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B-Learning and Technology: Enablers for University Education Resilience. An Experience Case under COVID-19 in Spain

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Abstract: Innovative teaching methodologies begat blended learning, which seems to facilitate engineering students' achievement of competencies required for the 21st century and has proven to be essential to keep quality standards as university education has suffered the COVID-19 pandemic. In this paper, we approach the use of b-learning and digital technologies before the pandemic started, and how it worked like a vaccine, enabling university education resilience and facilitating the sustainability of the students learning process. A questionnaire-based study is presented, in which the data came from Aerospace Engineering students following a Mathematics subject in a Technological University in Spain. ANOVA and ANCOVA analysis provided a significant difference in the appreciation of the adaptation based on the prior application of b-learning methodologies or more traditional methodologies. Results obtained indicated that the use of digital resources and educational platforms caused a noticeable change in the students' way of learning, improving habits and digital skills.

Keywords: b-learning; educational platform; pandemic resilience; education sustainability

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1. Introduction

The irruption of COVID-19 in the form of a global pandemic generated an unexpected and stressful situation that societies were not prepared for, giving its members the opportunity to show the best of themselves. Universities did not clash with this landscape [1–10]. Indeed, one day after the World Health Organization declared COVID-19 as a global pandemic on Wednesday 11th March [11], not only lecture staff but also students at Technical University of Valencia (UPV) acknowledged with a very short email from our rector that all teaching activity would move from face-to-face to online the following week. There was no procedure guide, and UPV did not give up on finishing the academic year. Similar lockdown situations were experienced all over the world on other nearby dates as this pandemic evolved at differently spreading rates in different countries from the very beginning [12].

The literature shows ways to transition online, generally based on different stages [13], and its advantages, including, inter alia, its collaborative and flexibility possibilities [14,15] or using open educational resources, mainly at secondary school [16]. However, nothing was written about doing the transition in one day and without due preparation [17].

There were indeed studies, as summarized in the literature review [18], exposing pros and cons of distance learning, where the latter exceeded the former, a conclusion that was shared in a recent post-pandemic large study based on Romanian universities [19]. These non-positive perceptions did not emerge from an educational landscape with a blended methodology (b-methodology) on stage. Nevertheless, the use of a b-methodology [20–29], which seemed to be adequate for students to play the main character role in their sustainable own learning process and master the 21st century required competencies [30–35], before the pandemic enabled the authors to develop a sensible and steady resilient response in front of a hectic challenge where no available answer was acceptable.

In this paper, we analyze the usefulness of blended methodologies (b-methodologies) digitally based, specifically, as a key factor for university resilience and to satisfy the students' present needs as well as new ways of students' learning [36–40]. Our approach pays special attention to how it has worked at a technological university by considering the methodological, technological and personal adaptation of subjects, the university, and students, respectively, thus filling a gap in this field of research by comprehensively considering these three features [1–10,41,42].

The paper structure is as follows. Section 2 describes the general setting of this paper. Section 3 tackles blended methodologies as a resilient conveyor of university education. Section 4 insights the challenges e at Technical University of Valencia after the general lockdown owing to COVID-19 pandemic. The last three sections include results, discussion and conclusions, taking into account the perspective of students following an annual Mathematics subject in the first year of Aerospace Engineering at UPV.

2. Materials and Methods

The existence of new technologies and educational platforms have allowed new educational methodologies to rise above the educational ecosystem as an adaptive process initiated a few years ago to train future generations with skills for innovation and creativity that are required at the workplace [43–45]. Indeed, digitalization has enhanced the learning/teaching experience between students and instructors co-creating a place to share knowledge. Furthermore, open educational platforms such as Sakai [46] facilitated institutions to create their learning spaces within a standardized, well-structured learning environment where instructors could incorporate a wide variety of learning tools and technology-enabled instructional approaches, as well as feedback from digital assessment.

Years before COVID-19 irrupted, Technical University of Valencia developed PoliformaT [47], a platform based on Sakai, which gave support to face-to-face teaching, providing collaborative and blended learning (b-learning, or BL for short) to students that were used to dealing with digital technologies in their normal lives. This platform encouraged modes of instruction that engaged students actively and deeply in their learning process [27,29,48,49]. The undergoing usage of PoliformaT eased the migration from a face-to-face based methodology into a 100% online approach with just a few hours advance notice; on the other hand, it also suggested that the vulnerability of the learning space and the need to develop new standards that will remain for certain after the pandemic.

In this paper, we consider how two digital tools—the aforementioned PoliformaT, widely used at UPV before the COVID-19 lockdown, and Teams, a hub for team collaboration created by Microsoft [50] whose use has been institutionalized at UPV after—have helped students, and to what extent, in the sustainability of their learning process. We delve into their use within the flip-teaching (FT) methodology [51–54]. The opinions of the students that followed the subject of Mathematics I in the first year of BEng Aerospace Engineering were requested anonymously once the following academic year had started, with time to have a perspective view. We analyzed the results obtained from 84 students that answered the questions.

The information has been organized into several categories, which allowed the understanding and interpretation of the research approach in a structured and systematic way. A process of categorization by nuclei or thematic and vertebral axes has been carried out, once all the relevant information had been collected. When defining the categories, three specific dimensions consistent with the purpose of the study were firstly delimited, conforming to the first column of Table 1 that appears under the heading dimensions, which we explain next.

Table 1. Dimensions and categories used in the analysis.

Dimensions	Categories
Methodological adaptation	General adaptation Subject-level evolution B-learning adaptation
Technological adaptation	Educational platforms Digital resources
Personal adaptation	Self-perception Increasing digital competencies

The "Methodological adaptation" dimension refers to the opinion and conception of students towards the change in methodology carried out in the university environment after the outbreak of the pandemic and the restrictive measures on face-to-face learning. This dimension encompasses the opinions on the performance and adaptability at the methodological level of the university in the first four weeks and its evolution in the following six months. It includes students' opinions on b-learning methodologies and their appreciation of how they influence the process of adapting to a completely online teaching situation. This dimension also consists of three categories: subject-level adaptation, b-learning adaptation and general adaptation.

The "Technological adaptation" dimension studies the opinion and valuation by students of the digital tools used by the university to alleviate the methodological change in their use, from the outbreak of the pandemic to the present moment. In addition, the digital resources used that could be integrated in the future as elements of the learning process are shown. In this dimension, the opinions of the two platforms used for communication, evaluation and availability of teaching resources are studied, both individually and in their interaction. The categories included are educational platforms and electronic resources.

Finally, the "Personal adaptation" dimension is included, in which students assessed their ability to adapt to new methodologies, the digital evolution they have experienced and the skills and capacities they have developed.

2.1. Questionnaire

To conduct our research on b-learning and digital technologies usage before the pandemic and how it enhanced university education resilience and facilitated the sustainability of the students learning process, some students from Higher Technical School of Design Engineering (ETSID) at the Technical University of Valencia (UPV) completed a questionnaire as the main research method.

This was a questionnaire-based study in which the answers were collected online. The questionnaire was intended to take approximately 10 min to complete and consisted of 39 questions, 35 of them employing Likert scales (10-, 5-, 3- levels that depended on the evaluable items and the level of detail required), 3 with multiple-choice answers and 1 open question about students' motivation. Questions related to personal digital skills or appreciation of the adaptation were normally established on a 10-level Likert scale. It was sought to balance the number of questions from the questionnaire in each category to obtain the following distribution: 15 questions belong to the "Methodological adaptation" dimension, 14 to the "Technological adaptation" dimension and 10 to the "Personal adaptation" dimension.

2.2. Participants and Data Collection

A total number of 117 students of the subject Mathematics I of the Aerospace Engineering Degree, without differentiating their gender, were asked to fill in a questionnaire, of which 84 completed it. The sample size therefore represents 71.79% of the total number of students from the aforementioned subject. The age of students ranged between 18 and 19 years.

A convenience sample was used for the purpose of the current study, since respondents happened to be available during two academic years, the first one coinciding with the onset of the pandemic and the second one with the stabilization of educational methodologies six months later.

Students' responses were collected at the end of the first semester of their second academic year 2020/2021, meaning that they had been students of Mathematics I during the outbreak of the pandemic in the 2019/2020 academic year and had sufficient data to be able to give an informed opinion.

The authors were lecturing at ETSID when the online questionnaire was distributed through the PoliformaT (Sakai) educational platform, and it was available for two days, requesting that the students to participate in the study through the accessible communication channels.

The purpose of the survey was previously presented to the students, but in a succinct way so as not to influence their opinions in any way. The survey was anonymous, it was not obligatory, and students were informed that they could stop completing the questionnaire at any time they wished. Indeed, 10 students, apart from the 84 who completed the survey, did not finish taking the questionnaire or answered less than 10%. Their partial answers have not been taken into consideration in the study.

2.3. Hypothesis and Data Analysis Methods

The objective of this study was to study the influence of b-learning and the use of digital technologies before the pandemic, and whether this influence was positive, improved the resilience of university education and facilitated the sustainability of the students' learning process. In this analysis, a study of the veracity of the following hypotheses was proposed:

Hypothesis 1 (H1). *B-learning methodologies enhanced subject adaptation to online teaching.*

Hypothesis 2 (H2). *Digital technologies facilitated university adaptation.*

Hypothesis 3 (H3). *Initial digital skills influenced the perception of the adaptation.*

Hypothesis 4 (H4). *The adaptation process has caused a change in the students' way of learning.*

The analysis and treatment of the data were carried out with the R and RStudio software. Excel software was used for the graphs derived from the data. The interactions between variables were studied and considered. Paired t-tests were applied to determine any significant difference between the means of the variables studied, such as students' opinion on the university's adaptive capacity within 4 weeks and 6 months after the pandemic, or the students' opinion on the resources available in UPV educational platforms, just after the pandemic and six months later. An analysis of variance (ANOVA) was also carried out to determine if there are significant statistical differences on the variables "appreciation of the university's methodological and technological adaptation" and "the appreciation of the adaptation of the subjects" based on the methodology taught up to that point (BL/not BL). ANCOVA analysis has been applied to determine the influence of the initial digital skills (covariate) on the perception of the adaptation of the university and the subjects depending on one factor (BL/not BL). Levene's test was performed to check the homocestaticity of the variables involved in the ANCOVA analysis.

2.4. Limitations

This study was been carried out by taking into account the results obtained from a questionnaire of convenience. This implies that the results can be extrapolated at most to other universities with a similar STEM environment. A broader study in other technological universities as well as universities covering a wider spectrum, with a greater number of respondents, would reinforce the results obtained in this study.

3. B-learning: Enabler for University Education Resilience

After the Joint Declaration of the European Ministers of Education convened in Bologna on 19 June 1999, [55], several universities started a process moving from a teacher-centered model to one based more on student needs and pace. Technical University of Valencia was one of the universities encouraging FT since 2014 [56].

Throughout this section, we review its capabilities, focusing on the case of a b-learning environment that, before face-to-face lockdown in March 2020, was fully implemented in lab computer sessions of the subject Mathematics I in Aerospace Engineering at UPV and partially in its Theory and Practice component.

FT arose in the context of the available digital tools at the end of the 20th century and, additionally, the different learning styles that were appealing to the youngest generations.

Among the first practitioners in implementing FT, we find Baker [57] who, in 2000, called it "classroom flip". He aimed at aligning the technological and pedagogical trends at that time, since the former was intended mainly for online education, and the latter supported by findings about how people learn [58,59], which considered that the students were active characters that learned best in settings where faculty are viewed to serve as mentors [60]. The classroom flip was claimed to "bring the benefits of increased interactivity and collaboration into their classes—both online and in the classroom, without sacrificing any content."

At the same time, also in 2000, Lage/Platt/Treglia [61] recalled that events that had traditionally taken place inside the classroom now might take place outside the classroom and vice versa. The idea was to appeal most, if not all, of the different learning styles of students such as dependent, collaborative and independent [62], or with other forms of learning based on how they relate to the world (Introvert or Extrovert), process information (Sensing or Intuitive), make decisions (Thinking or Feeling) or evaluate the environment (Judging or Perceiving). These personal features influence their learning process. Op. cit. coined this methodology "Inverted Classroom", though it can draw closer to what nowadays we understand as BL as a variety of tools were used in different formats to accommodate and appeal to different learning styles.

This pattern of flipped teaching that reverses and links between activities outside and inside the classroom [63], is a way to reinvent the classroom experience by empowering students to develop higher cognitive skills and thus foster meaningful learning [64]. The goal is that students, whatever discipline they are studying, play an active role and become responsible for their own learning process [63–67].

Under a traditional methodology, the teaching/learning dichotomy is clearly separated and comes in that order, transmission and assimilation [61]. The first phase is mainly developed with the teacher taking the role of sage on the stage with the purpose of transmission of knowledge, whereas the students play a passive role [57]. In the assimilation phase, students must be active in making the effort to assimilate and may apply the information acquired in their assignments, lab practices or in-group activities [68]. In this second phase, the teachers can be present (e.g., in lab sessions) or absent (e.g., in assignments).

The FT methodology reverses these two main stages of the traditional model: the new knowledge is acquired, firstly, outside the classroom through material prepared or provided to be worked on, in advance, as well as exercises or assignments provided, and secondly, during in-class individual or cooperative activities [69]. Hence, the classroom is transformed into a meeting and debate point [70], reverting their load compared to traditional classes [52].

Whenever a non-traditional methodology is developed without following the above two clear phases of the students working in advance and discussing/working in the classroom and there is a combination of the above with digital technologies, it is widely understood as a BL methodology.

Developing a course under an FT or BL methodology requires a lot of preparation [71,72], and trying to do it in a single course may be too demanding. For that reason, some practitioners implement it gradually in some parts of the subject, giving room to measure the impact on the students' learning process. These (small) partial implementations are called micro-FT methodologies [29,63], and may remain as that within a BL methodology or progress to a full FT methodology within two or three academic years.

The literature on e-learning, FT and BL has grown, as shown throughout this paper, and there is a consensus among researchers and practitioners from its birth on its effectiveness in emphasizing the active role that the students play in their own learning process [69].

What is most important from our point of view is that students become aware of their active role so that their learning process becomes sustainable as soon as possible, while they achieve competencies and skills that they will be using in their long-life learning.

We embrace this perspective, and in its deployment, we undertook a b-methodology based on FT aimed at averting situations pointed out by some researchers as drawbacks of FT related to students' involvement [41,67–69] or lecturers' preparation [41,42,73,74].

Our BL implementation based on FT followed a typical 3-stage BBD process (B = before, B = before, D = during each class), which we will explain, stage by stage, in the three forthcoming subsections. Typically, because for some given topic, it eventually became BDD or BDA, with A = after; thus our BL approach was indeed blended. For convenience, we will write FT–BL as it relies heavily on FT and brings the Teaching/Learning dichotomy back into stage even though, under this methodology, the teacher moves more towards something akin a coach in the students learning process.

3.1. Autonomous Learning

In this first stage, called Autonomous Learning, each student acquires knowledge in an out-of-class environment by working (part of) the syllabus along some resources provided through the PoliformaT platform. These resources consist of notes, video notes and exercises with solutions. Hence, the platform works as a distant extension of the educational environment of the university. Students may follow their own pace, review notes or take time to ensure their learning. Urgent doubts are solved via chat or e-mail with the lecturer.

From a didactic point of view, video notes at this stage reinforce the competencies that students have previously achieved or can introduce new concepts, serving as guides for an autonomous learning process outside of the classroom. PoliformaT enables the creation of these videos, called Polimedias. These Polimedias, with an average duration of about 10 min, have shown to be an outstanding material in the learning environment inside the university. Indeed, students would rather use video resources than any other format.

Figure 1 gathers these basic tools of PoliformaT as well as Tests and Quizzes tool to assess knowledge, Chat and Messages tools to communicate with teachers and their classmates, and other Resources, where students find additional learning material and exercises for practice. They all constitute the basic tools for FT-BL methodology.

3.2. Online Knowledge Assessment

The second stage, called Online Knowledge Assessment, can be viewed as an extension of the first one. Its goal is to assess the students' autonomous learning. This stage is not aimed at evaluating the students, but rather their acquired knowledge, so that the lecturer gets timely feedback to help him or herself design the next stage.

The evaluation of the learning process is performed through the PoliformaT platform, specifically with the Test and Quizzes tool. Therein, the students, once they have worked out the material provided or suggested, take a test that is assessed immediately through the platform. Hence, the students, as well as the teacher, receive quick feedback on the understanding of concepts by the class. The tests that are carried out have the advantage that, in addition to providing a grade, indicate to students which questions were correct and which were not, hinting at some clues on significant shortcomings or deficiencies in the latter case.

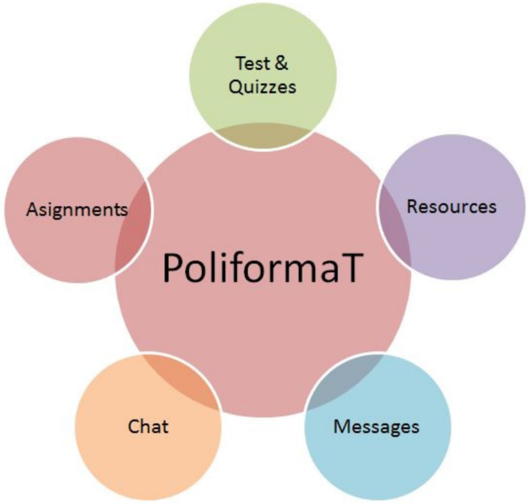

Figure 1. Basic tools provided by the educational platform PoliformaT.

3.3. In-Class Reinforcement

The third stage, called In-Class Reinforcement, consists of some activities developed to reinforce or enhance the knowledge acquisition and competencies achievement that the students have worked out-of-class. This methodology maximizes the interaction between teacher and students, since time inside the classroom focuses on reinforcing knowledge acquisition and competencies achieved through activities. These activities, which are carried out based on the results obtained by the students in the online knowledge assessment tests, consisted of a variety of strategies ranging from simple resolution of doubts, problem-solving through group collaboration, game-based learning activities, project-based learning activities, etc. One of the strengths of this methodology is that once the concepts are prepared outside the classroom, the students have a very positive predisposition to interact with each other and the instructors at large. The shortcomings are clearer, and the doubts are much more surgical and precise.

Figure 2 represents in detail the aforementioned three stages.

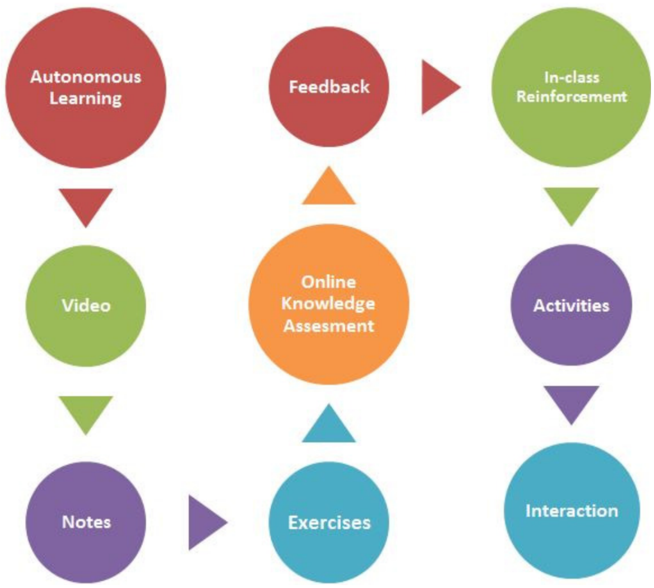

Figure 2. Flipped teaching–blended learning (FT–BL) methodology within a 3 BBD process (B = before, B = before, D = during each class).

4. The Inflection Point to Spreading Digital Technology in 2020: COVID-19

When COVID-19 irrupted, overall mobility restrictions for lecturers and students forced schools to change teaching methodologies. Online teaching replaced face-to-face classes, and despite the initial confusion that this produced, teaching platforms and educational tools managed to redirect the situation and maintain continuity in the educational process.

Many logistic problems were confronted, such as bandwidth, capacity of the servers, the infrastructure to teach online classes and access to connection points. The transformations that occurred in the methodology of the subjects were clearly less abrupt for those whose degree of digitization was higher before the pandemic.

The adaptation carried out at UPV mainly consisted of replacing all the face-to-face teaching sessions with an online methodology through the Teams hub, showing a high resilience of the university staff that in a very short period of time managed to maintain the standards and the quality of the subject content. In our case, with FT-BL standardly used, some arrangements of the coaching activities also took place.

In fact, the first stage, Autonomous Learning, did not need to evolve and remained reasonably the same, except for the considerable increase of the resources provided via PoliformaT, mainly digital visual and web content material.

Analogous circumstances involved the Online Knowledge Assessment that kept the PoliformaT supported knowledge tests and feedback.

The biggest change took place during the In-class Reinforcement stage, which migrated to Teams. The hub allowed the broadcasting of the online classes to all students and the recording of the sessions and added a new element, namely interaction without social contact between lecturers and students, which was felt as a barrier at the beginning but in no time allowed a fluid interaction. The two platforms complemented each other to fulfill all the elements that were available in a pre-COVID-19 session with face-to-face interaction.

Figure 3 shows how the UPV educational platform and communication software coexist in a university ecosystem, complementing each other, showing the resilience that the university education system at UPV has based its strength and its adaptability to communicative digital tools not originally meant for education.

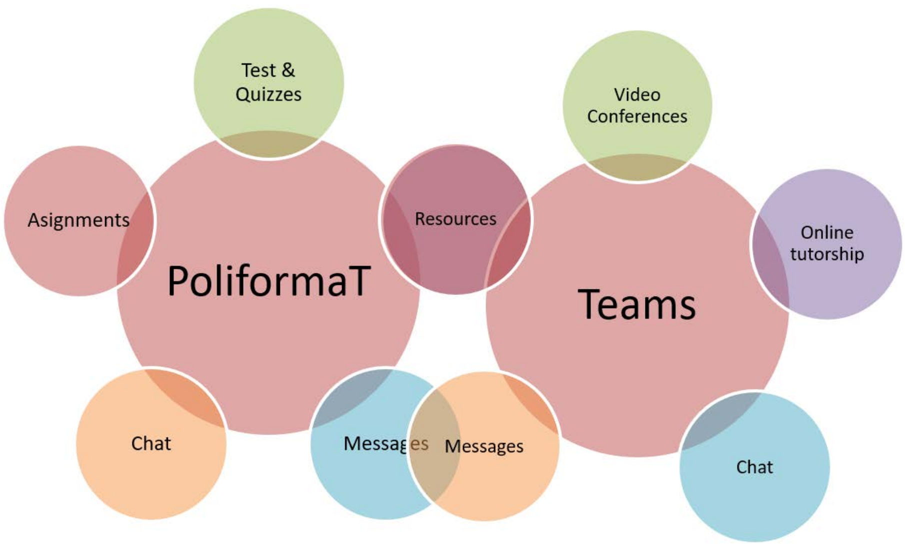

Figure 3. Educational environment at University of Valencia (UPV) after the pandemic began.

The two hubs, Teams and PoliformaT, can provide educational content to students, and while the former has been mainly used for synchronous and asynchronous audiovisual communication, the latter specialized in the assessment of content. The combined use of both platforms allowed students to reach more open access content by modifying their previous learning process design that just used PoliformaT.

5. Results

This section presents the results obtained in the survey. The results have been divided into seven sections that study the impact of sanitary restrictions in the university environment on different variables and the interaction between them.

5.1. General Adaptation

Table 2 gathers students' answers on the adaptation of the university to the pandemic situation. The answers to questions "How do you assess the adaptation process carried out by the university after the sanitary restrictions imposed by the government during the first four weeks?" and "How do you assess the adaptation process carried out by the university after the sanitary restrictions imposed by the government during the first 6 months?" were valued from 1 to 5, with 1 being "very badly" and 5 "very good". The data obtained show a higher mean in the assessment of adaptation after six months than after four weeks, but with a similar standard deviation (Table 2). This difference in the appreciation of adaptation may be due to many factors, such as personal resilience to a sudden change or the progressive improvement of the university methodological and technological policies. The interaction between them cannot be ruled out, although this study focuses on the influence of these policies and previous methodologies.

Table 2. Students' opinion on the university adaptive capacity within 4 weeks and 6 months after the pandemic began.

	Mean	Sd	IQR	Cv	Skewness	Kurtosis
Adaptation.4.weeks	3.62	1.07	1	30	−0.68	−0.05
Adaptation.6.months	3.86	1.03	2	0.27	−0.92	0.56

If a hypothetical test is carried out to compare the means, where the alternative hypothesis is that the mean of the data after six months is greater than the mean after four weeks, we obtain the data presented in Table 3, which allow us to assume with a significance level of 0.05 that the alternative hypothesis is valid.

Table 3. Paired t-test for the mean difference of students' opinion on the university adaptive capacity within 4 weeks and 6 months after the pandemic began.

	t	df	*p*-Value	H1	Conf. Interval	Mean Diff.
Adaptation 4.weeks vs. 6.months	−4.78	83	0.000007249	True	(−0.34, −0.14)	−0.24

Students were surveyed about their appreciation of the resilience of the university, based on the technological resources available, and the responses indicated that 51.2% thought that the university had been very resilient, 34.5% that it was quite resilient, 4.8% that it was somewhat resilient, 7.1% that it was not very resilient and 2.4% that it was not at all resilient.

5.2. Subject Adaptation and B-Learning

The fact that each lecturer had to adapt his/her subject to the new online system through the aforementioned platforms led to a possible disparity in their pace of adjustment towards the new circumstances. In order to seek if the students appreciated some difference, the following questions were formulated: (a) "How do you assess the methodological adaptation of the subjects after the face-to-face restrictions?" (b) "How do you assess the methodological adaptation of the subject of theory/practice of Mathematics I?" (c) "How do you assess the adaptation of the Mathematics I Computer Lab Sessions?" and (d) "Do you think that the FT methodology that was applied before the pandemic facilitated the adaptation to distance teaching?" They all had rating responses from 1 to 5, where 1 meant a very low/bad adaptation and 5 a very good/high adaptation.

Figure 4 reflects the students' opinion on the adaptation process of classes in general in all their subjects (blue), in Maths I concerning Theory and Practice (TP) (red) and Maths I Computer Lab Sessions (green), respectively. In addition, the right bars (purple) represent the number of students that thought that FT made the transition smoother in general.

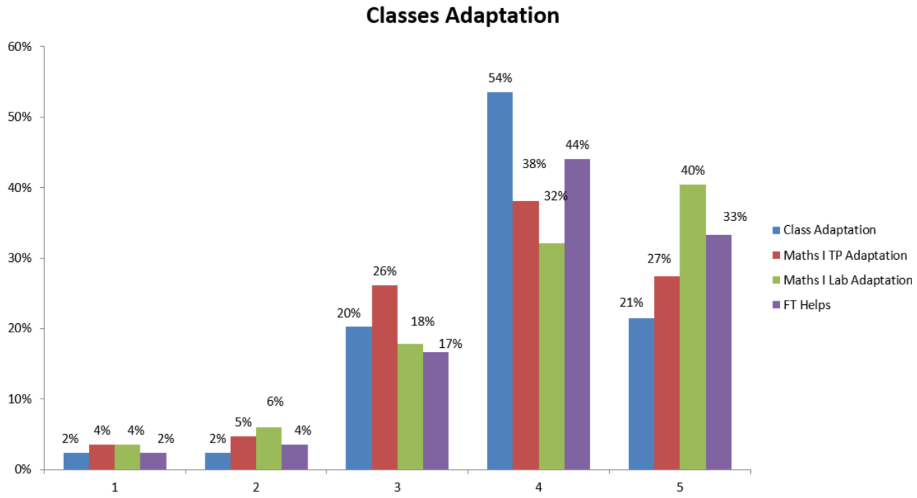

Figure 4. Students' opinion on the adaptation: in general, Maths Theory and Practice (TP), Maths Lab and FT.

We recall that in Mathematics I Lab sessions, FT was implemented from the beginning of the course, as explained in Section 3.

Table 4 provides a brief comparison showing a significant difference between the adaptation of the Computing Lab Sessions of the subject, the rest of the subjects, and even with the Theory/Practice of the same Mathematics I (TP) subject. In general, the students' perception was that the FT methodology had facilitated the shift to online teaching.

Table 4. Students' opinion on the adjustment of subjects towards online education.

	Mean	**Sd**	**IQR**	**Cv**	**Skewness**	**Kurtosis**
General	3.90	0.85	0.25	0.22	−0.99	1.93
Maths I (TP)	3.81	1.01	2.00	0.27	−0.75	0.42
Lab. Maths	4.00	1.10	2.00	0.27	−1.01	0.49
Flip. Lab	4.02	0.93	1.00	0.23	−1.06	1.34
	t	**df**	***p*-value**	**H1**	**Conf. Interval**	**Mean diff.**
Lab. Maths vs. General	1.13	83	0.2593	True	(−0.08, 0.30)	0.11
Lab. Maths vs. Maths I (TP)	2.54	83	0.0127	True	(0.04, 0.34)	0.19

On the other hand, the data obtained indicated that 33% of the students thought that this methodology did help a lot in the adaptation process, 44% thought that it had helped significantly, 17% that it helped more or less, and 6% thought that it did not really help at all or that it did a little (see Figure 5).

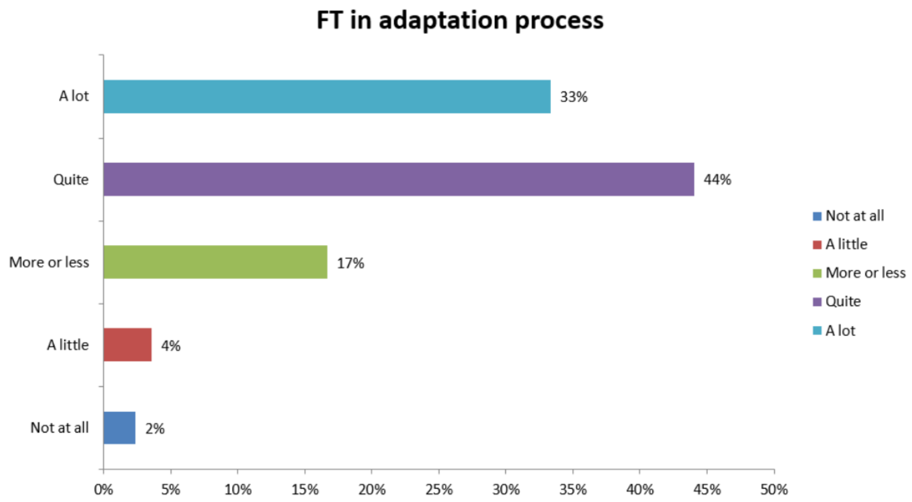

Figure 5. Students' opinion on the adaptability of the subject with a flip-teaching methodology.

We can therefore infer according to the opinion of the students that the university has improved its methodological adaptation in recent months. This may be due to the stabilization of the situation, the teacher and students' adaptation to technological tools and the increasing amount of teaching material at their disposal.

5.3. The Educational Platforms

Regarding the digital resources offered, the students were asked: (a) "Do you think that the quality/quantity of the resources offered through the platforms (Teams and PoliformaT) has been sufficient during the first four months of the pandemic?" and (b) "Do you think that the quality/quantity of the resources offered through the platforms (Teams and PoliformaT) is sufficient after six months of the pandemic?" The answers were evaluated from 1 to 5, where 1 meant very bad/little and 5 very good/abundant.

It is clear that when the abrupt adaptation to online teaching happened, the university's digital resources were scarce, and the perception improved when the adaptation process had stabilized a bit. The answers, however, are relevant to provide an idea of the progression in quantity and quality of resources from the students' perspective.

Indeed, when students were asked about the quantity and quality of the resources supplied by the combination of both hubs, Teams and PoliformaT, at the beginning and after six months, we observe that there exists a significant difference between the means of their perception (3.70/5 at the beginning and 4.14/5 after six months), with a very similar standard deviation in both cases. (Table 5).

Table 5. Students' opinion on the resources available in UPV educational platforms, just after the pandemic and six months later.

	Mean	Sd	IQR	Cv	Skewness	Kurtosis
Beginning	3.70	1.03	1	0.28	−0.87	0.30
Nowadays	4.14	1.05	1	0.25	−1.18	0.44

Again, if a hypothetical test is carried out to compare the means, where the alternative hypothesis is that the mean of the data after six months is greater than the mean after four weeks, we obtain the data presented in Table 6, which enables us to assume with a significance level of 0.05 that the alternative hypothesis is valid.

Table 6. Paired t-test for the mean difference of students' opinion on the resources available in UPV educational platforms, just after the pandemic and six months later.

	t	df	*p*-Value	H1	Conf. Interval	Mean Diff.
Resources. 4.weeks vs. 6.months	−5.06	83	0.0000024	True	(−0.61, −0.27)	−0.44

Students were surveyed on whether they thought that the combined use of both educational tools Teams and PoliformaT had mitigated the effects of changing methodology with the question "Do you think that the technological elements provided by the combination of the Teams and PoliformaT platforms have softened the abrupt change to the new online teaching methodology?" Rated from 1 very poor to 5 very much, the result was that 56% of the students thought that the use of these platforms had helped them a lot, whereas 39% thought that they had helped them significantly enough, and only 5% of the students thought otherwise (see Figure 6).

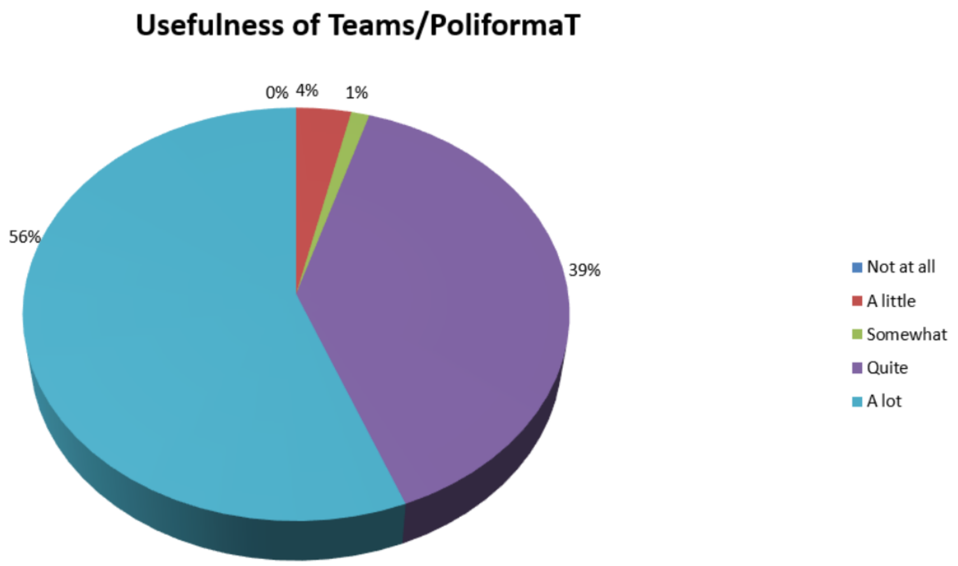

Figure 6. Usefulness of Teams/PoliformaT combined to mitigate effects of changing methodologies.

The hubs used for the educational transition differ in many of the elements implemented. Teams is a tool more linked to the interaction between members of the educational community (external as well), while PoliformaT is more oriented to the internal management of the subject, exams and evaluations. Both share communication elements such as chat, mail or the provision of resources. However, its role in the methodological adaptation has not been the same. Students were asked their general opinion about the Teams, PoliformaT platforms and the joint use of both through the questions: "Rate from 1 to 5 the Teams, PoliformaT platforms and the Teams/PoliformaT combination (1 very little useful 5 very useful)". Figure 7 collects the students' opinion on the usage of the two tools where they assigned a value between 1 and 5, with 1 being completely dislike and 5 beingcompletely like. Therein, we observe that there is a slight preference of Teams over PoliformaT.

Thus, we may infer that the vast majority of students' perspective is positive on the consequences of applying these educational platforms as enablers of the new teaching environment. Table 7 gathers the statistics of these results of the students' opinion on either or combined use of both platforms.

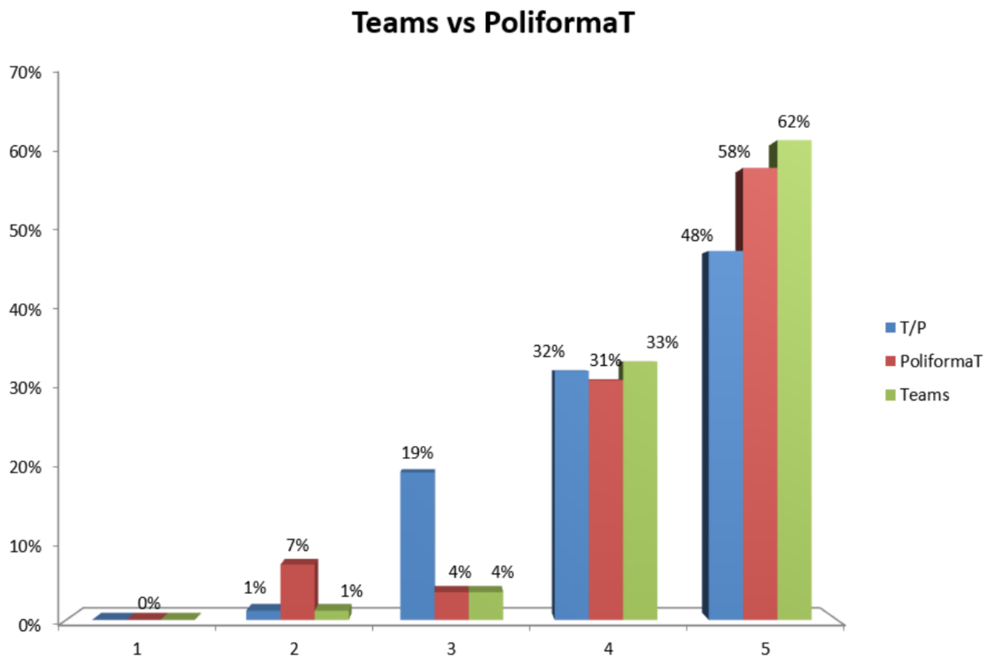

Figure 7. Educational environment at UPV after the pandemic.

Table 7. Students' preference between PoliformaT, Teams or a combined use of both.

	Mean	Sd	IQR	Cv	Skewness	Kurtosis
PoliformaT	4.40	0.87	1	0.20	−1.58	1.94
Teams	4.56	0.63	1	0.14	−1.43	2.34
PoliformaT/Teams	4.26	0.81	1	0.19	−0.66	−0.72

When students were requested to explain the rationale for this difference, they highlighted the communication strengths of Teams compared to PoliformaT. A fortiori, this indicates that students appreciate direct and instant online communication with mates and lecturers over any other form, like forums and email provided by PoliformaT.

From an interactive point of view, the Teams platform can offer the best opportunity to engage students effectively during e-learning, although this can present challenges. It has been found that some students who did not participate actively in synchronous classes interacted more actively through the use of mail or PoliformaT chat. This highlights the diversity of needs and learning styles of students, as pointed out in [61,75].

5.4. Digital Resources

Curiously, once adapted to the new digital environment and the new post-COVID-19 methodology, 100% of the students affirmed that they would like to keep the digital elements that were being used, such as the recording of classes, video notes and the possibility to receive classes at home.

Among all the digital resources that students would like to keep once the pandemic restrictions have ended, it is worth highlighting recorded classes (mentioned by 96% of students), video notes (74%), online tutorials (51%) and the ability to receive classes at home (43%).

This indicates the predisposition of students to find a balance between classroom educational methodologies and certain online resources that facilitate the management of student learning. As indicated in [76], once the situation stabilizes, we need to focus on the intersections and productive capacities of traditional and online forms of learning and how they can cooperate more effectively to facilitate learning outcomes and provide more equitable opportunities for students. Given that the resources available on the educational platforms used can be accessible from different digital devices (mobiles, tablets, computers), this has minimized the impact on students with fewer resources. It has not been the case that students have not been able to access content online due to a lack of resources in our study. However, the impact of digital poverty should be studied more in depth, which we propose as a future work.

5.5. Self-Perception

Regarding the transition from face-to-face to online methodology, the students, when asked "Does the new distance teaching improve or worsen the student's interest/motivation/focus?" (rated as 1 it worsened, 2 it does not change, and 3 it improves), perceived that their motivation, interest in the subjects and ability to focus had decreased (see Figure 8). They blamed the sudden change that the pandemic had produced. Approximately 80% thought that these three items worsened, 20% thought that they improved and, significantly, none thought that there was no difference.

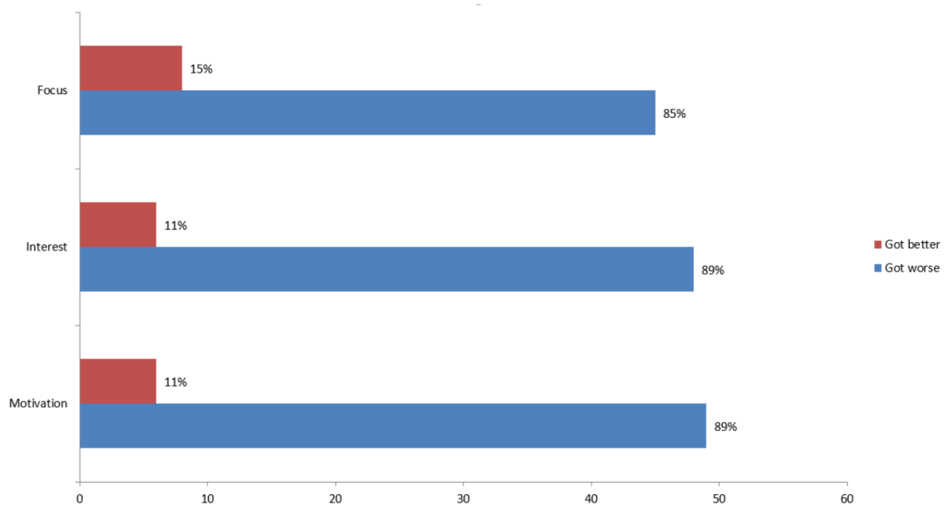

Figure 8. Students' perception of their motivation, interest in the subjects and ability to focus after the pandemic began.

In response to the question about whether they (the students) had the perception that in the actual university environment, and considering the technological and methodological resources used today, the university's resilience had increased, 78.6% of them affirmed that they did have that feeling, compared to 21.4% who stated that they did not feel any improvement in their resilience.

5.6. Increasing Digital Competencies

Finally, their answers to "Do you think that your management of digital resources has improved as a result of the process of adaptation to the new methodology?" (1, not at all; 5, very much) indicated that the use of these new resources together had improved their handling of digital resources (both, university-based and external); 62% of students believed that it had improved a lot, 26% that it had improved quite a bit, 7% that it had improved somewhat and 5% that it had improved only a little, as shown in Figure 9. No one thought that they had improved not at all.

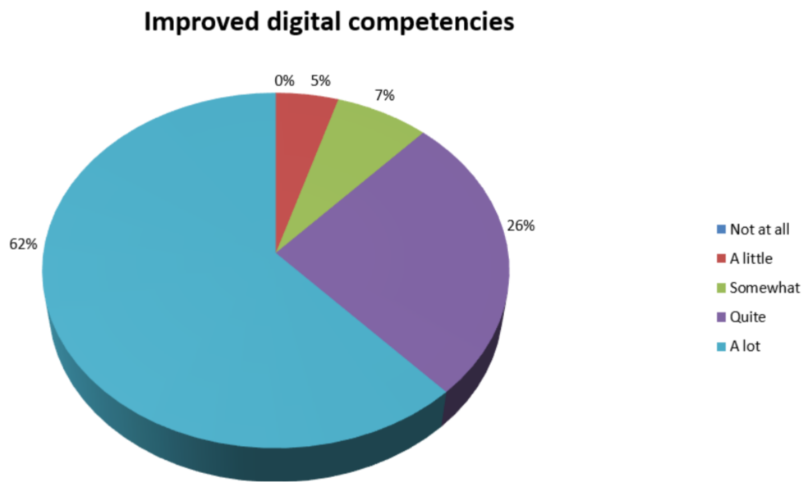

Figure 9. Students' opinion on their handling of digital resources.

5.7. ANOVA and ANCOVA Analysis

An analysis of variance (ANOVA) was carried out to determine if there are significant statistical differences in the variables UR = appreciation of the university's adaptation (methodological and technological) and SR = appreciation of the adaptation of the subjects (methodological adaptation) based on the methodology taught up to that point (group FT or not FT).

The descriptive statistics are shown in Table 8 and ANOVA results in Table 9.

Table 8. Descriptive statistics of the ANOVA analysis.

	N	Mean	Std. Dev.	Std. Error	LL	UL	Min.	Max.
UR								
No FT	38	3.79	1.189	0.193	3.40	4.18	1	5
FT	46	3.41	1.376	0.203	3.00	3.82	1	5
Total	84	3.58	1.301	0.142	3.87	3.87	1	5
SR								
No FT	38	4.71	1.541	0.250	4.20	5.22	1	8
FT	46	6.80	1.759	0.259	6.28	7.33	3	10
Total	84	5.86	1.958	0.214	5.43	6.28	1	10
DS								
No FT	38	7.50	1.428	0.232	7.03	7.97	4	10
FT	46	7.33	1.674	0.247	6.83	7.82	4	10
Total	84	7.40	1.561	0.170	7.07	7.74	4	10

Regarding the results on the UR variable, we observed that there is no statistically significant effect of the group (FT/no FT) on the appreciation of the methodological and technological adaptation of the university (F = 1.759, $p = 0.188$, see Table 8).

However, there is a statistically significant effect of the group (FT/no FT) on the appreciation of the methodological adaptation of the subjects (F = 32.948, $p < 0.01$, see Table 8).

In all the cases, the Levene test was performed to check the homocestaticity (see Table 10).

Table 9. ANOVA analysis.

UR vs. FT	SS	df	MS	F	Sig.
Between	2.949	1	2.949	1.759	0.188
Within	137.468	82	1.676		
Total	140.417	83			
SR vs. FT	**SS**	**df**	**MS**	**F**	**Sig.**
Between	91.231	1	91.231	32.948	<0.01
Within	227.055	82	2.769		
Total	318.286	83			
DS vs. FT	**SS**	**df**	**MS**	**F**	**Sig.**
Between	0.629	1	0.629	0.256	0.614
Within	201.609	82	2.459		
Total	202.238	83			

Table 10. Levene's tests for homoscedasticity.

UR	Levene Statistic	df1	df2	Sig.
Based on Mean	3.338	1	82	0.710
Based on Median	2.449	1	82	0.121
Based on Median and adjusted df	2.449	1	81.264	0.121
Based on trimmed mean	3.850	1	82	0.053
SR	**Levene**	**df1**	**df2**	**Sig.**
Based on Mean	1.647	1	82	0.203
Based on Median	1.047	1	82	0.309
Based on Median and adjusted df	1.047	1	81.759	0.309
Based on trimmed mean	1.615	1	82	0.207
DS	**Levene**	**df1**	**df2**	**Sig.**
Based on Mean	1.618	1	82	0.207
Based on Median	1.686	1	82	0.198
Based on Median and adjusted df	1.686	1	81.783	0.198
Based on trimmed mean	1.573	1	82	0.213

Students have shown a positive appreciation of the fact that the subjects with an FT methodology suffered a less traumatic adaptation than those in which this methodology was not carried out, indicating a significant capacity to absorb part of the impact caused by the pandemic. One of the main reasons is the educational autonomy that this type of methodology provides to students.

As seen in Section 5.5, students consider that their digital skills have improved during the adaptation process. However, the initial digital skills (DS) that students had before the pandemic could have had a significant effect on the appreciation of the methodological and technological adaptation of the university. This item appeared in the questionnaire and asked students to assess their initial digital skills before the pandemic and was valued from 1, very low/null, to 10 very high/expert.

Indeed, assuming that the effect of DS on UR depends on the group, an ANCOVA analysis of one factor (FT/ no FT) was carried out with DS as the covariate, showing that the effect of DS on UR did not depend significantly on the group (p = 0.399 > 0.05, see Table 11).

Table 11. ANCOVA analysis with interaction between UR and digital skills (DS).

Source	SS (Type III)	df	MS	F	Sig.
UR					
Correction Model	19.009	3	6.003	4.062	0.010
Intercept	11.081	1	11.081	7.498	0.008
Group	1.781	1	1.781	1.205	0.276
Group × DS	1.064	1	1.064	0.720	0.399
DS	10.935	1	10.935	7.399	0.008
Error	118.230	80	1.478		
Total	1222.00	84			
Corrected Total	136.238	83			

However, if a simpler model is calculated without interaction between FT/no FT groups and DS, it is observed that there are no significant differences in the UR response between the two groups. On the other hand, the UR value does depend significantly on the DS (p = 0.003), and the effect of DS on UR is the same in the two groups (see Table 12).

Table 12. ANCOVA analysis without interaction between UR and DS.

Source	SS (Type III)	df	MS	F	Sig.
UR					
Correction Model	16.945	2	8.472	5.753	0.005
Intercept	10.050	1	10.050	6.824	0.011
Group	2.653	1	2.653	1.802	0.183
DS	13.570	1	13.570	9.214	0.003
Error	119.293	81	1.473		
Total	1222.00	84			
Corrected Total	136.238	83			

By estimating the parameters, specifically the slope of the regression lines, it is possible to quantify this effect. The fitted model is $y_{ij} = \mu + \alpha_i + \beta x_{ij} + \varepsilon_{ij}$, where the slope is estimated at $\hat{\beta}$ = 0.259, so the higher the DS value, the higher the expected UR value is (see Table 13).

Table 13. Parameter estimation without interaction between UR and DS.

Parameter	B	Std. Error	t	Sig.	LL	UL
Intercept	1.512	0.651	2.322	0.023	0.217	2.808
Group = No FT	0.358	0.266	1.342	0.183	−0.173	0.888
Group = FT	0					
DS	0.259	0.085	3.035	0.003	0.089	0.429

To verify that group factors do not have a significant effect on the DS variable, an ANOVA of this variable was performed according to the groups under study, obtaining that there is no significant difference between the means of both groups (Table 9).

6. Discussion

The arrival of the COVID-19 pandemic in March 2020 meant a radical change in university education around the world, moving from face-to-face to completely online education, and in this paper, we explored if BL, which encourage an active role of students in their learning process [10–29], and digital technologies facilitate the university resilience under a stressful situation like the one suffered with the COVID-19 irruption.

Students' opinions was requested on several features related to the technological, methodological, and personal adaptation of the university, the subjects and themselves to the new, previously unknown, setting. Data came from Aerospace Engineering students at Universitat Politècnica de Valencia (UPV) after six months of the university's face-to-face lockdown when all instruction moved into an online format supported by the Sakai-based platform that they had been using previously to the lockdown plus the Teams hub created by Microsoft. The students expressed that, despite losing motivation, interest and concentration when working from an environment outside the university, most of them (85.7%) thought that the university had shown an adequate adaptation process. When it came to the different subjects' methodologies, 77% thought that the pace of adaptation had been favored significantly when the subjects had been using b-learning methodologies in advance. Their feeling was almost enthusiastic in what concerns the combined use of the two digital tools provided to cope with the loss of face-to-face interaction. This high percentage might indicate that their perception of the adaptative process is even higher than what they expressed when requested on it. This positive feeling opposes others found in the literature, where the technological environment was either not as high as in Aerospace Engineering nor the b-learning starting point is known [19,41,42].

Students showed a positive opinion of their own resilience as well as the university's in case a similar situation might happen again. This may be linked to the fact that almost all of them expressed that they had improved their digitization skills. A consequence of this may be that students wish to maintain certain electronic and digital privileges once the pandemic ends and face-to-face interaction comes back.

The results obtained in this paper seem to convey that using BL methodologies, digitally supported, facilitate the university resilience in general, and especially, of its students who will get used to playing an active role in their learning process and will become more self-reliant than with traditional methodologies.

7. Conclusions

After the outbreak of the pandemic, face-to-face restrictions at the university caused a radical change in educational methodology and in the digitization of the means of transmitting information. The use of BL methodologies has proven to be a facilitating element in the process of adapting the subjects, since it allowed students greater freedom in their pace of learning, greater adaptation to the assimilation of content in non-controlled environments, and less dependence on the usual resources employed in face-to-face sessions. The students reflected in their opinions a less negative impact on the adaptations of the subjects who used this BL methodology than in those who did not use it. The resilience of the university also depended on the technological factor and the digitization of the educational process. This capacity for digitizing the learning process was based on technological resources and hubs such as Teams and PoliformaT (UPV).

Student feedback shows that the freedom to learn at their own pace is a benefit that should be maintained within a culture of long-term learning. The use of many of the digital resources used by the university to alleviate the lack of face-to-face sessions has caused a manifest change in the students' way of learning, who have improved habits and digital skills that will be very useful in the learning process and in their future work life. It should be noted that this adaptation was more fluid for students who initially had a higher self-assessment of their digital skills, as part of the adaptation process depended on them. Audiovisual content, one of the strongest and most reliable digital elements, has also proven to be some of the most valued by students, who are very reluctant to lose it. It should not and cannot be forgotten or underestimated that today's students are users of technology and experts in network resources, and it is common for them to obtain the content they want however and whenever they want.

The role of lecturers has also undergone an important change, as the design of the subjects must consider that the digitization of the university has undertaken an evolution that otherwise would have possibly taken a few years to reach its current level.

The creation of quality content, both text and audiovisual elements, supporting the learning process, has become much more relevant and does not depend so much on the presence of the teacher in face-to-face sessions but on an adequate orientation of their learning. This break with the traditional method of learning and the elements that have favored the resilience of the university have led to an evolution of learning methods at the university and its role in modern society, which should be the subject of future research.

The positive assessment of the university adaptation from the methodological and technological point of view and the smoothing role that BL methodologies have played must be taken as an opportunity and incentive to accelerate and make the transition towards the real needs that the students of Generation Z would have demanded otherwise, [36–40]. The pandemic in some way has become the trigger for an update rather than a reform of the methodologies at the university level, in which the capabilities of BL have acquired significant importance in the present and future new models of learning.

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