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Resilient Strategies for Internet-Based Education: Investigating Engineering Students in the Canary Islands in the Aftermath of COVID-19

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Abstract: The COVID-19 pandemic has brought about notable changes in the education sector, specifically the shift towards online learning. This study examined the experiences of 124 engineering students in the Canary Islands, an EU ultra-peripheral region, as they adapted to online education during the pandemic. A comprehensive survey assessed students' experiences in five key dimensions, including satisfaction with traditional face-to-face learning, perceptions of the engineering department's transition to online learning, module-specific adaptations, personal adaptation strategies, and the adaptation of teaching staff. The study's methodology involved statistical analyses using Microsoft Excel v16.0 and SPSS 27 tools to identify patterns and draw conclusions. The findings indicate a nuanced landscape. Students demonstrated strong technological literacy and readiness for online learning. However, they expressed concerns about educators' digital proficiency and perceived a decline in educational quality. These results emphasize the critical need for sustainable, adaptable, and inclusive educational strategies, particularly in regions like the Canary Islands that face unique challenges. The implications of the study have broader relevance to digital education. It is essential to note the need for educators to receive comprehensive training in digital tools and methodologies to improve the quality of online learning.

Keywords: ultra-peripheral region; education transformation; STEM; higher education

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1. Introduction

As the COVID-19 pandemic unfolded in 2020 governments across the world implemented measures to mitigate the spread of the virus. These measures meant significant changes to daily life at every level of society including in higher education [1,2]. Indeed, in terms of its impact on the education, the COVID-19 pandemic could be considered an unparalleled global experiment which has had profound and long-lasting repercussions for teaching and learning dynamics particularly in the way it may have accelerated the adoption of sustainable practices and technologies into the fabric of educational institutions [3].

The rate at which modern technology is reshaping society is unprecedented [4,5] and universities must keep pace with these changes to continue to meet the needs of society [6,7]. In addition to responding to the social, cultural, and technological changes taking place, universities also need to remain accountable to their students, staff, and society at large [8,9]. Furthermore, digitalization has altered the economic landscape of education forcing universities to consider new strategies and rethink how to conduct business successfully and achieve their goals [10,11].

When the World Health Organization declared COVID-19 a global pandemic on 11 March 2020, governments across the world responded with a range of approaches to the crisis [12]. For example, the Spanish government declared a state of alert on 14 March 2020, through Royal Decree 463/2020, and in common with measures taken in many countries across the globe, it limited peoples' freedom of movement and closed down all public spaces including retail and hospitality spaces, museums, and, importantly, schools and universities [13]. The sudden closure of the education sector resulted in a profound disruption to university teaching activities [14] which, in Spain, was ongoing not only through the remainder of the 2019–2020 academic year but also extended into the following year (2020–2021) [15]. This kind of situation was not uncommon across the globe and has led to a cascade of consequences for institutions, teachers, and the student experience [16–18].

As in much of the rest of the world, Spain's pandemic-related closure of schools and universities rapidly triggered a move to online, distance learning to ensure educational continuity for students [19,20]. Distance learning has many benefits including being less circumscribed by the issues of time, space, and the synchronous interaction associated with traditional classroom-based learning; however, for institutions organized around face-to-face learning it presents significant challenges for all educational stakeholders [21]. After the peak of the pandemic, as restrictions were lifted, a hybrid model (mixing online and face-to-face teaching and learning modalities) became common, bringing with it a new set of advantages and disadvantages [22].

In many ways the COVID-19 health crisis gave universities a timely wake-up call about the need to embrace the digital revolution while at the same time emphasizing the importance of higher education taking the lead in innovation in teaching methodologies [23,24] and in developing more resilient education systems [25]. Thus, the numerous transformations brought on by the pandemic, while beneficial, have, for many organizations, highlighted a gap between their strategic plans and actual progress made. In addition, several aspects of the increasing digitalization of education have made faculty members feel particularly vulnerable; insufficient technological know-how among teachers combined with a lack of sufficiently high-quality digitized learning resources and content [26] thus emerges as one of the principal challenges of the moment.

Failures in the implementation of online learning by higher education institutions during the pandemic are largely due to the lack of proper planning, design, and development of the educational programs offered [27]. Indeed, Ref [28] emphasize the distinction between what might be termed conventional online instruction which has been shown to be effective and the strategies put in place as crisis measures with very few resources during the pandemic. The case of the pandemic is an example of emergency remote teaching, whereby educators use digital educational tools but deliver a curriculum or instructional content designed to be taught in physical classrooms or through hybrid or blended courses [29]. Beyond this issue, there were also many other obstacles to learning encountered during the pandemic experience of online education ranging from a lack of devices to inadequate infrastructure such as internet connectivity. These observations are not new; studies concerning the most comparable scenario from recent history, the 2009 H1N1 pandemic, revealed that higher education institutions were similarly ill-equipped and unprepared for online learning [30].

Concerning higher education students, as noted by Lim and Wang ([31], p. 12), despite being of a generation characterized as digital natives, accustomed to using devices in their everyday lives, in many cases they either do not own appropriate devices to access online learning or lack a solid foundation in digital literacy. In this publication, authors go on to explain how both these factors can hinder students' ability to learn effectively in online environments [31]. These observations would seem to be supported by the findings of some post pandemic research on this issue, for example [32] concerning Indonesia, and [33] concerning Ethiopia, which both found a connection between a lack of technological preparedness and poor outcomes.

That the online context becomes a barrier to effective learning is likely to contribute to demotivation among students. Indeed, in a study of Japanese medical students' attitudes to learning during the COVID-19 pandemic, the experience of online learning was one of the most cited factors in lowering their motivation to study [34]. Similarly, a study of Pakistani school students suggests that negative experiences of online learning were significant factors—alongside financial and other socioeconomic factors—in students' decisions to drop out of education during the pandemic [35].

The concept of student motivation is closely linked to the idea of student satisfaction [36]. Indeed, good levels of student satisfaction are essential to maintaining and increasing students' academic engagement and reducing drop-out rates. Therefore, higher education institutions worldwide use student surveys [37] to measure student satisfaction so enabling them to assess how successfully they are meeting students' needs and determine the effectiveness of their methodologies [38]. This information can then be used to feed-back into decisions about issues that affect students thereby improving students' overall educational experience [39].

2. Literature Review

The temporary closure of schools and universities called for emergency remote learning, where teaching and learning were shifted from face-to-face to online [40,41]. Emergency distance learning can be defined as a temporary shift of instructional delivery to an alternative delivery mode due to crisis circumstances [42]. In the literature, Emergency Remote Teaching (ERT) responds to the demands of unpredictable situations, which presents challenges such as demotivation, anxiety and confusion, but provides teachers and students with initial experience in using and experimenting with technology tools in an online environment [43].

However, these practices are a result of previous trends in online learning. Since integrating ICT into education, many universities have adopted this way of teaching and learning to facilitate access to learning for students from anywhere and at any time. Online education is a mode that is carried out in virtual learning environments (VLE), through the Internet and with the active use of digital devices [44–46]. The shift to a learner-centred approach in online learning distinguishes it from traditional face-to-face learning, while its differentiation from ERT lies in its deliberate planning and organisational structure, which has involved several years of studies, theories, models, standards and evaluation [47]. This shift and distinction has allowed for the adoption of other models, such as hybrid learning and flipped classrooms, to adapt to online teaching and learning.

However, the development of digital and social skills has been the success of online education; teachers and students are adopting new ways of teaching and learning that allow them to interact with each other and with content through technological devices. As a result, these skills are rapidly becoming vital competencies for citizens to acquire in an increasingly digital world. Domestication theory highlights how individuals place technology in their daily lives [48,49], where various social, cultural, economic and political factors influence the use and engagement of computer and internet technologies. This availability and access to technology in all aspects of life has facilitated and encouraged digital acceptance. In online education, technology acceptance uses a model to understand the adoption and use of e-learning in underdeveloped countries [50] and its integration in fields such as STEM to enhance learning and promote inclusivity and equity. Today's learners are used to using devices in their daily lives, but integrating technology into their studies requires careful and organised planning. The Unified Theory of Acceptance and Use of Technology (UTAUT) suggests that acceptance is achieved through perceived usefulness, ease of use, intention to use, subjective norms and facilitating conditions [51]. Despite the benefits and opportunities offered by information and communication technology in education and the adaptations made by ERT, setbacks and challenges have also been identified, such as the lack of social interaction, digital literacy and readiness, and the unplanned implementation process of online education [52]. This digital divide has become

more pronounced during periods of increased reliance on digital technologies and has been addressed more in terms of how socio-demographic factors shape educational experiences and outcomes [53].

Our theoretical approach is based on notions of digital learning adaption and educational resilience, which are directly relevant to the investigation of engineering students' experiences during the COVID-19 transition to online education. This approach helped shape our study aims and questions, directing our investigation of how pupils in a particular geographic and educational setting, such as the Canary Islands, reacted to the abrupt shift to digital learning environments. For example, we used the notion of educational resilience to assess students' abilities to retain effective learning in the face of disruptive changes. This theoretical approach is critical for understanding the differences in student experiences, particularly in adjusting to online learning tools and techniques.

As the above discussion demonstrates, there has been a significant amount of research into the transformation of education caused but the COVID-19 pandemic. However, the impact of the pandemic on teaching and learning processes in STEM subjects specifically is an area requiring more investigation, especially regarding students in highly peripheral regions, such as the Canary Islands. This work aims to addresses this gap by examining the perceptions of online education during the COVID-19 pandemic among students in the Engineering department at the University of las Palmas de Gran Canaria (ULPGC), contributing to the understanding of sustainable educational practices in unique regional contexts.

3. Research Questions

The principal aim of this work is to assess the level of overall satisfaction with online teaching during COVID-19 among Engineering students from the Canary Islands, an ultra-peripheral region of the EU. Assessing contributes to the development of resilient, adaptable, and inclusive educational practices in geographically isolated regions. These are key components of sustainable education systems in the digital age. To this end, we will address the following research questions:

RQ1: Are students generally satisfied with their online education experience and the skills they have acquired?
RQ2: During the period of online education required due to the COVID-19 pandemic, how well do engineering students at ULGC feel:

(1) The engineering department adapted?
(2) Course modules were adapted?
(3) They and their teachers adapted?

RQ3: What lessons can be learned from this experience to create a sustainable digital education environment?

4. Materials and Methods

This is an exploratory, descriptive study based on the quantitative analysis of data collected through a survey. Our corpus is a convenience sample of students from the School of Industrial and Civil Engineers at the University of Las Palmas de Gran Canaria (ULPGC) in the Canary Islands, Spain. Within this sample, students represented a variety of engineering specialisms including electrical, naval, and chemical engineering. Data collection took place between July 2021 and October 2023.

The corpus was recruited during normal class time (in-person) with questionnaires handed out to students at the beginning of lectures to maximize response rates. Students were informed of the purpose of the research emphasizing that participation in the survey was not mandatory. In addition, students were assured and that data protection guidelines would be followed, highlighting that anonymity and confidentiality were guaranteed.

There was no pre-existing questionnaire tailored to our research objectives; thus, a customized survey was created (see Appendices A–C). The authors' personal experiences

of transitioning from traditional in-person teaching to online teaching during the pandemic were key in designing this survey.

The questionnaire comprised closed-ended questions to be answered on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). This range of answer options was considered sufficient to capture the nuances of respondents' opinions and feelings [54–56], but, given the limited range of emotional responses recorded and to simplify interpretation, the results were subsequently consolidated into a three-point scale [57–59]. The questionnaire covered six key areas: one concerning sociodemographics (5 questions), general satisfaction (18 questions), satisfaction with skills and traits acquired for employability (23 questions) and four concerning the move to online education, specifically, departmental adaptation (4 questions), module-specific adaptation (6 questions), students' adaptation (13 questions), and teachers' adaptation (6 questions).

The questionnaire was developed through a rigorous process based on a theoretical review. It was tailored to our context, which involves engineering students transitioning to online education in the Canary Islands. We incorporated elements from established scales in digital learning and educational resilience to ensure the relevance of each question to our study's topic.

The preliminary scale was sent to several experts to develop a Delphi technique. A panel of content experts from Edutools, a consolidated Educational Research Group of the Government of Castilla y León (Spain), was selected to develop the questionnaire. The experts conducted a content analysis and generated a list of possible topics. The instrument's reliability was assessed through a pilot study, ensuring the questions' clarity, relevance, and reliability before finalization. The reliability of the Likert scale used to evaluate the internal consistency of the questionnaire was measured using Cronbach's alpha coefficient [60]. An alpha coefficient approaching 1.0 indicates a high level of reliability, while values exceeding 0.7 are considered acceptable for Likert-like surveys [61]. The scale obtained a coefficient above 0.7 with the sample used in the pilot study, confirming the instrument's internal consistency.

5. Results and Discussion

5.1. Corpus Characterization

Referring to Table 1, the sample comprises 124 students most of whom are male (84%), as is still common in many STEM programs. The majority of the corpus (65%) are enrolled in their third year (typically over 21 years old), while 35% are enrolled in their fourth year (typically over 22 years old). The age distribution thus spans a range from 20 to 27 years old but is heavily weighted towards the younger age groups (20–23 years old). In terms of devices used to access online learning during the COVID-19 pandemic, all students reported using a smart phone and 75% said they used a computer while 41% said they used a tablet. It is important to note here that students' exposure to appropriate devices outside of a learning context seems to facilitate their use for educational purposes [60,61]. Thus, it appears that participants in this study were well prepared for online learning with ample access to and experience in the use of the necessary tools for effective online learning.

Table 2 illustrates which factors influenced students' choice of undergraduate degree. Three dimensions had a high mode prevalence for one option showing strong consensus among participants: items 6a; 6e, and 6f. Of these the biggest positive influence on students' decision is item 6f with 73% of respondents agreeing or strongly agreeing (score 4–5) that a degree should be chosen based on the job opportunities it might offer. In contrast, students gave low importance to tradition and the limitations of admission scores with 74% in each case strongly disagreeing (score 1–2) that these are relevant factors. This can be attributed to one of two possible scenarios: either STEM programs are accessible to those with relatively modest academic credentials, alleviating concerns about rigorous admissions requirements, or, alternatively, prospective STEM students, who are often characterized by higher intellectual capacity, may inherently have fewer concerns about meeting such criteria.

Table 1. Sociodemographic data (questions 1 to 5).

Variable	Scale	No.	%
Gender	Male	104	84
	Female	20	16
Age	-	20–27	100
Year	3rd	80	65
	4th	44	35
Device the student uses:	Computer	93	75
	Tablet	51	41
	Smartphone	124	100

Table 2. Factors influencing undergraduate degree choice. Participants rated items from 1 (strongly disagree) to 5 (strongly agree). Mode Prevalence: High (>70%), Average (50–70%), Low (<50%). The % of respondents is rounded to whole numbers.

Question 6: Why Did You Choose Your Degree Course?						
Item	**Score**	**No.**	**%**	**Mean**	**Mode**	**Mode Prevalence**
(a) Because of tradition	**1–2**	92	74	2.3	1–2	**High**
	3	16	13			
	4–5	16	13			
(b) Because of family recommendation	**1–2**	38	31	3.0	3	Low
	3	52	42			
	4–5	34	27			
(c) Because I have a vocation	**1–2**	10	8	3.7	4–5	Average
	3	36	29			
	4–5	78	63			
(d) Because of the recommendations of other people	**1–2**	74	60	2.4	1–2	Average
	3	30	24			
	4–5	20	16			
(e) Because I was unable to do any other degree due to my university entrance score	**1–2**	92	74	1.9	1–2	**High**
	3	4	3			
	4–5	28	23			
(f) Because it offers the best job opportunities	**1–2**	16	13	4.1	4–5	**High**
	3	18	15			
	4–5	90	73			
(g) Because I could not afford to study outside my home region	**1–2**	58	47	2.8	1–2	Low
	3	22	18			
	4–5	44	35			
(h) Because I didn't want to study outside my home region	**Low**	40	32	3.3	4–5	Average
	Average	18	15			
	High	66	53			

Other factors where there is moderately strong consensus on their positive influence included having a vocation (item 6c) and not wanting to relocate to study (item 6h) with 63% and 53%, for each item respectively, agreeing/strongly agreeing that these were important

in their decision making. Concerning students' wish to avoid relocation to study, this may be due to the considerable distance between the Canary Islands and the Iberian Peninsula (1700 km). It is also worth noting that this is a reason for ULPGC maintain its diversity of courses to satisfy students' needs. At the other end of the scale, recommendations from other people (item 6d), are seen as largely unimportant with 60% strongly disagreeing that they are relevant to choosing a university degree.

5.2. Student General Satisfaction

Student satisfaction levels for some crucial aspects of their academic life are presented in Table 3. Several items demonstrate that students have quite positive attitudes towards their studies, most notably, 77% of students agree/strongly agree that they enjoy the classroom atmosphere (item 7o: score 4–5). Furthermore, 73% of students thought they would choose the same course again (item 7r; score 4–5), demonstrating that most students seem to be very satisfied with their studies. There are moderate levels of satisfaction with the course content and specializations offered (item 7k) with the majority (58%) scoring 3 for this item while 31% score this item 4–5. Most students feel their course offers a high level of academic demand (item 7m)—as might be expected of a STEM subject—with 53% of students rating this item 4–5. In addition, real-world preparation, represented by the availability of internship opportunities (item 7p) registers good satisfaction rates for significant number of students with 56% of students giving this item a score of 4–5.

Table 3. Student satisfaction with various aspects of their academic experience. Participants rated items from 1 (strongly disagree) to 5 (strongly agree). Mode Prevalence: High (>70%), Average (50–70%), Low (<50%). The % of respondents is rounded to whole numbers.

Question 7: Do You Agree or Disagree with the Following Statements about Your Degree Course?						
Item	**Score**	**No.**	**%**	**Mean**	**Mode**	**Mode Prevalence**
(a) The general quality of academic counseling and guidance is good	**1–2**	42	34	2.7	1–2	Average
	3	72	58			
	4–5	10	8			
(b) The syllabus is adequate	**1–2**	10	8	3.2	3	Average
	3	86	69			
	4–5	28	23			
(c) The theoretical training is good	**1–2**	14	11	3.0	**3**	**High**
	3	94	76			
	4–5	16	13			
(d) The practical training is good	**1–2**	52	42	2.6	3	Average
	3	58	47			
	4–5	14	11			
(e) The teaching staff delivering my course contents are competent	**1–2**	34	27	2.9	3	Average
	3	68	55			
	4–5	22	18			
(f) My course enables me to develop key skills and competencies	**1–2**	28	23	3.0	3	Average
	3	62	50			
	4–5	34	27			
(g) The teaching methodologies used and the activities we are given are well thought out	**1–2**	42	34	2.9	3	Low
	3	48	39			
	4–5	34	27			

Table 3. *Cont.*

Question 7: Do You Agree or Disagree with the Following Statements about Your Degree Course?						
Item	**Score**	**No.**	**%**	**Mean**	**Mode**	**Mode Prevalence**
(h) The assessment of student work is adequate	**1–2**	16	13	3.4	3	Average
	3	56	45			
	4–5	52	42			
(i) The evaluation criteria and methods are adequate	**1–2**	32	26	3.0	3	Average
	3	58	47			
	4–5	34	27			
(j) The general quality of teaching is good	**1–2**	22	18	3.0	3	Average
	3	86	69			
	4–5	16	13			
(k) My course offers a good range of topics and specializations	**1–2**	14	11	3.2	3	Average
	3	72	58			
	4–5	38	31			
(l) There is good communication with teachers in the classroom	**1–2**	14	11	3.3	3	Average
	3	66	53			
	4–5	44	35			
(m) I think my course offers a high level of academic demand	**1–2**	22	18	3.5	4–5	Average
	3	36	29			
	4–5	66	53			
(n) I get enough attention from teaching staff outside the classroom (for example, in tutorials).	**1–2**	16	13	3.1	3	Average
	3	86	69			
	4–5	22	18			
(o) The atmosphere in class is good	**1–2**	4	3	4.1	**4–5**	**High**
	3	24	19			
	4–5	96	77			
(p) My course offers appropriate internships outside the university classroom (for example, in educational centers or other types of educational and social institutions)	**1–2**	8	6	3.6	4–5	Average
	3	48	38			
	4–5	72	56			
(q) My course is good preparation for joining my future profession.	**1–2**	14	13	3.4	3	Low
	3	46	44			
	4–5	44	42			
(r) I would choose this course again	**1–2**	4	3	4.0	**4–5**	**High**
	3	30	24			
	4–5	90	73			

On the negative side, fully 76% are neutral (score 3) concerning the theoretical training offered on their course (item 7c), with a mere 13% agreeing/strongly agreeing that this is a satisfactory aspect (score 4–5). Similarly, 47% and 42% are, respectively, neutral (score 3) or in disagreement/strong disagreement (score 1–2) that the practical side of their course is satisfactory (item 7d). Furthermore only 27% agree/strongly agree (score 4–5) that current teaching methodologies and the activities they are required to complete (item 7g) are satisfactory.

Other points to highlight include the fact that only 27% of students agree/strongly agree that their course provides them with key skills and competencies (item 8f) although the majority feel their course is good preparation for their future careers (item 7q) with 44% and 42% scoring this factor, respectively, 3 and 4–5. Meanwhile most students are neutral (score 3) about the syllabus (item 7b) and the standard of academic counselling (item 7a) (69% and 58%, for each item, respectively).

The results of this section suggest students are, in general, satisfied with their academic journey. This is particularly evident in their positive perception of the classroom atmosphere and the finding that most would choose their current degree again. Despite this, students appear to want better theoretical and practical training and, in addition, very few are happy with current teaching approaches. This could be addressed by the re-design of existing courses such that they are more tuned to providing students with the skills and competencies they will require in their professional careers. In this regard, there should be more provision of internship opportunities to enhance students' real-world experience and, at the same time, increase their employability.

The reasons students feel are most influential in their decision to continue their degree are shown in Table 4. The six motivating factors of greatest importance are: the personal goal of graduating (item 8b); interesting internship opportunities (item 8e); peer support (item 8f); broadening horizons (item 8h); finding a sense of belonging (item 8k); and the faculty atmosphere (item 8m). Of these six factors peer motivation seems to be of greatest influence with the highest percentage of students (87%) agreeing/strongly agreeing on its importance (score 4–5).

Table 4. Factors motivating undergraduate students to continue their studies. Participants rated items from 1 (strongly disagree) to 5 (strongly agree). Mode Prevalence: High (>70%), Average (50–70%), Low (<50%). The % of respondents is rounded to whole numbers.

Question 8: What Are Your Reasons for Continuing Your Current Course of Studies?						
Item	**Score**	**No.**	**%**	**Mean**	**Mode**	**Mode Prevalence**
(a) I think my degree is intellectually stimulating	**12**	16	13	3.5	4–5	Low
	3	50	40			
	4–5	58	47			
(b) Completing my degree is a goal I have set for myself	**1–2**	4	3	4.2	4–5	**High**
	3	24	19			
	4–5	96	77			
(c) Continuing my degree is the easiest option	**1–2**	86	69	2.1	1–2	Average
	3	22	18			
	4–5	16	13			
(d) Although I don't find my degree stimulating, it is my only option	**1–2**	82	66	2.1	1–2	Average
	3	28	23			
	4–5	14	11			
(e) The internships offered with this degree are interesting	**1–2**	10	8	3.8	4–5	**High**
	3	24	19			
	4–5	90	73			
(f) My classmates are a positive and encourage me to continue my degree	**1–2**	4	3	4.2	4–5	**High**
	3	12	10			
	4–5	110	87			

Table 4. *Cont.*

Question 8: What Are Your Reasons for Continuing Your Current Course of Studies?						
Item	**Score**	**No.**	**%**	**Mean**	**Mode**	**Mode Prevalence**
(g) Although there have been times when I have felt unable to continue my degree, the support I have received has encouraged me to continue	**1–2**	10	8	3.5	3	Average
	3	64	52			
	4–5	50	40			
(h) My degree has broadened my perspectives on what I want to do later	**1–2**	10	8	3.9	4–5	**High**
	3	22	18			
	4–5	92	74			
(i) Obtaining my degree will allow me to access a good job	**1–2**	22	18	3.6	4–5	Average
	3	24	19			
	4–5	78	63			
(j) The financial support (scholarships, grants, etc.) I have received has been an important incentive to continue my degree	**1–2**	46	37	2.5	1–2	Average
	3	6	5			
	4–5	72	58			
(k) At university I have found a group of people I identify with, and I feel a sense of belonging	**1–2**	4	3	4.0	4–5	**High**
	3	24	19			
	4–5	96	77			
(l) I have good relationships with faculty members	**1–2**	32	26	3.0	3	Average
	3	62	50			
	4–5	30	24			
(m) I like the atmosphere in my faculty	**1–2**	10	8	4.0	4–5	**High**
	3	18	15			
	4–5	96	77			

Regarding internships, 73% of students agree/strongly agree that opportunities to complete this kind of work-related placement are highly motivating. This is no doubt related to students' concerns about employment beyond their degrees and a desire to gain relevant experience. The support of peers is also noteworthy as a motivator (item 8f) with 87% of students scoring this 4–5. This may be connected with the high level of demand in STEM degrees which can make students doubt their ability to complete their degree (e.g., [62]), thus support from their peers is perhaps more important to these students than those completing other types of degree.

For 63% of students, finding a job after graduation is an essential motivator for continuing their studies (item 8i) while for 58% financial support is deemed a strong motivating factor (item 8j). It is also noteworthy that continuing being the easy option (item 8c) or the only option (item 8d) are not considered important motivating factors with 69% and 66%, respectively, scoring these 1–2. Finding the degree intellectually stimulating split student opinion with 47% agreeing/strongly agreeing (score 4–5) that this is a motivating factor while a similar percentage (40%) are only averagely motivated by this factor (score 3). These findings suggest that the curriculum may need significant revision to provide greater challenge for students.

The main takeaway from this section is that many of students' biggest motivators are personal or social. Employment related factors are also among the greatest motivators, but interestingly the actual degree contents are deemed less so. Regarding the social dimension, represented by peer support, a sense of belonging, and the faculty atmosphere (items f, k, and m), these highlight the importance of fostering supportive university communities that not only provide students with academic training but also promote their and emotional

and social well-being. This is in keeping with existing research into student motivation in university education which highlights how students achieve best when both their academic and their well-being needs are met (e.g., [63,64], the soft skills they learn in the process being essential in their future careers [65].

5.3. Satisfaction with Acquired Skills and Traits Enhancing Employability

Table 5 provides information regarding students' perceptions of the employability skills and personality traits they have developed during their course encompassing both the hard and soft skills considered necessary for a successful and satisfying career. Among the attributes and skills examined, those related personal, moral qualities stand out: 79% and 90% of students agree/strongly agree that they possess the traits of, respectively, honesty (item 9s) and integrity (item 9t) while 76% agree/strongly agree that they are self-confident (item 9q). This hopefully reflects how effectively the education received by these ULPGC students has instilled and reinforced these positive personal values.

Table 5. Degree of skills acquisition and personality traits related to employability. Participants rated items from 1 (strongly disagree) to 5 (strongly agree). Mode Prevalence: High (>70%), Average (50–70%), Low (<50%). The % of respondents is rounded to whole numbers. Note that the COVID-19 experience was reduced and less detailed.

Q9: Do You Feel You Have the Following Skills and Personality Traits Related to Employability?						
Item	**Score**	**No.**	**%**	**Mean**	**Mode**	**Mode Prevalence**
(a) I am good at reading and interpreting technical reports	**1–2**	10	8	3.3	3	Average
	3	74	60			
	4–5	40	32			
(b) I am good at writing technical documents	**1–2**	10	8	3.4	4–5	Low
	3	56	45			
	4–5	58	47			
(c) I am a good oral communicator	**1–2**	32	26	2.9	3	Average
	3	74	60			
	4–5	18	15			
(d) I am a good listener	**1–2**	6	5	3.8	4–5	Average
	3	36	29			
	4–5	82	66			
(e) I am good at math	**1–2**	10	8	3.3	3	Average
	3	74	60			
	4–5	40	32			
(f) I am good at learning new things	**1–2**	4	3	3.7	4–5	Average
	3	42	34			
	4–5	78	63			
(g) I can think creatively	**1–2**	10	8	3.2	3	Average
	3	80	65			
	4–5	34	27			
(h) I have good engineering decision-making and problem-solving skills	**1–2**	18	15	3.3	3	Average
	3	66	53			
	4–5	40	32			

Table 5. *Cont.*

Q9: Do You Feel You Have the Following Skills and Personality Traits Related to Employability?						
Item	**Score**	**No.**	**%**	**Mean**	**Mode**	**Mode Prevalence**
(i) I am good at applying my understanding of engineering and scientific principles to real-life problems	**1–2**	6	5	3.5	3	Average
	3	62	50			
	4–5	56	45			
(j) I have skills specific to my engineering discipline	**1–2**	10	8	3.5	3	Low
	3	58	47			
	4–5	56	45			
(k) I can take responsibility	**1–2**	16	13	3.3	3	Average
	3	68	55			
	4–5	40	32			
(l) I am cooperative	**1–2**	14	11	3.3	3	Average
	3	70	56			
	4–5	40	32			
(m) I can take on a challenge	**1–2**	6	5	3.4	3	Average
	3	78	63			
	4–5	40	32			
(n) I have ambition	**1–2**	16	13	3.6	4–5	Average
	3	40	32			
	4–5	68	55			
(o) I am optimistic	**1–2**	22	18	3.5	4–5	Low
	3	42	34			
	4–5	60	48			
(p) I am curious	**1–2**	4	3	4.0	4–5	**High**
	3	24	19			
	4–5	96	77			
(q) I have self-confidence	**1–2**	8	6	4.0	4–5	**High**
	3	22	18			
	4–5	94	76			
(r) I have self -control	**1–2**	16	13	3.5	4–5	Average
	3	44	35			
	4–5	64	52			
(s) I am honest	**1–2**	4	3	4.1	4–5	**High**
	3	22	18			
	4–5	98	79			
(t) I have integrity	**1–2**	0	0	4.3	4–5	**High**
	3	12	10			
	4–5	112	90			
(u) I am flexible	**1–2**	6	5	3.5	3	Average
	3	72	58			
	4–5	46	37			

Table 5. *Cont.*

Q9: Do You Feel You Have the Following Skills and Personality Traits Related to Employability?						
Item	**Score**	**No.**	**%**	**Mean**	**Mode**	**Mode Prevalence**
(v) I have a business mindset	**1–2**	32	26	3.2	4–5	Low
	3	40	32			
	4–5	52	42			
(w) I am knowledgeable about contemporary issues in engineering	**1–2**	4	3	4.1	4–5	**High**
	3	18	15			
	4–5	102	82			

A significant portion of students (82%) report having a solid awareness of new technologies (item 9w). In conjunction with the finding that 77% of students agree/strongly agree that they are curious, this is highly encouraging given that these students are working towards a degree in engineering which is a rapidly changing field requiring a keen interest in innovation.

For several other specifically engineering-related skills, however, most students rated themselves as only average (score 3): maths (item 9e: 60%); creative thinking (item 9g: 65%); engineering decision making and problem solving (item 9h: 53%); applying their knowledge to real-life problems (item 9i: 50%); and proficiency in their specific area of engineering (item 9j: 47%). This is a little discouraging as while it suggests that students feel generally technically competent there is clearly much room for improvement.

Other areas in which students claim some confidence is listening (item 9d: 66% score 4–5); foreign languages (item 9e: 63% score 4–5) with the majority of students also feeling they have ambition (item 9g: 55% score 4–5) and self-control (item 9r: 52% score 4–5). In addition, it is interesting to note that in terms of core communicational skills students seemed least comfortable with oral communication (item 9c) with only 15 % scoring this 4–5 in comparison to reading and interpreting (item 9a) or writing technical documents (item 9b) where, respectively, 32% and 47% felt they had a good level of skill; all of which are far lower percentages than for listening skills (see above). It is essential that students develop confidence in all areas of communication so that they are fully prepared for their future careers. These skills could be promoted by introducing more seminars and opportunities for group discussions and student presentations of their work.

Concerning more general skills and traits, here the results are mixed. On the more positive side most students scored 3 for being able to take on challenges (item 9m: 63%) and responsibility (item 9k: 55%); being flexible (item 9v: 58%); and being cooperative (item 9l: 56%). However, work is needed to improve students' perceptions of their optimism (item 9o) and business mindset (item 9v), since although most respondents in each case scored these 4–5 the percentages are very low, respectively, 48% and 42%. It is interesting—and concerning—that this last group of skills are the most related to management, marketing, and business [66,67]. The development of students' business understanding [68] is essential for their future career success, however, there is a problematic and long-standing lack of interest in entrepreneurship not just in universities in the Canary Islands but also across the entire Spanish university system [69]. The findings presented here reflect this issue and, in this regard, it would be advisable to incorporate more business-focused courses into current degree programs and introduce more collaboration with the local business community to help students gain more confidence in these critical skills and turn them into more marketable professionals.

5.4. Satisfaction with Online Teaching and Learning during the Pandemic

5.4.1. The Engineering Department's Adaptation to Online Education

This dimension includes four items concerning students' general perceptions about the success or otherwise of the engineering department's transition from face-to-face to online education during the COVID-19 pandemic. The results are shown in Table 6.

Table 6. The transition to online education. Participants rated items from 1 (strongly disagree) to 5 (strongly agree). Mode Prevalence: High (>70%), Average (50–70%), Low (<50%). The % of respondents is rounded to whole numbers.

Question 10: How Well Do You Think the Engineering Department at ULPGC Adapted to Online Learning?						
Item	**Scale**	**No.**	**%**	**Mean**	**Mode**	**Mode Prevalence**
(a) The department adapted adequately to virtual teaching	**1–2**	102	82	1.9	1–2	**High**
	3	20	16			
	4–5	2	2			
(b) The department always kept me informed of the changes being made to online teaching modalities.	**1–2**	26	21	3.3	4–5	Average
	3	36	29			
	4–5	62	50			
(c) The virtual media used by the department for online teaching were adequate.	**1–2**	48	39	2.7	3	Average
	3	50	40			
	4–5	26	21			
(d) The online platforms used by the department were user-friendly (in terms of accessibility, interactivity, and usability).	**1–2**	60	48	2.3	1–2	Low
	3	56	45			
	4–5	8	6			

Unfortunately, 82% of students disagree/strongly disagree with the statement "The department adapted adequately to virtual teaching". This is most likely a consequence of the lack of preparedness for the abrupt shift to online learning necessitated by the pandemic, as highlighted in [70,71]. On a more positive note, most students felt that once online learning was underway, the department communicated adequately about any changes being implemented (item 10b: 50% scored 4–5) a factor highlighted as critical to student success during the digital transition (e.g., [72]).

Regarding the virtual media deployed by the engineering department for online teaching (item 10c), findings are encouraging with 61% of respondents agreeing/strongly agreeing that they were adequate; although a significant percentage (39%) disagree/strongly disagree with this. Less encouraging results are obtained regarding the accessibility, interactivity and usability of online platforms used by the department (item 10d) with 48% of students scoring 1–2 for this item. Previous research indicates that effective and user-friendly tools can significantly improve the online learning experience (e.g., [73]), thus, this last finding is concerning and suggests the urgent need for improvements before implementing further online learning options.

5.4.2. Module Adaptation to Online Education

Here we consider 6 items to assess student perceptions of how well individual course modules were adapted to online teaching and learning during the pandemic. The results are presented in Table 7.

Table 7. Adaptation of course modules to online education. Participants rated items from 1 (strongly disagree) to 5 (strongly agree). Mode Prevalence: High (>70%), Average (50–70%), Low (<50%). The % of respondents is rounded to whole numbers.

Question 11: How Well Did the Engineering Department at ULPGC Adapt Its Course Modules to Online Teaching?						
Item	**Scale**	**No.**	**%**	**Mean**	**Mode**	**Mode Prevalence**
(a) I think that traditional face-to-face course plans were adapted sufficiently well.	**1–2**	96	77	1.9	1–2	**High**
	3	22	18			
	4–5	6	5			
(b) The course contents were appropriate for the online modality.	**1–2**	98	79	2.1	1–2	**High**
	3	18	15			
	4–5	8	6			
(c) The adaptation of learning activities to the online modality was satisfactory.	**1–2**	92	74	2.1	1–2	**High**
	3	26	21			
	4–5	6	5			
(d) The learning materials delivered online were sufficiently useful.	**1–2**	56	45	2.5	1–2	Low
	3	52	42			
	4–5	16	13			
(e) I had all the resources I needed to successfully complete assessed tasks.	**1–2**	34	27	3.0	3	Low
	3	52	42			
	4–5	38	31			
(f) The assessment systems used by teachers in the online modality were optimal to evaluate the achievement of the learning objectives	**1–2**	90	73	2.1	1–2	**High**
	3	24	19			
	4–5	10	8			

As can be observed, it seems that students are dissatisfied with efforts to adapt course modules to online education in four of the six areas investigated with the majority of students disagreeing/strongly disagreeing (score 1–2) with the assertions that course plans had been well adapted to online teaching (item 11a: 77%); that course contents were appropriate for online teaching (item 11b: 79%); that learning activities had been satisfactorily adapted to online teaching (item 11c: 74%); and that assessment systems had been adequate during the period of online learning (item 11f: 73%). Regarding the usefulness of online learning materials (item 11d) the majority were dissatisfied with 45% scoring 1–2 for this item although this is a less significant result. The only moderately positive finding is that most students were either neutral (score 3: 42%) or in agreement/strong agreement (score 4–5: 31%) with the assertion concerning access to necessary resources to complete assessment tasks (item 11e).

The level of dissatisfaction seen here may well be related to teachers' lack of preparation for online learning leading to poorly adapted course modules (e.g., [74]). Designing courses for online study requires careful planning in terms of adapting curricula, training teaching staff, and designing appropriate assessment methods; during the accelerated transition necessitated by the COVID-19 pandemic clearly, it was not possible to address these challenges adequately and the engineering department's failure in this regard appears to have compromised students' online learning experience. This finding is common in other research concerning university adaptation to online education and student satisfaction with the result, see for example: [75–78].

In this way, it is advisable for universities to invest in training initiatives for staff in the delivery of online courses as well as taking time to plan improved online curricula not only for use in the event of any future pandemic but also to move with the trend of increasing

digitalization in education. This approach will ensure a more motivating and fulfilling experience of online learning for students in the future.

5.4.3. Student Adaptation to Online Education

This dimension consists of 13 items interrogating aspects of students' own personal adjustment to online education. Below, Table 8 explains the results of this dimension in each of the items that comprise it.

Table 8. Personal adaptation of students to online education. Participants rated items from 1 (strongly disagree) to 5 (strongly agree). Mode Prevalence: High (>70%), Average (50–70%), Low (<50%). The % of respondents is rounded to whole numbers.

Question 12: How Well Do You Feel You Adapted to Online Education?						
Item	**Scale**	**No.**	**%**	**Mean**	**Mode**	**Mode Prevalence**
(a) My digital skills allowed me to adapt to the new form of online teaching.	**1–2**	2	2	3.9	4–5	**High**
	3	26	21			
	4–5	96	77			
(b) Online teaching was more convenient for me.	**1–2**	44	35	2.5	3	Average
	3	62	50			
	4–5	18	15			
(c) Online teaching facilitated my learning process.	**1–2**	114	92	1.5	1–2	**High**
	3	8	6			
	4–5	2	2			
(d) Online classes helped me optimize my time.	**1–2**	44	35	2.9	3	Low
	3	48	39			
	4–5	32	26			
(e) Online modules were more exciting and enjoyable.	**1–2**	88	71	2.0	1–2	**High**
	3	26	21			
	4–5	10	8			
(f) When teaching was online, I put in more effort and worked harder to pass my modules.	**1–2**	86	69	2.2	1–2	Average
	3	36	29			
	4–5	2	2			
(g) My motivation to learn was the same as before the pandemic.	**1–2**	100	81	1.6	1–2	**High**
	3	22	18			
	4–5	2	2			
(h) I would have learned more with face-to-face teaching.	**1–2**	2	2	4.2	4–5	**High**
	3	30	24			
	4–5	92	74			
(i) The quality of teaching I received was better than it would have been in a classroom setting.	**1–2**	96	77	1.8	1–2	**High**
	3	26	21			
	4–5	2	2			
(j) When teaching was online, the development of key job-related skills suffered.	**1–2**	18	15	3.9	4–5	**High**
	3	18	15			
	4–5	88	71			

Table 8. *Cont.*

Question 12: How Well Do You Feel You Adapted to Online Education?						
Item	**Scale**	**No.**	**%**	**Mean**	**Mode**	**Mode Prevalence**
(k) I felt more lost in subjects than I would have with face-to-face teaching.	**1–2**	108	89	1.6	1–2	**High**
	3	12	10			
	4–5	2	2			
(l) Given the choice, I would prefer online teaching in the future.	**1–2**	20	16	3.2	3	Average
	3	72	58			
	4–5	32	26			
(m) Throughout the pandemic, I had access to a computer, tablet, mobile phone, and the ability to connect to the Internet.	**1–2**	0	0	4.8	4–5	**High**
	3	2	2			
	4–5	122	98			

Students feel they adapted well in two areas: most students (70%) agree/strongly agree that their digital skills enabled them to adapt successfully to online education (item 12a) while an even larger proportion (98%) agree/strongly agree that they had access to the necessary digital tools (item 12m). These results show students were technically well prepared for the transition to online learning and are perhaps not surprising considering that we are dealing with a generation of digital natives.

With respect to other items in this dimension, results are overwhelmingly negative. In terms of how students felt about the quality of online teaching and its overall effect on their education, the majority disagree/strongly disagree (1–2) that the quality of teaching on online courses was as good as for those delivered face-to-face (item 12i: 77%) and that online courses facilitate learning (item 12c: 92%); while most students agree/strongly agree (4–5) that the development of their job-related skills was adversely affected (item 12j: 71%) and that they would have learned more in face-to-face lessons (item 12h: 74%).

Furthermore, regarding items related to the more personal experiences of online learning most disagree/strongly disagree (1–2) that online modules were more enjoyable (item 12e: 71%) or improved motivation (item 12f: 81%) compared to those taught face-to-face although there were similar levels of disagreement/strong disagreement with the assertion that students might feel more lost during the online teaching period (item 12k: 89%). Finally, in an item related to motivation, a small majority of students (69%) disagree/strongly disagree with the idea that they put more effort into online learning.

The results concerning personal experiences are of course intimately linked to students' perceptions about the quality of the online education they received. Indeed, other works makes a direct link between low motivation and the feeling that online education is not as good as that delivered in traditional face-to-face settings (e.g., [79,80]). The forced nature of the COVID-19 online learning experience is also a factor cited by other authors as leading to the lack of enjoyment reported with respect to online courses (e.g., [81,82]). These works also mention the inadequacies of social interaction in online settings and this is consistent with other studies which identify several key areas that students missed during the period of online education, specifically, face-to-face interactions, direct engagement, and the more enriching environment of the physical classroom (c.f.: [83,84]). Similarly, the fact that students don't feel they put in more effort when learning online, related to low motivation, is consistent with a general perception of lax academic standards during the pandemic which in turn has been attributed to teachers' inexperience with methods of online evaluation (e.g., [85,86]).

Interestingly students were neutral (score 3) concerning the convenience of online courses (item 12b: 50%) and about the possibility of taking online courses in the future (item 12l: 58%). Similarly, students didn't appreciate the opportunities that online learning might offer for time optimization (item 12d) the majority being either neutral or disagree-

ing/strongly disagreeing with this proposition (35% score 3 and 35% score 1–2). These results tend to contradict other work where students seemed positive about the flexibility and accessibility of online courses (e.g., [87]) and it would be worthwhile investigating this point further.

The apparent paradox of how well students were prepared for online learning and their low opinions of its effectiveness and enjoyability seen in these results deserves attention. However, we would suggest that one way to address this is to ensure that in future, courses are structured such that students are encouraged to take a proactive role as knowledge builders in environments where they and their teachers actively inquire, interact, and collaborate.

5.4.4. Faculty Adaptation to Online Education

This dimension consists of five items focusing on how well members of the teaching faculty adapted to online education. Results are shown in Table 9.

Table 9. Adaptation of faculty to online teaching. Participants rated items from 1 (strongly disagree) to 5 (strongly agree). Mode Prevalence: High (>70%), Average (50–70%), Low (<50%). The percentage of respondents is rounded to whole numbers.

Question 13: How Well Did Your Teachers Adapt to Online Education?						
Item	**Scale**	**No.**	**%**	**Mean**	**Mode**	**Mode Prevalence**
(a) Teachers communicated efficiently	**1–2**	34	27	2.9	3	Average
	3	64	52			
	4–5	26	21			
(b) Teachers' level of digital literacy meant they had sufficient skills to teach online.	**1–2**	90	73	2.0	1–2	**High**
	3	16	13			
	4–5	18	15			
(c) Teachers were flexible during the phase of adaptation to online teaching.	**1–2**	10	8	4.1	4–5	**High**
	3	26	21			
	4–5	88	71			
(d) Teachers seemed motivated by online teaching.	**1–2**	110	89	1.5	1–2	**High**
	3	14	11			
	4–5	0	0			
(e) Teachers seemed to find it easy to adapt to online teaching.	**1–2**	8	6	3.5	3	Average
	3	72	58			
	4–5	44	35			
(f) Teachers seemed to find online tutoring as effective as face-to-face tutoring.	**1–2**	70	56	2.2	1–2	Average
	3	48	39			
	4–5	6	5			

On the positive side, 71% agree/strongly agree that teaching staff were flexible during the period of transition to online education (item 13c: score 4–5), a factor that is critical to ensuring effective online learning. However, most students disagree/strongly disagree (1–2) that teaching staff either had sufficient digital skills (item 13b: 71%) or that staff seemed motivated (item 13d: 89%) to teach online.

Students are also unimpressed by their teachers' use of online tutoring systems (item 13f: 56%, score 1–2). However, responses were more neutral with regards to teachers' communication (item 13a: 52%, score 3) and the ease with which their teachers appeared to adapt to the online modality (item 13e: 58%, score 3)

The issue of teachers' competence in the use of digital learning environments in university settings is well documented post pandemic. A several academics, for example, Refs. [66,88,89] have reported on their own experiences and highlight the difficulties they experienced mastering the use of online teaching technologies, integrating them with course module designs, and adapting assessment systems for online environments. As well as being an important factor in lowering morale among teaching staff [90], the lack of virtual-teaching skills among faculty members will have, no doubt, hindered their ability to create an engaging, socially and emotionally supportive environment in their online classrooms and this goes some way to explaining the results in the previous Section 5.4.3. This being the case, it is imperative for universities to initiate structured training programs for teaching staff to provide a comprehensive preparation for using digital education platforms.

The main results from the research are summarized in Table 10.

Table 10. Sociodemographic data, degree choice influences, satisfaction, and skill development of online trained engineering students after COVID-19.

Aspect	Percentage	Key Findings
Sociodemographic data	84% Male, 65% 3rd year, 75% use computer, 100% use smartphone.	The majority are male, predominantly 3rd-year students, with high access to computers and smartphones.
Factors influencing undergraduate degree choice	Jobs prospects (45: 73%), tradition (1–2: 74%), entrance score (1–2: 74%).	Strong preference for job opportunities, low importance to tradition and entrance scores.
Student general satisfaction	Good class atmosphere (4–5: 77%), would choose course again (4–5: 73%), good theoretical training (3: 76%).	High satisfaction with classroom atmosphere and course choice; moderate satisfaction with theoretical training.
Satisfaction with acquired skills and traits enhancing employability	High integrity (4–5: 90%), up-to-date (4–5: 82%), honesty (4–5: 79%), curiosity (4–5: 77%), self-confidence (4–5: 76%)	High integrity, up-to-date, honest, curious and self-confident. Needs improvement in theoretical and practical training aspects.
The engineering department's adaptation to online education	The department adapted adequately to virtual teaching (1–2: 82%)	Major dissatisfaction with the department's adaptation to online teaching.
Module adaptation to online education	Course content appropriateness (1–2: 79%), overall adaptation satisfaction (1–2: 77%), learning activities adaptation (1–2: 74%), appropriateness of assessment system (1–2: 73%)	High dissatisfaction with the adaptation of course modules to online education
Student adaptation to online education	Learning process facilitation (1–2: 92%), feeling lost in subjects (12: 89%), digital skills adaptation (4–5: 77%), better teaching quality in the classroom (1–2: 77%)	Students were well-equipped digitally but found online teaching less conducive to learning, with a majority indicating a preference for face-to-face teaching and expressing concerns about the effectiveness of online learning in various aspects.
Faculty adaptation to online education	Teachers seemed motivated (1–2: 89%), teachers' level of digital literacy (1–2: 73%), teachers were flexible (4–5: 71%),	Faculty showed flexibility but needed more digital literacy and motivation for online teaching.

6. Conclusions

Our findings provide insights that are consistent with and extend the theoretical frameworks of digital learning adaption and educational resilience. The study found that students had varying levels of flexibility, which is consistent with theories predicting variable reactions to educational disturbances. Furthermore, our findings highlight the relevance of readiness and support networks in supporting effective transitions to online

learning, which is a critical component of resilience in educational settings. These findings have significance for the development of current theories, particularly in terms of understanding how external variables such as geographical remoteness and technology infrastructure affect educational resilience. They also indicate areas for further theoretical research, such as the significance of unique student traits in adjusting to online education.

To summarize, our study's theoretical framework is inextricably tied to its important themes, and questionnaire preparation was a methodologically sound process that was firmly embedded in both theoretical and empirical contexts.

With respect to RQ1, while students showed remarkable satisfaction with the classroom environment and the likelihood of re-enrolling in their current courses, they identified theoretical and practical training gaps and a desire for refined teaching methods. The study also highlights the significant role of internships, linking them to concerns about employment after graduation and the value of relevant experience. Moreover, while students recognize the importance of peer support and other social aspects as central motivators in their academic journey, they express only modest enthusiasm for the intrinsic academic stimulation of their courses. In addition, while students strongly identify with personal and moral qualities, areas mainly related to engineering-specific, communication, and business-related skills show room for improvement and development within the curriculum.

Furthermore, when students are asked to compare the quality of the online education, they received during the COVID-19 pandemic to their experiences of face-to-face education they tend to rate the latter more favorably. Students found online courses less exciting (item 12e); less motivating (item 12g) and thought the teaching was lower quality (item 12i); adversely affected their acquisition of job-related skills (item 12j); and did not facilitate learning generally (item 12c).

The findings highlight the importance of sustainably designed curricula and teaching approaches better to meet student's needs and future career demands, advocating a balanced focus on technical and soft skills alongside enhanced business and entrepreneurship education.

Concerning RQ2a, unfortunately, 82% of students disagreed/strongly disagreed with the statement "The department adapted adequately to virtual teaching". This is most likely a consequence of the lack of preparedness for the abrupt shift to online learning necessitated by the pandemic, as highlighted in work by Lederman [70] and Selvaraj et al. [71]. On a more positive note, most students felt that once online learning was underway, the department communicated adequately about any changes being implemented (item 10b: 50% scored 4–5) a factor highlighted as critical to student success during the digital transition (e.g., [72]).

Regarding the virtual media deployed by the engineering department for online teaching (item 10c), findings are encouraging with 61% of respondents agreeing/strongly agreeing that they were adequate; although a significant percentage (39%) disagree/strongly disagree with this. Less encouraging results are obtained regarding the quality of online platforms used by the department (item 10d) with 48% of students scoring 1–2 for this item. Previous research indicates that effective and user-friendly tools can significantly improve the online learning experience (e.g., [73]), thus this last finding is concerning and suggests the urgent need for improvements before implementing further online learning options.

As can be observed, it seems that students are dissatisfied with their teachers' efforts to adapt course modules to online learning in four of the six areas investigated with the majority of students disagreeing/strongly disagreeing (score 1–2) with the assertions that course plans had been well adapted to online teaching (item 11a: 77%); that course contents were appropriate for online teaching (item 11b: 79%); that learning activities had been satisfactorily adapted to online teaching (item 11c: 74%); and that assessment systems had been adequate during the period of online learning (item 11f: 73%). Regarding the usefulness of online learning materials (item 11d) the majority were dissatisfied with 45% scoring 1–2 for this item although this is a less significant result. The only moderately positive finding is that most students were either neutral (score 3: 42%) or in agreement/strong agreement

(score 4–5: 31%) with the assertion concerning access to necessary resources for assessment tasks (item 11e).

This dissatisfaction is no doubt related to teachers' lack of preparation for online learning leading to poorly adapted course modules (e.g., [74]). Designing courses for online study requires careful planning in terms of adapting curricula, training teaching staff, and designing appropriate assessment methods; during the accelerated transition necessitated by the COVID-19 pandemic clearly, it was not possible to address these challenges adequately and the engineering department's failure in this regard appears to have compromised students' online learning experience. This finding is common in other research concerning university adaptation to online learning and student satisfaction with the result (see, for example: [75–78]).

In this way, it is advisable for universities to invest in training initiatives for staff in the area of online learning as well as taking time to plan improved online curricula not only for use in the event of any future pandemic but also to move with the trend of increasing digitalization in education. This approach will ensure a more motivating and fulfilling experience of online learning for students in the future.

Concerning RQ2c the findings presented here suggest that students were better prepared for online education than their teachers. Findings demonstrate that students adapted well to online teaching, having both the digital skills and access to devices necessary to make the transition. However, students do feel that the quality of their education and their motivation suffered due to online teaching, and, in addition they do not appear to appreciate the potential flexibility of this modality. These findings highlight the need to encourage students to establish independent work schedules such that they learn to prioritize, plan, manage stress, and set their own goals. In addition, despite students' technical skills with digital devices and media, it may be the case that they lack what might be termed more professional digital skills. To address this, a way forward might be to offer online mentorship or internship schemes whereby students could develop skills and knowledge of software applications (Excel, Photoshop, etc.), the use of AI, writing, and presentation.

Students' opinions of how well teaching staff adapted to online learning are also instructive. While appreciating their teachers' flexibility during the period of online learning, students had real concerns about their digital literacy and lack of motivation. This reveals a need for targeted teacher training in the design and delivery of online courses to ensure teaching staff can take full advantage of digital teaching platforms in the future.

Finally, regarding RQ3, as the above discussion demonstrates there are numerous lessons to be learned. The research highlights the necessity of providing support for both teachers and students to ensure the success and sustainability of online learning. Universities should invest in training teaching staff, equipping them with practical online teaching tools, and fostering an environment where best practices in sustainable digital education are shared and implemented.

The findings reveal that students use technology more than just as presented. Instead, they adapt and customize it to fit their learning styles, preferences, and circumstances. This active engagement provides strong empirical evidence for existing theories while offering new insights into how technology is utilized in the context of post-pandemic education. According to the Technology Acceptance Model (TAM), students' adoption and use of online learning tools are significantly influenced by their perceived utility, particularly during the COVID-19 crisis. It is essential to acknowledge the efforts of educators in enhancing the user-friendliness of these digital platforms. The relevance of the Unified Theory of Acceptance and Use of Technology (UTAUT) is also evident in this context, especially considering the social pressures students faced during the pandemic and the significant efforts made by universities to ensure a smooth transition to online learning. Additionally, the principles of the Domestication Theory were more prominent than ever. Students did not simply use technology but rather personalized and integrated it into their daily learning routines, adapting it to meet their unique contextual demands and individual needs.

All things considered, we want to acknowledge certain limitations in our study that require consideration. First, convenience sampling may only partially represent the diversity of the broader student body, potentially affecting the applicability of our findings. However, we are confident that the insights gained from our investigation provide significant value and establish a solid basis for future explorations in this field. Moreover, it is essential to consider the potential for response bias when conducting survey-based research, as students' current circumstances may impact their answers. Furthermore, our findings may have limited applicability beyond engineering, as we focused solely on these particular STEM disciplines. Finally, our findings provide valuable insights applicable to ultra-peripheral regions. However, it is essential to exercise caution when extrapolating them to other contexts due to the unique socioeconomic landscape of the Canary Islands.

Future research on this topic could extend to disciplines beyond STEM. Moreover, conducting similar studies in other ultraperipheral regions would allow for comprehensive research. Valuable insights could be gained from longitudinal studies observing the variation in students' adaptation to online learning over time. Additionally, tracking changes in curricula and teaching methods in response to online learning may be another fruitful area of study.

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Institutional Review Board Statement: This study was conducted in accordance with national and international regulations that define when a research project requires the approval of an ethics committee (Declaration of Helsinki, Spanish Organic Law 3/2018, and Regulation (EU) 2016/679 of the European Parliament and of the Council). In accordance with these regulations, the Ethics Committees of the University of Las Palmas de Gran Canaria and the University of León (Spain) indicate the cases in which their approval is required for the development of a research project, mainly when the projects involve research on human subjects, the use of biological samples of human origin, animal experimentation, the use of biological agents, the use of genetically modified organisms (https://www.ulpgc.es/vinvestigacion/ceih accessed on 4 December 2023; https://www.unileon.es/investigadores/vicerrectorado/comite-etica accessed on 4 December 2023). In addition, this research did not involve the collection of primary data from human participants, the information was collected using a non-invasive method (anonymous survey), and the results are presented in aggregate form, always respecting the confidentiality and anonymity of individuals. For all of the above, this research did not require the approval of the Ethics Committee of the Universities of Las Palmas de Gran Canarias and the University of León (Spain).

Informed Consent Statement: A preliminary information sheet explained the nature and objectives of the project, what data would be collected, how it would be used and how access to the results would be provided. Implicit consent was obtained simply by completing the survey form, in accordance with Spanish law.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Engineering Students' Perception of Online Learning during COVID-19

Q1: Gender:

Female	Male	Other

Q2: Age:

Q3: Select your degree course:

Electrical Engineering	Chemical Engineering	Naval Engineering

Q4: Select your current year of study:

1	2	3	4

Q5: During the COVID-19 pandemic, what device did you have regular access to in order to study online?

Computer	Smartphone	Tablet

Appendix B. Satisfaction with Face-to-Face Learning

Q6: Why did you choose your degree course?
Rate the options from 1 (strongly disagree) to 5 (strongly agree)

Item	1	2	3	4	5
(a) Because of tradition					
(b) Because of family recommendation					
(c) Because I have a vocation					
(d) Because of the recommendations of other people					
(e) Because I was unable to do any other degree due to my university entrance score					
(f) Because it offers the best job opportunities					
(g) Because I could not afford to study outside my home region					
(h) Because I didn't want to study outside my home region					
Other (indicate which) _ _ _ _					

Q7: Do you agree or disagree with the following statements about your degree course?
Rate the options from 1 (strongly disagree) to 5 (strongly agree)

Item	1	2	3	4	5
(a) The general quality of academic counseling and guidance is good					
(b) The syllabus is adequate					
(c) The theoretical training is good					
(d) The practical training is good					
(e) The teaching staff delivering my course contents are competent					
(f) My course enables me to develop key skills and competencies					
(g) The teaching methodologies used and the activities we are given are well thought out					
(h) The assessment of student work is adequate					
(i) The evaluation criteria and methods are adequate					
(j) The general quality of teaching is good					

(k) My course offers a good range of topics and specializations
(l) There is good communication with teachers in the classroom
(m) I think my course offers a high level of academic demand
(n) The attention of the teaching staff outside the classroom (for example, in tutorials).
(o) The atmosphere in class is good
(p) My course offers appropriate internships outside the university classroom (for example, in educational centers or other types of educational and social institutions)
(q) My course is good preparation for joining my future profession.
(r) I would choose this course again

Q8: What are your reasons for continuing your current course of studies? Rate the options from 1 (strongly disagree) to 5 (strongly agree)

Item	1	2	3	4	5
(a) I think my degree is intellectually stimulating					
(b) Completing my degree is a goal I have set for myself					
(c) Continuing my degree is the easiest option					
(d) Although I don't find my degree stimulating, it is my only option					
(e) The internships offered with this degree are interesting					
(f) My classmates are a positive and encourage me to continue my degree					
(g) Although there have been times when I have felt I did not have the ability to continue my degree, the support I have received has encouraged me to continue					
(h) My degree has broadened my perspectives on what I want to do later					
(i) Obtaining my degree will allow me to access a good job					
(j) The financial support (scholarships, grants, etc.) I have received have been an important incentive to continue my degree					
(k) At university I have found a group of people I identify with, and I feel a sense of belonging					
(l) I have good relationships with faculty members					
(m) I like the atmosphere in my faculty					
Other reasons (please specify)					

Q9: Do you feel you have the following skills and personality traits related to employability? Rate the options from 1 (strongly disagree) to 5 (strongly agree)

Item	1	2	3	4	5
(a) I am good at reading and interpreting technical reports					
(b) I am good at writing technical documents					
(c) I am a good oral communicator					
(d) I am good at listening					
(e) I am good at math					
(f) I am good at learning new things					
(g) I can think creatively					

(h) I have good engineering decision-making and problem-solving skills
(i) I am good at applying my understanding of engineering and scientific principles to real-life problems
(j) I have skills specific to my engineering discipline
(k) I can take responsibility
(l) I am cooperative
(m) I can take on a challenge
(n) I have ambition
(o) I am optimistic
(p) I am curious
(q) I have self-confidence
(r) I have self -control
(s) I am honest
(t) I have integrity
(u) I am flexible
(v) I have a business mindset
(w) I am knowledgeable about contemporary issues

Appendix C. Satisfaction with Online Learning during the Pandemic

Q10: How well do you think the engineering department at ULPGC adapted to online learning?

Rate options on a scale from 1 (strongly disagree) to 5 (strongly agree) rate the following statements concerning your university's online teaching provision:

Item	1	2	3	4	5
(a) The department adapted adequately to virtual teaching					
(b) The department always kept me informed of the changes being made to online teaching modalities.					
(c) The virtual media used by the department for online teaching were adequate.					
(d) The online platforms used by the department were appropriate (in terms of accessibility, interactivity, and usability).					

Q11: How well did the engineering department at ULPGC adapt its course modules to online teaching?

Rate options on a scale from 1 (strongly disagree) to 5 (strongly agree).

Item	1	2	3	4	5
(a) I think that traditional face-to-face course plans were adapted sufficiently well.					
(b) The course contents were appropriate for the online modality.					
(c) The adaptation of learning activities to the online modality was satisfactory.					
(d) The learning materials delivered online were sufficiently useful.					
(e) I had all the resources I needed to successfully complete assessed tasks.					
(f) The assessment systems used by teachers in the online modality were optimal to evaluate the achievement of the learning objectives.					

Q12: How well do you feel you adapted to online learning?
Rate options on a scale from 1 (strongly disagree) to 5 (strongly agree).

Item	1	2	3	4	5
(a) My digital skills allowed me to adapt to the new form of online teaching.					
(b) Online teaching was more convenient for me.					
(c) Online teaching facilitated my learning process.					
(d) Online classes helped me optimize my time.					
(e) Online modules were more exciting and enjoyable.					
(f) When teaching was online, I put in more effort and worked harder to pass my modules.					
(g) My motivation to learn was the same as before the pandemic.					
(h) I would have learned more with face-to-face teaching.					
(i) The teaching I received was the same as it would have been in a classroom setting					
(j) When teaching was online, the development of key job-related skills suffered.					
(k) I felt more lost in subjects than I would have with face-to-face teaching.					
(l) Given the choice, I would prefer online teaching in the future.					
(m) Throughout the pandemic, I had access to a computer, tablet, mobile phone, and the ability to connect to the Internet.					

Q13: How well did your teachers adapt to online education?
Rate options on a scale from 1 (strongly disagree) to 5 (strongly agree).

Item	1	2	3	4	5
(a) Teachers communicated efficiently					
(b) Teachers' level of digital literacy meant they had sufficient skills to teach online.					
(c) Teachers were flexible during the phase of adaptation to online teaching.					
(d) Teachers seemed motivated by online teaching.					
(e) Teachers seemed to find it easy to adapt to online teaching.					
(f) Teachers seemed to find online tutoring as effective as face-to-face tutoring.					

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