning experiment, *Chronicle of Higher Education*, March, 2020.
2. I. Dussel, La formación docente y los desaíos de la pandemia, *Educación, Formación e Investigación*, **6**, pp. 11–25, 2020.
3. M. D. H. Rahiem, Technological barriers and challenges in the use of ICT during the COVID-19 emergency remote learning, *Universal Journal of Educational Research*, **8**, pp. 6124–6133, 2020.
4. S. Donitsa-Schmidt and R. Ramot, Opportunities and challenges: teacher education in Israel in the Covid-19 pandemic, *Journal of Education for Teaching*, **46**, pp. 586–595, 2020.
5. J. Crawford, K. Butler-Henderson, J. Rudolph, B. Malkawi, M. Glowatz, R. Burton, P. Magni and S. Lam, COVID-19: 20 countries' higher education intra-period digital pedagogy responses, *Journal of Applied Learning & Teaching*, **3**, pp. 1–20, 2020.
6. M. C. López-De-la-Madrid, Impacto de las tecnologías de la información y la comunicación (TIC) en el docente universitario: el caso de la Universidad de Guadalajara, *Perspectiva Educacional*, **52**, pp. 4–34, 2013.
7. G. Gallello, S. Machause López and A. Diez Castillo, Respuesta docente frente a la pandemia de la COVID-19: el uso de Blackboard y Flipped Teaching en la asignatura de Metodología Arqueológica, *In-Red 2020-VI Congreso Nacional de Innovación Educativa y Docencia en Red 2020*, pp. 603–615, 2020.
8. F. J. García Peñalvo, M. Á. Conde García, M. Alier Forment and M. J. Casany Guerrero, Opening learning management systems to personal learning environments, *Journal of Universal Computer Science: JUCS*, **17**, pp. 1222–1240, 2011.
9. L. Espino-Díaz, G. Fernandez-Caminero, C. Hernandez-Lloret, H. Gonzalez-Gonzalez and J. Alvarez-Castillo, Analyzing the impact of COVID-19 on education professionals. toward a paradigm shift: ICT and neuroeducation as a binomial of action, *Sustainability*, **12**, p. 5646, 2020.
10. G. Basilaia and D. Kvavadze, Transition to online education in schools during a SARS-CoV-2 coronavirus (COVID-19) pandemic in Georgia, *Pedagogical Research*, **5**, 2020.
11. O. B. Adedoyin and E. Soykan, Covid-19 pandemic and online learning: the challenges and opportunities, *Interactive Learning Environments*, pp. 1–13, 2020.
12. A. Bozkurt and R. C. Sharma, Emergency remote teaching in a time of global crisis due to CoronaVirus pandemic, *Asian Journal of Distance Education*, **15**, pp. i–vi, 2020.
13. C. Hodges, S. Moore, B. Lockee, T. Trust and A. Bond, The difference between emergency remote teaching and online learning, *Educause review*, **27**, pp. 1–12, 2020.
14. J. Cabero Almenara, J. Barroso Osuna and M. C. Llorente Cejudo, El diseño de Entornos Personales de Aprendizaje y la formación de profesores en TIC, *Digital education review*, **3**, 2010.
15. F. Trujillo Sáez, M. Fernández Navas, R. Montes Rodríguez, A. Segura Robles, F. J. Alaminos Romero and A. Y. Postigo Fuentes, *Panorama de la educación en España tras la pandemia de COVID-19: La opinión de la comunidad educativa*. Fundación de Ayuda contra la Drogadicción (Fad), Madrid, 2020.
16. F. J. García-Peñalvo, A. Corell, V. Abella-García and M. Grande, La evaluación online en la educación superior en tiempos de la COVID-19, *Education in the Knowledge Society*, **21**, 2020.
17. M. Adnan and K. Anwar, Online Learning amid the COVID-19 Pandemic: Students' Perspectives, *Online Submission*, **2**, pp. 45–51, 2020.
18. S. Tejedor, L. Cervi, A. Pérez-Escoda and F. T. Jumbo, Digital literacy and higher education during COVID-19 lockdown: Spain, Italy, and Ecuador, *Publications*, **8**, p. 48, 2020.
19. S. Liu, A Multivariate Model of Factors Influencing Technology Use by Preservice Teachers during Practice Teaching, *Educational Technology & Society*, **15**, p. 137, 2012.
20. M. Pérez Martín, Necesidad explícita de formación digital del profesorado, *XXV jornadas universitarias de tecnología educativa*, pp. 61–68, 2017.
21. A. Caravantes, I. Pablo-Lerchundi, G. Martí-Blanc, J. L. Martín-Núñez and J. A. Sánchez-Núñez, Training profile of faculty in applied sciences, *The International Journal of Engineering Education*, **34**, pp. 1504–1515, 2018.
22. F. J. García-Peñalvo, El sistema universitario ante la COVID-19: Corto, medio y largo plazo, 2020.
23. C. M. Toquero, Challenges and Opportunities for Higher Education Amid the COVID-19 Pandemic: The Philippine Context, *Pedagogical Research*, **5**, 2020.
24. I. Prokopenko and S. Berezhna, Higher education institutions in Ukraine during the coronavirus, or COVID-19, outbreak: new challenges vs new opportunities, *Romaneasca pentru Educatie Multidimensionala*, **12**, pp. 130–135, 2020.
25. R. Brent, M. Prince and R. Felder, Promoting and Managing Student-Student Interactions in Online STEM Classes. *International Journal of Engineering Education*, **18**, pp. 27–37, pp. 797–813, 2021
26. Universidad Politécnica de Madrid, Portal de transparencia. https://transparencia.upm.es/, Accessed 10 March 2020.
27. Instituto de Ciencias de la Educación de la UPM, Impacto de la docencia a distancia, *Retrieved from: http://www.ice.upm.es/datos/archivos/pdf/DTW1028VMJ.pdf*, 2020.
28. A. L. Strauss, *Qualitative Analysis for Social Scientists,* Cambridge university press, 1987.
29. R. Moralista and R. M. Oducado, Faculty Perception Toward Online Education in Higher Education During the Coronavirus Disease 19 (COVID-19) Pandemic, *Available at SSRN 3636438* **8**, pp. 4736–4742, 2020.
30. M. Fernández Enguita, Una pandemia imprevisible ha traído la brecha previsible, *Retrieved from: https://bit.ly/2VT3kzU*, 2020.
31. F. J. García Peñalvo, A. Corell, La COVID-19: ¿enzima de la transformación digital de la docencia o reflejo de una crisis metodológica y competencial en la educación superior?, *Campus Virtuales*, **9**, pp. 83–98, 2020.

32. M. Maggio, Las prácticas de la enseñanza universitarias en la pandemia: de la conmoción a la mutación, *Campus Virtuales*, **9**, pp. 113–122, 2020.
33. C. Torrecillas. El reto de la docencia online para las universidades públicas españolas ante la pandemia del Covid-19, *ICEI Papers COVID-19, 16. Retrieved from: https://eprints. ucm. es/60050*, 2020.
34. I. De los Ríos, S. Sastre-Merino, C. Fernández, C. Núñez del Río, E. Reyes, N. García, La evaluación a examen, *V Congrés Internacional UNIVEST'15*, pp. 386–391, 2015.
35. M. S. Ibarra Saiz, G. Rodríguez Gómez, Aprendiendo a evaluar para aprender en la Educación Superior, *Revista Iberoamericana de Evaluación Educativa*, **13**, pp. 5–8, 2020.
36. W. Zhan, B. Hur, Y. Wang, S. Cui and B. Yalvac, Creating Maker Culture in an Engineering Technology Program, *International Journal of Engineering Education*, **37**, pp. 712–720, 2021.
37. A. U. Yerden and N. Akkus, Virtual Reality Remote Access Laboratory for Teaching Programmable Logic Controller Topics, *International Journal of Engineering Education*, **36**, pp. 1708–1721, 2020
38. C. Redecker, European Framework for the Digital Competence of Educators: DigCompEdu, in Y. Punie (ed.), JRC Working Papers JRC107466, Publications Office of the European Union, Luxembourg, 2017.
39. J. A. Sánchez Núñez, Formación inicial para la docencia universitaria, *Revista Iberoamericana de Educación*, 2007.
40. A. Fernández March, La formación inicial del profesorado universitario: el título de Especialista Universitario en Pedagogía Universitaria de la Universidad Politécnica de Valencia, *Revista interuniversitaria de formación del profesorado*, **22**, pp. 161–187, 2008.

Susana Sastre-Merino, PhD, is Assistant Professor at the Institute for Educational Sciences of the Technical University of Madrid (UPM) where she teaches Educational Innovation and Research in a Master Program for Secondary Education teachers in STEM areas, and long-life training courses for Higher Education professors, and takes part of the Initial Training Program for UPM professors. She also has experience in secondary education teaching. She has participated in numerous Educational Innovation Programs related to teaching in STEM areas, specially focused on the development and evaluation of transversal competences. She has several articles and books chapters related to capacity building and education.

Mª Cristina Núñez-del-Río has a PhD in Educational Sciences. She is Associate Professor at the Institute for Educational Sciences – ICE at the Universidad Politécnica de Madrid. She leads the Research Group ForPROFE She is an expert in Methods of Applied Statistics. Her lines of research focus on educational guidance and attention to diversity. She is the author of more than 30 papers in national and international journals, books and book chapters. She has also been a counselor for more than 15 years in a special education center. Since 2011 she has been working as a senior lecturer at the Institute of Education Sciences of the Technical University of Madrid (UPM). ORCID: https://orcid.org/0000-0002-3349-8015.

Arturo Caravantes had a MA in Industrial Engineering and PhD in Process Control and Artificial Intelligence, professor at the Educational Sciences Institute (ICE) of the Universidad Politécnica de Madrid since 1996. His research mainly focuses on Modelling of Intelligent Educational System and Educational Technology Implementation. He has developed and applied several educational systems and models such as AVTIX, MAP and GEK.

Juan Luis Bravo-Ramos has a PhD in Mass Media Communication Sciences. Since 1981 he has been Full Professor at the Institute for Educational Sciences – ICE at the Universidad Politécnica de Madrid. Coordinator of educational projects and specialist in Information and Communication Technology (ICT). His research mainly focuses on the use of the mass media in the classroom to support scientific dissemination. He is also experimenting with the evaluation and co-evaluation of students' knowledge through the use of rubrics and self-rubrics with different models and means (telephones, virtual classrooms, spreadsheets, printed material, etc).