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Digital Generation Influence on the Post-COVID-19 Use of Digital Technologies in Engineering Education: A Statistical Study

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Abstract: The COVID-19 pandemic caused a global health crisis that led to a sudden migration of many educational activities to digital environments. This migration affected the digitization process of higher education. This paper conducts a quantitative statistical analysis of the impact that the COVID-19 pandemic had on the habits of use of information and communication technologies (ICT) among 426 Latin American university professors in engineering areas. In particular, this impact has been analyzed in terms of the digital generation of the participating professors. To achieve this, the responses given by them on a validated questionnaire were examined for the purposes of this research. As a result, the COVID-19 pandemic has led to an increase of up to 47% in the use of ICT among engineering professors, but unevenly according to the different uses of these tools within the teaching activity. In addition, in engineering areas, it seems that digital natives have increased their use of ICT more than digital immigrants after the pandemic (between 8% and 20%, depending on the type of digital tool in question). It is suggested that universities take measures for the digital integration of older professors.

Keywords: pandemic; education; digital generation; information and communication technologies; engineering; higher education

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1. Introduction

The COVID-19 pandemic greatly affected the educational domain, among others, and several schools and institutes had to initially close down and adjust to the norm of distance education [1,2]. Students being able to continue their education was a significant achievement, which was made feasible due to the efforts of all the involved stakeholders and the adoption of new approaches and methods [3,4]. Having to rapidly adjust and transition from face-to-face to online learning brought about several challenges as well as new opportunities [4,5]. As this way of teaching was unplanned and imposed to meet the new educational demands and continue the educational process, it was not thoroughly designed to offer long-term and stable online learning experiences. Instead, it was characterized as an emergency form of learning and teaching [5–7].

Nonetheless, distance and online education was gaining ground [8], as the adoption and integration of digital technologies in educational activities enabled the realization of online learning environments [9], which were essential throughout the pandemic in all educational levels [10]. Due to advances in information and communication technologies (ICT), these virtual learning environments provided ubiquitous learning opportunities, offered access to educational material and resources, and enabled learners and teachers to be connected to and engaged in teaching and learning activities, despite them being in different places and time zones [11–13]. During the pandemic, ICTs became essential cognitive learning tools [14] whose role was imperative in the educational process [15]. Therefore, it can be inferred that ICT and virtual learning environments played a vital role in

supporting and enriching teaching and learning activities throughout the pandemic [16,17], which justifies their increased use in K–12 education [18] and higher education settings [19], even in the post COVID-19 era.

Despite the clear lack of adequate training in terms of technological skills, practical knowledge of new technologies, and suitable pedagogical approaches [20], which was one of the main limitations [21] that affected the educational process [22,23], this transition resulted in members of the educational community cultivating their digital competences and becoming more familiar with ICT [24–26]. Even though the development of digital skills was expected under these circumstances, the factors that influenced the use of digital technologies in the post-COVID-19 era are still to be explored. These factors can vary based on different regions, countries, educational levels, subjects, and even individual characteristics. For instance, more practical subjects and courses that required students' active involvement and hands-on experiences were affected to a larger degree in comparison to more theoretical ones [18]. Due to their nature of requiring the cultivation of reasoning skills and conducting laboratory experiments [27], higher education engineering courses have been significantly affected by the adoption and integration of ICT both during and after the COVID-19 pandemic [28]. As a result, several studies have explored how and to what extent the COVID-19 pandemic has impacted engineering education and how it has developed in the post-COVID-19 era [29–32]. Additionally, there has been an increased interest in how such courses developed in regions such as Latin America [33,34], since they maintained a blended learning approach [35] despite facing academic and social challenges [36]. Several factors that influenced engineering education within the Latin American region have been examined, such as the digital divide [37], access to appropriate equipment and technologies [38], training and knowledge of ICT [39], the impact of knowledge areas in ICT use [26], students' engagement [40], learning resources and materials [41], and digital stress [41,42].

Furthermore, one of the factors that has not been examined yet but could potentially influence how digital technologies are being adopted and used in engineering education in the post-COVID-19 era is an individual's digital generation. The digital generation is divided into digital immigrants and digital natives based on whether an individual was born before the bloom of digital technologies or has grown up surrounded by and exposed to them [43,44]. In the context of this study, Prensky's original distinction was used to differentiate between digital immigrants and digital natives, which renders 1980 as the year of birth to distinguish between the two groups [43,44]. Specifically, digital immigrants cultivated their digital competences over the years by adopting and integrating ICT into their daily lives and routines, while digital natives are tech-savvy and have a natural aptitude for digital technologies due to their being surrounded by technology since birth [43–46]. The individuals of the two digital generations are characterized by different experiences, skills, and levels of proficiency in handling technological applications and devices, which can affect their behavior toward, viewpoints of, and competences in using technology in education [47–53]. This divergence can be the cause of various problems in educational contexts, particularly in technology-enhanced learning environments [54]. Hence, it has been employed in several research studies as a means to distinguish between generations and as an assessment factor [42].

Consequently, this study aims to evaluate how the COVID-19 pandemic impacted the habits of using ICT among Latin American university professors in engineering education. Particularly, this study follows a quantitative approach and uses a validated questionnaire that focuses on the influence of the digital generation. This study will help address the problem of incorporating technical education teachers into the digitalization process of higher education and identify factors that influence this process. This will help universities to take measures and design appropriate training on digitalization. The participants' responses are examined through statistical analyses. Although there are different classifications of ICT [55,56], to aid this study, the classification of ICT and learning management systems (LMS) suggested by Garrote-Jurado et al. [57] is used, as it is the easiest for participants

to comprehend due to its simplicity and the clear boundaries it sets between the different categories of ICT. More specifically, ICT tools are separated into four categories that involve the use of ICT tools as a means to: (i) interact through reactions and feedback and to present content in a dynamic way which encourages students' active involvement and collaboration (e.g., discussion boards, etc.); (ii) communicate and disseminate information among educational stakeholders by enabling bidirectional communication (e.g., emails, social media, etc.); (iii) distribute and share learning content, material, and resources mostly from teachers to students (e.g., online platforms, etc.); and (iv) administrate and evaluate courses by monitoring and documenting the educational process (e.g., surveys, etc.) [33,53–55]. To meet the aim of the study, the following research questions (RQs) were set to be explored:

- RQ1: Have Latin American engineering professors increased the frequency of ICT use in their teaching activities after the COVID-19 pandemic?
- RQ2: Has this frequency variation, if any, occurred with the same intensity in the different families of ICT tools, according to the different uses in the teaching activity? (The classification of ICT tools by Garrote-Jurado et al. [55] is used).
- RQ3: Does the digital generation of engineering professors influence how the COVID-19 pandemic has caused the frequency of ICT use to vary?

Based on the above-mentioned questions, this article is structured as follows: in Section 2, related studies are presented, and their results are highlighted and synthesized. In Section 3, the main variables and hypotheses are showcased, details about the participants and the data collection process are given, and the instrument and statistical analysis methods used are described. In Section 4, the results of the study in terms of the participant distribution and frequency of use of ICT tools are analyzed. In Section 5, the findings of this study are discussed and related to those of the literature. Finally, in Section 6, the outcomes of this study are summarized and highlighted.

2. Related Work

In this section, other related studies that focused on analyzing engineering professors' perspectives regarding ICT use and tools during the pandemic are presented. The specifications of the studies and their results are described. Particularly, engineering education was significantly affected by the pandemic due to it requiring hands-on activities and experiential learning. Hence, the role of ICT, digital competencies, and digital tools as well as the factors that influenced their adoption and use were vital in the context of engineering education. Throughout the pandemic, the educators' roles remained crucial in the educational process. As a result, several studies examined professors' perspectives and attitudes to determine how the COVID-19 pandemic impacted engineering education in higher education and how it affected their use of ICT, digital tools, and digital competences.

Regarding the impact of the COVID-19 pandemic on engineering education, several studies have provided overviews on the topic of online engineering education [30], the challenges and opportunities that arose in engineering education [31], as well as the status of online engineering before, during, and after the COVID-19 pandemic [28]. Other studies explored the educational stakeholders' perspectives. Asgari et al. [29] conducted an observational study involving 110 university professors and 627 higher education students regarding engineering online education. Several general challenges were observed, such as security and privacy issues, technical problems, and a lack of hands-on training. The study highlighted the need for appropriate teaching approaches and methods to effectively integrate experiential learning in online learning environments. Vergara-Rodriguez et al. [32] examined higher education students' perspectives on virtual learning environments and virtual laboratories as well as educational trends in engineering education in the post-COVID-19 era. Based on the results, the students highly valued face-to-face teaching and actual laboratories, but also regarded highly and were favorable toward virtual laboratories. The significance of hybrid environments to be developed and integrated into teaching and learning is highlighted.

As far as the cultivation of digital competencies is concerned, Jorge-Vázquez et al. [25] focused on identifying the conditioning factors and the digital competency levels of university faculty by examining 216 university professors. Most professors had or developed an intermediate level of digital competencies, with younger professors showcasing more advanced digital skills. The strategic leadership and technological resources of universities played a vital role in the effective adoption and integration of ICT. The need to further improve the digital skills of the faculty was highlighted. Antón-Sancho et al. [26] examined the viewpoints of 716 higher education professors from different universities in Latin America regarding how the use of ICT can be affected by the subject and knowledge area. Their results revealed that the use of ICT significantly increased for all education stakeholders, but did so unevenly, which has rendered the teaching activities in the post-COVID-19 era more heterogeneous. Additionally, professors from the social sciences and engineering displayed a more drastic increase in the use of ICT.

Vergara-Rodriguez et al. [42] focused on identifying which variables most affected professors' abilities to adapt to using ICT and digital learning environments effectively. In their study, they examined data from 908 university professors. Based on their findings, the professors' digital competencies and self-confidence in using ICT were positively correlated with ICT adaptation. This effect was less impactful on digital natives. On the other hand, the professors' digital skills and stress were negatively correlated with their ability to adapt their practices to digital environments. This effect was less impactful on digital immigrants. Additionally, differences were observed based on the professors' area of knowledge and gender. In another study, Vergara-Rodriguez et al. [36] explored how the COVID-19 pandemic influenced university professors' use of ICT. Particularly, they analyzed the responses of 116 university professors from different universities. Their results revealed that throughout the pandemic, the university faculty digital competencies improved, and their use of ICT increased. In addition, gender gaps in the ability to effectively use ICT were greatly reduced, with female professors reporting a more significant improvement and increase in the use of digital tools. In another recent study, Vergara et al. [57] focused on the habits that characterize engineering professors when using ICT as a means of teaching. More specifically, the perspectives of Latin American higher education engineering professors were examined. Overall, a significant increase (40%) in the use of ICT in learning and teaching activities was observed. Female engineering professors showcased a higher increase in their ICT use in comparison with male engineering professors, and this fact was more evident in private universities than in public ones. Due to the nature of the engineering field and its pedagogical specificities, the need to further promote and improve training for engineering professors was highlighted.

Antón-Sancho et al. [35] focused on how the COVID-19 pandemic influenced university professors' use of digital tools and ICT in the context of science and technology education. More specifically, they examined the viewpoints of 340 university professors. Their results revealed that although the professors did not receive adequate training, through their own efforts, they managed to develop their digital skills, which were deemed intermediate. This fact was particularly true for professors in sciences and health sciences. The overall increase in faculty digital competencies helped reduce the digital divide among professors of different genders and digital generations. Liesa-Orús et al. [16] investigated 345 university professors' perspectives regarding the use of ICT tools to assist in the development of 21st century skills and the technological barriers and challenges faced by higher education professors. The benefits and potentials of ICT to improve learning and students' 21st century skills development were highlighted. A particular emphasis was put on students' improved critical thinking, collaboration, and communication. Núñez-Canal et al. [23] looked into the digital competencies that university professors cultivated during the COVID-19 pandemic. More specifically, they examined the perspectives of 251 university professors. Their results revealed a close relationship between the professors' digital skills and their influence on students' learning. The professors' attitudes toward ICT in education, their prior knowledge and skills, and the training they received

were key elements to the students' learning process. Hence, digital competences arose as a vital pedagogical aspect in the post COVID-19 era. In addition, they highlighted the need for pedagogical changes and changes in university leadership and management.

Other studies such as Gómez-Poyato et al. [10] focused on higher education students' viewpoints about whether the integration of ICT in education and the cultivation of digital skills satisfactorily met their needs. A total of 309 students participated, who highlighted the importance of further improving ICT training to develop both general digital competencies and job-specific skills. Furthermore, Guillén-Gámez et al. [22] compared 715 higher education students', graduates', and professors' attitudes toward digital technologies and the use of ICT in education. Their results revealed that there was a significant difference between how the students and graduates viewed digital technologies and how the professors did, with the students and graduates depicting a more positive attitude. Despite this fact, no differences were observed in terms of the use and knowledge dimensions between the professors and graduates.

3. Materials and Methods

This section goes over the methods adopted and materials used in this study. More specifically, the main variables and hypotheses are presented, and the participants and data collection process are described. The details about instrument used and the statistical analyses implemented are also provided.

3.1. Variables

In this subsection, the main variables examined using the research instrument used are presented. The explanatory variable considered in this study is the digital generation of the participants (dichotomous variable, with possible values of digital native or digital immigrant). The explained variables are the frequencies of use of the different ICT families (interaction, communication, distribution, and evaluation) in engineering education. The explained variables are quantitative, measured on a Likert scale from 1 to 5, where 1 is a null frequency, 2 is infrequent, 3 is an intermediate frequency, 4 is frequently, and 5 is very frequently. The variations in the frequencies of use of the different families of ICT tools after the pandemic were measured by calculating the rate of variation based on the participants' responses to questions about their frequency of use before and after the pandemic.

3.2. Hypotheses

The null hypotheses explored to meet the study aim are showcased in this subsection. In particular, to meet the aim of this study, the following null hypotheses are examined:

- H_{01}: There has been no significant variation in the frequency of use of the different families of ICT teaching tools after the COVID-19 pandemic in engineering education among the participants.
- H_{02}: The digital generation of the participating engineering professors does not significantly influence the variation that the COVID-19 pandemic has caused in the frequency of use of the different families of ICT teaching tools.

3.3. Participants and Data Collection

This subsection goes over the details of the participants and presents the data collection process in detail. The participants were selected by means of a non-probabilistic convenience sampling process. Specifically, the target population consisted of registered attendees to a training course given by the authors on the didactic use of ICT in engineering education. This training consisted of a single theoretical session, repeated every two weeks between January and June 2023, whose objective was to present the didactic applicability of ICT in engineering education; the classification of ICT according to the different teaching uses: (i) interaction, (ii) communication, (iii) distribution of didactic content, and (iv) evaluation of learning and course administration; and to present some examples of ICT tools from each of the above families. The criteria for inclusion in the study were:

(i) being a university professor of engineering degrees at a university in Latin America and the Caribbean, and (ii) having attended the training session on the didactic use of ICT in engineering education given by the authors.

The online questionnaire used as a research instrument was created using Google Forms™ v.1.2.8 and was sent to the attendees of the training session by email. Of the 512 attendees, 462 professors responded to the questionnaire. All the responses received were validated, in the sense that they were complete. The conceptualization exercise carried out during the training session allowed us to assume that the participants had sufficient and homogeneous knowledge about the didactic use of ICT in the various dimensions of engineering education. Participation was voluntary, free, anonymous, and informed.

3.4. Instrument

The research instrument used in the context of this study is described in this subsection. The research instrument is a four-item questionnaire. Each item involves the frequency of use of each of the families of ICT tools used in engineering education: (i) interaction, (ii) communication, (iii) content sharing, and (iv) course evaluation and administration. Each item is a twofold question, in the sense that the frequency of use of the corresponding ICT tool family before the COVID-19 pandemic and after is requested. All of these frequencies have been measured on a Likert scale from 1 to 5, where the value of 1 corresponds to the lowest frequency (null) and the value of 5 to the highest (very frequently). The instrument has been validated for its construct and also for its reliability [58].

3.5. Statistical Analysis

This subsection goes over the statistical analysis methods used to examine the factors related to the engineering professors' perspectives regarding ICT use and tools. The present research is quantitative and is based on an analysis of the frequencies of ICT use before and after the COVID-19 pandemic expressed by the participants. The *t*-test for comparison of means with Welch's correction (without assuming equality of variances) was used to test whether there has been a significant variation in the frequency of ICT use after the pandemic compared to before the pandemic for each family of ICT tools (hypothesis H_{01}). This test allows us to decide, with statistical significance, whether there is a real difference between the mean responses given by the two populations under analysis (digital immigrants and digital natives). In addition, a multifactor analysis of variance (MANOVA) was used to test whether the post-pandemic variations in the frequency of ICT use were similar or different according to the digital generation of the engineering professors (hypothesis H_{02}). This test measures whether the variation in the frequencies of ICT use after the pandemic behaves significantly differently in digital natives and digital immigrants or, on the contrary, in an analogous way. In all the statistical tests, 0.05 was used as the level of significance. This means that the existence of significant differences in each of the situations analyzed is conditional on the corresponding statistical test yielding a *p*-value of less than 0.05.

4. Results

In this section, the results of this study are presented and analyzed, and the hypotheses are examined. In particular, the participant distribution in terms of gender, university type, digital generation, and country are explored. The results regarding the frequency of use of ICT tools and the different families of ICT tools are also presented and described.

4.1. Distribution of Participants

The participants' distribution is presented in this subsection. More specifically, their gender and country are examined, and the type of university in which they teach as well as their digital generation are explored.

A total of 462 engineering professors (300 males and 162 females) participated in the study. The gender distribution is not homogeneous (chi-square = 41.22, *p*-value < 0.0001). The gender gaps in the participants' valuations were not analyzed precisely because of this

lack of homogeneity in the distribution. A total of 51.95% of the professors taught in private universities and 48.05% taught in public universities. The distribution of the participants in private and public universities was homogeneous (chi-square = 0.70, p-value = 0.40). The distribution of the participants according to their digital generation (49.37% digital immigrants and 50.65% digital natives) was homogeneous (chi-square = 0.08, p-value = 0.78), which reinforces that there was no bias in the comparative analysis of the participants' responses based on their digital generation. Among the participants, there was representation from 10 countries in the Latin American and Caribbean regions (Table 1). There needs to be more homogeneity in the distribution of the participants by country of origin (chi-square = 1409.10, p-value < 0.0001), which makes it difficult to perform a comparative analysis of the responses by country.

Table 1. Distribution of participants by country and digital generation.

Country	Participants (% of the Total Population)	Digital Immigrants (% in Each Country)	Digital Natives (% in Each Country)
Argentina	6.71	80.65	19.35
Bolivia	1.52	1.43	98.57
Brazil	4.11	100.00	0.00
Colombia	10.61	2.04	97.86
Dominican Republic	1.52	100.00	0.00
Ecuador	5.41	52.00	48.00
Mexico	7.79	50.00	50.00
Nicaragua	2.60	50.00	50.00
Peru	58.44	48.90	51.10
Puerto Rico	1.30	100.00	0.00

4.2. Frequency of Use of ICT Tools

To examine how frequently engineering professors use ICT tools, this subsection goes over their use of ICT tools prior to and after the pandemic. Emphasis is also given to the different families of ICT tools used among the participants.

Figure 1 represents the mean valuations given by the participants (on a scale of 1–5) to the frequencies of use of each of the four families of ICT tools analyzed, both before the COVID-19 pandemic and after. The representation in terms of lines allows us to illustrate whether the growth in the frequencies studied was greater or less, depending on the slopes of the lines. In general terms, the participating engineering professors significantly increased their use of ICT tools in all the teaching areas studied after the COVID-19 pandemic (Figure 1). The greatest increases occurred in the use of tools for communication (with an increase of 46.73% after the pandemic compared to before the pandemic; $t = -22.92$, p-value < 0.0001) and, above all, for evaluation and administration (with an increase of 47.00%; $t = -19.71$, p-value < 0.0001). The increases in the use of tools designed for interaction with students (16.33%; $t = -10.74$, p-value < 0.0001) and content sharing (26.65%; $t = -16.74$, p-value < 0.0001) were smaller. The families of tools that increased the most were precisely those that were used less frequently before the pandemic (Figure 1). All this allows us to confirm the alternative hypothesis H_{01} (the existence of significant differences between the frequencies of ICT use before and after the pandemic).

A MANOVA test was conducted on the independent populations of digital natives and immigrants. This test allows us to assess whether there are significant differences between them in terms of the increase in the use of different ICT tools after the pandemic. The results show that the digital immigrants increased their use of ICT less than digital natives in the families of tools for interaction, communication, and sharing of didactic materials (Table 2). As for the evaluation and administration tools, the increase in their use after the pandemic was analogous in digital natives and immigrants since the differences between the respective increases were not significant (Table 2). Therefore, except for the assessment tools, the alternative hypothesis H_{02} (a significant influence of the digital generation of

engineering professors on the increases in the frequency of ICT use after the COVID-19 pandemic) is confirmed.

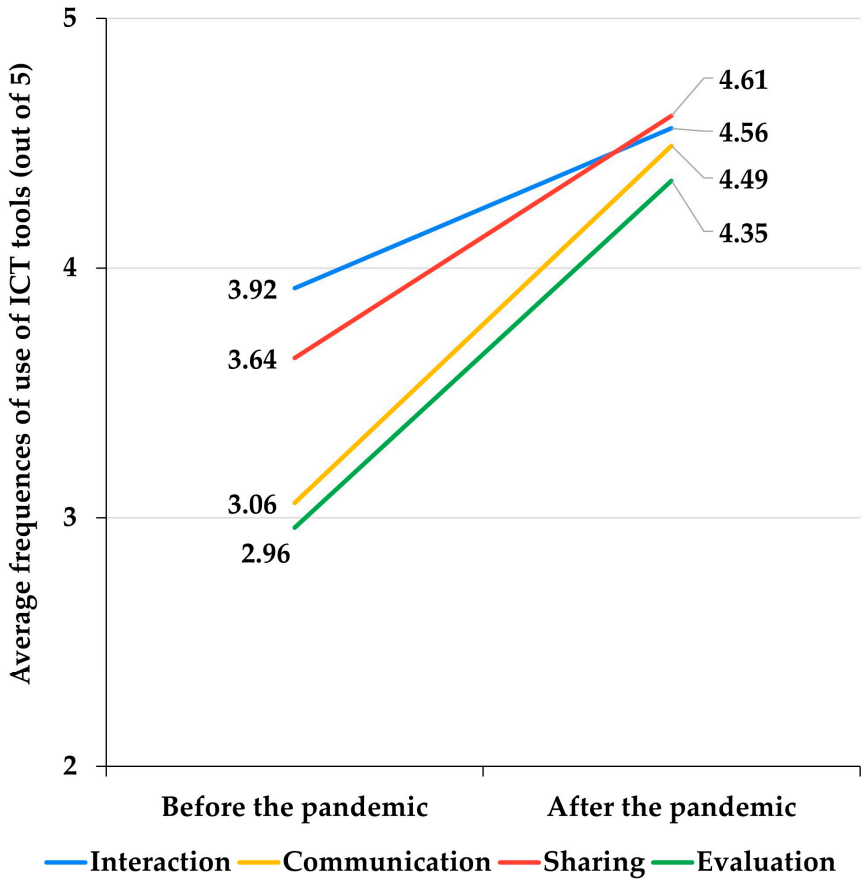

Figure 1. Frequencies of use of different families of ICT tools among participants before and after the pandemic.

Table 2. Mean frequencies of ICT use before and after the COVID-19 pandemic among digital natives and digital immigrants and MANOVA test statistics for comparison of means.

	Native			Immigrants			F-Statistic	*p*-Value
	Pre-Pandemic	Post-Pandemic	Increment (%)	Pre-Pandemic	Post-Pandemic	Increment (%)		
Interaction	3.84	4.64	20.83	4.00	4.47	11.75	7.39	0.0067 *
Communication	2.95	4.59	55.59	3.18	4.39	38.05	12.05	0.0005 *
Sharing	3.62	4.72	30.39	3.66	4.50	22.95	5.04	0.0250 *
Evaluation	2.95	4.36	47.80	2.97	4.34	46.13	0.09	0.7670

* $p < 0.05$.

5. Discussion

This section provides an in-depth look into the results and findings of this study while also relating the results to those of the literature. The use of ICT became a common daily occurrence for the educational community during the pandemic. It was thus evident that by using ICT more frequently, educational stakeholders' digital skills would improve, which in turn could benefit the overall educational domain [16]. Hence, ICT tools and digital competences were crucial pedagogical aspects during the COVID-19 pandemic and will play an even more significant role in education in the post-COVID-19 era [23]. Although the COVID-19 pandemic affected all educational levels, experiential subjects that required

hands-on activities were influenced to a larger extent [18]. Due to its experiential nature, engineering education is a distinct example of this [28,30,31].

Although the digital skills of engineering professors and the frequency of their using ICT increased during the COVID-19 period, there were several factors that influenced the engineering professors' frequencies of using ICT. This quantitative study looked into the engineering professors' perspectives and experiences using ICT tools while focusing on the influence of the participants' digital generation and of the different families of ICT tools. Hence, an online survey, in which 462 higher education engineering professors of public and private universities from 10 different countries in the Latin American and Caribbean region participated, was carried out. In contrast to the distribution of gender, which was not homogeneous, the distributions between digital immigrants and digital natives as well as between public and private universities were homogeneous. Furthermore, the majority of the participants were from Colombia, followed by Mexico and Argentina. The countries that had the most digital immigrant professors were Brazil, Dominican Republic, and Argentina, while Bolivia and Colombia were the countries with the most digital native professors.

Regarding the participants' frequency of using ICT in their teaching, a significant increase was observed across all families of ICT tools (RQ1). Tools for communicating as well as for administrating and evaluating showed a higher increase in use, which highlights their role in the teaching and learning activities and indicates that they were not being widely used prior to the pandemic. The ICT tools in the interaction and sharing categories also presented an increase, but to a lesser extent, as these tools were commonly used even before the pandemic. Therefore, significant differences in the frequency of use were observed among the different ICT tools (RQ2).

In addition to the overall increase in using ICT in education, the participants' generation influenced the frequency of their ICT tool use. Particularly, digital native professors showcased a significant increase in the use of interaction, communication, and distribution of didactic content ICT tools in comparison to digital immigrant professors. These results highlight the fact that digital native professors were already familiar with ICT tools and integrated them in their teaching activities more frequently even before the pandemic in comparison to digital immigrant professors. On the other hand, the administrative and evaluating ICT tools revealed a similar increase for both digital immigrant and digital native professors. In combination with the previous findings, these results highlight the lack of integrating appropriate ICT tools for administrating and evaluating teaching and learning activities prior to the pandemic, as well as the vital role of ICT tools in the educational process. The most significant differences were observed for the ICT tools in the communication, administration, and evaluation families, which were the least frequently used tools among engineering professors prior to the pandemic (RQ3).

Based on the results and despite the lack of suitable training and guidance during the COVID-19 pandemic, engineering professors, among other educational stakeholders, managed to develop their digital competencies, use ICT more frequently, and integrate ICT in their teaching more effectively through their own effort. This is consistent with the results obtained in other studies within engineering faculties [58], in the broader context of science and technology faculty [35], and even in the generic field of higher education [36]. The increase in ICT tool use was more evident for digital immigrant professors who were less acquainted with them in comparison with digital native professors who were more familiar with and skilled in ICT tools and had already integrated them in their teaching, as has been proven in several studies carried out in Latin American professors' populations [25,26,42]. Therefore, the results obtained in the present work confirm that age, as a variable correlated to the digital generation, affects the ICT integration process among engineering professors. Specifically, digital natives showed a greater capacity to incorporate digital technologies in the teaching environment than digital immigrants. This is probably because digital immigrants have received less training in digital competence and have spent a significant part of their careers making little use of them. This would explain their resistance to their

use. However, it was also observed that there were no significant differences between the digital natives and digital immigrants in terms of the use of ICT for evaluation. This is probably because the use of ICT is traditionally lower in this area of application, which would also act as a factor of resistance to their incorporation. This resistance factor seems to be independent of the digital generation of engineering professors.

The preceding results obtained here are also consistent with previous works among Mexican professors, which confirm that older professors present greater resistance to the integration of digital technologies in teaching activities [33,34]. These events have reduced, to a degree, the digital divide among engineering professors of different digital generations. This phenomenon had already been observed previously in the field of science and technology [35], and in general, in various areas of knowledge [26]. Furthermore, professors' digital skills, attitudes toward ICT, and self-confidence in using ICT tools can significantly affect their ability to effectively integrate ICT tools in their teaching, which in turn can influence students' learning and performance, as previously noted in [23,42]. For that reason and to meet the needs and pedagogical specificities of engineering education, it is imperative to develop and integrate appropriate training programs [58] which will allow teachers and professors to become more familiar with ICT, improve their digital skills, and integrate experiential learning [29] in hybrid learning environments and virtual laboratories, which can enrich overall engineering education [32]. Additionally, the need to provide appropriate technological resources and establish changes in university leadership and management as well as in policy making [23,25] is evident.

6. Limitations and Lines of Future Research

Although the sample size was large, the distribution of participants in the two digital generations analyzed (digital natives and immigrants) was not homogeneous, which could lead to some type of bias in the results. Given this limitation, it is proposed to conduct a study analogous to the one conducted here, but with a sample of participants homogeneously distributed across digital generations to confirm the results obtained. Furthermore, there were countries in which there were no digital natives within the sample of participants analyzed. This limits the study because it prevents a differential analysis based on country. It is proposed as a future line to select a sample that is homogeneously distributed by digital generation and country, which will allow this differential analysis to be carried out. Likewise, the results are limited by the strictly quantitative nature of the analysis performed. It is therefore proposed to complete the analysis by means of a qualitative study that will allow for a deeper understanding of the reasons behind the participants' responses and, therefore, the results that have been presented. Furthermore, the fact that the data collection was non-probabilistic could lead to the appearance of biases in the results. It is proposed to carry out probabilistic data collection as future work. Finally, the analysis is limited to the study of digital generation as an explanatory variable. This limits the extent of the results. It is proposed to carry out a study that incorporates other explanatory variables of a sociological type such as gender, or of an academic type such as tenure, type of university (public or private), or the area of knowledge of the participants.

7. Implications

Professors still show a lack of training and security in their use of ICTs for teaching, which prevents them from considering a full digitalization process in higher education. This occurs even among engineering professors, who should reasonably be the best trained in the use of technologies. All this implies the need to reinforce training plans for the development of digital and techno-pedagogical skills of professors by universities. Furthermore, the resistance observed on the part of older professors (digital immigrants) to the integration of digital resources leads us to think that this training should be differentiated according to the digital generation of the professor. This would make it easier to meet the specific needs of each of the generations. In addition, it is suggested that universities establish uniform guidelines for the use of ICT for the different teaching activities to be met by all

professors. This would act as an incentive for professors who are more resistant to the use of technologies to normalize their use in lectures.

8. Conclusions

To summarize the findings of this study, Latin American engineering professors have significantly increased their use of ICT tools for teaching purposes after the COVID-19 pandemic compared to their use before the pandemic. However, this increase has been uneven depending on the family of ICT tools considered. Specifically, the greatest increases have occurred in communication (46.73%) and evaluation (47.00%) tools, which are the tools that engineering professors used less frequently before the pandemic. Consequently, after the COVID-19 pandemic, there has been a certain balance in the frequency of use of the four different families of ICT tools in engineering education: (i) interaction, (ii) communication, (iii) sharing materials, and (iv) administration and evaluation.

Also, the digital generation of engineering professors significantly influences the magnitude of the increase in ICT usage after the pandemic. Digital natives have increased their use of ICT for student interaction more than digital immigrants (almost 10% more), as well as for communication (nearly 20% more), and content sharing (about 8% more). However, there were no significant differences between digital natives and digital immigrants in terms of their post-pandemic increase in the use of ICT for administration and evaluation.

These results show that there are two different speeds in the process of ICT integration in engineering education in Latin America depending on the digital generation of the professors. Therefore, it is recommended that universities develop training sessions in digital skills to help engineering professors decide to use ICT resources (mainly the older ones, who are the most resistant).

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References

1. World Health Organization. WHO Director-General's Opening Remarks at the Media Briefing on COVID-19. 2020. Available online: https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19{-}{-}-11-march-2020 (accessed on 27 August 2023).
2. UNESCO. 1.3 Billion Learners Are Still Affected by School or University Closures, as Educational Institutions Start Reopening around the World. 2020. Available online: https://en.unesco.org/news/13-billion-learners-are-still-affected-school-university-closures-educational-institutions (accessed on 27 August 2023).
3. Trust, T.; Whalen, J. Should teachers be trained in emergency remote teaching? Lessons learned from the COVID-19 pandemic. *J. Technol. Teach. Educ.* **2020**, *28*, 189–199.
4. Abaci, S.; Robertson, J.; Linklater, H.; McNeill, F. Supporting school teachers' rapid engagement with online education. *Educ. Technol. Res. Dev.* **2021**, *69*, 29–34. [CrossRef]
5. Ferri, F.; Grifoni, P.; Guzzo, T. Online learning and emergency remote teaching: Opportunities and challenges in emergency situations. *Societies* **2020**, *10*, 86. [CrossRef]
6. Hodges, C.B.; Moore, S.; Lockee, B.B.; Trust, T.; Bond, M.A. The Difference between Emergency Remote Teaching and Online Learning. Educause Review. 2020. Available online: https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning (accessed on 27 August 2023).
7. Bond, M. Schools and emergency remote education during the COVID-19 pandemic: A living rapid systematic review. *Asian J. Distance Educ.* **2020**, *15*, 191–247.
8. Simonson, M.; Zvacek, S.M.; Smaldino, S. *Teaching and Learning at a Distance: Foundations of Distance Education*, 7th ed.; Information Age Publishing: Charlotte, NC, USA, 2019.

9. Clark, R.C.; Mayer, R.E. *E-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning*; John Wiley & Sons: Hoboken, NJ, USA, 2016.
10. Gómez-Poyato, M.J.; Eito-Mateo, A.; Mira-Tamayo, D.C.; Matías-Solanilla, A. Digital skills, ICTs and students' needs: A case study in social work degree, University of Zaragoza (Aragón-Spain). *Educ. Sci.* **2022**, *12*, 443. [CrossRef]
11. Simonson, M.; Schlosser, L.A. *Distance Education: Definition and Glossary of Terms*, 3rd ed.; Information Age Publishing: Charlotte, NC, USA, 2009.
12. Hu, M.; Li, H. Student engagement in online learning: A review. In Proceedings of the 2017 International Symposium on Educational Technology (ISET), Hong Kong, China, 27–29 June 2017. [CrossRef]
13. Wallace, R.M. Online learning in higher education: A review of research on interactions among teachers and students. *Educ. Commun. Inf.* **2003**, *3*, 241–280. [CrossRef]
14. Jonassen, D.H. *Computers as Mindtools for Schools: Engaging Critical Thinking*; Prentice Hall: Kent, OH, USA, 2000.
15. Batra, S.; Kumar, S. Amalgamation of ICT in education during COVID-19. *Res. Rev. Int. J. Multidiscip.* **2022**, *7*, 71–74. [CrossRef]
16. Liesa-Orús, M.; Latorre-Cosculluela, C.; Vázquez-Toledo, S.; Sierra-Sánchez, V. The technological challenge facing higher education professors: Perceptions of ICT tools for developing 21st century skills. *Sustainability* **2020**, *12*, 5339. [CrossRef]
17. Saif, S.M.; Ansarullah, S.I.; Ben Othman, M.T.; Alshmrany, S.; Shafiq, M.; Hamam, H. Impact of ICT in modernizing the global education industry to yield better academic outreach. *Sustainability* **2022**, *14*, 6884. [CrossRef]
18. Lampropoulos, G.; Admiraal, W. The impact of COVID-19 pandemic on primary, secondary, and k-12 education: A systematic review. *Int. J. Stud. Educ.* **2023**, *5*, 348–440. [CrossRef]
19. Sormunen, M.; Heikkilä, A.; Salminen, L.; Vauhkonen, A.; Saaranen, T. Learning outcomes of digital learning interventions in higher education. *CIN Comput. Inform. Nurs.* **2021**, *40*, 154–164. [CrossRef] [PubMed]
20. Schildkamp, K.; Wopereis, I.; Kat-De Jong, M.; Peet, A.; Hoetjes, I. Building blocks of instructor professional development for innovative ICT use during a pandemic. *J. Prof. Cap. Community* **2020**, *5*, 281–293. [CrossRef]
21. Bingimlas, K.A. Barriers to the successful integration of ICT in teaching and learning environments: A review of the literature. *EURASIA J. Math. Sci. Technol. Educ.* **2009**, *5*, 235–245. [CrossRef] [PubMed]
22. Guillén-Gámez, F.D.; Mayorga-Fernández, M.J. Quantitative-comparative research on digital competence in students, graduates and professors of faculty education: An analysis with ANOVA. *Educ. Inf. Technol.* **2020**, *25*, 4157–4174. [CrossRef]
23. Núñez-Canal, M.; Obesso, M. de las M. de; Pérez-Rivero, C.A. New challenges in higher education: A study of the digital competence of educators in covid times. *Technol. Forecast. Soc. Chang.* **2022**, *174*, 121270. [CrossRef]
24. Esteve-Mon, F.M.; Llopis-Nebot, M.Á.; Adell-Segura, J. Digital teaching competence of university teachers: A systematic review of the literature. *IEEE Rev. Iberoam. Tecnol. Aprendiz.* **2020**, *15*, 399–406. [CrossRef]
25. Jorge-Vázquez, J.; Náñez Alonso, S.L.; Fierro Saltos, W.R.; Pacheco Mendoza, S. Assessment of digital competencies of university faculty and their conditioning factors: Case study in a technological adoption context. *Educ. Sci.* **2021**, *11*, 637. [CrossRef]
26. Antón-Sancho, Á.; Sánchez-Calvo, M. Influence of knowledge area on the use of digital tools during the COVID-19 pandemic among Latin American professors. *Educ. Sci.* **2022**, *12*, 635. [CrossRef]
27. Baggott-La-Velle, L.; McFarlane, A.; Brawn, R. Knowledge transformation through ICT in science education: A case study in teacher-driven curriculum development-Case-Study 1. *Br. J. Educ. Technol.* **2003**, *34*, 183–199. [CrossRef]
28. Anushalalitha, T. Precovid, covid and post covid classes and online engineering. In *Artificial Intelligence and Online Engineering*; Springer: Cham, Switzerland, 2023; pp. 533–546. [CrossRef]
29. Asgari, S.; Trajkovic, J.; Rahmani, M.; Zhang, W.; Lo, R.C.; Sciortino, A. An observational study of engineering online education during the COVID-19 pandemic. *PLoS ONE* **2021**, *16*, e0250041. [CrossRef]
30. Park, M.; Park, J.J.; Jackson, K.; Vanhoy, G. Online engineering education under COVID-19 pandemic environment. *Int. J. Multidiscip. Perspect. High. Educ.* **2021**, *5*, 160–166. [CrossRef]
31. Khan, Z.H.; Abid, M.I. Distance learning in engineering education: Challenges and opportunities during COVID-19 pandemic crisis in pakistan. *Int. J. Electr. Eng. Educ.* **2021**, 002072092098849. [CrossRef]
32. Vergara, D.; Fernández-Arias, P.; Extremera, J.; Dávila, L.P.; Rubio, M.P. Educational trends post COVID-19 in engineering: Virtual laboratories. *Mater. Today Proc.* **2022**, *49*, 155–160. [CrossRef] [PubMed]
33. Zamora-Antuñano, M.A.; Rodríguez-Reséndiz, J.; Cruz-Pérez, M.A.; Rodríguez Reséndíz, H.; Paredes-García, W.J.; Díaz, J.A.G. Teachers' perception in selecting virtual learning platforms: A case of mexican higher education during the COVID-19 crisis. *Sustainability* **2021**, *14*, 195. [CrossRef]
34. Zamora-Antuñano, M.A.; Rodríguez-Reséndiz, J.; Rodriguez Segura, L.; Cruz Perez, M.A.; Altamirano Corro, J.A.; Paredes-Garcia, W.J.; Rodríguez-Reséndiz, H. Analysis of emergency remote education in COVID-19 crisis focused on the perception of the teachers. *Sustainability* **2021**, *13*, 3820. [CrossRef]
35. Antón-Sancho, Á.; Fernández-Arias, P.; Vergara, D. Impact of the covid-19 pandemic on the use of ICT tools in science and technology education. *J. Technol. Sci. Educ.* **2023**, *13*, 130. [CrossRef]
36. Vergara-Rodriguez, D.; Concha, N.U.R.; Solis, R.M.; Anton-Sancho, A.; Fernandez-Arias, P.; Rubio-Cavero, M.P. Use of ICT tools in higher education in Peru during the COVID-19 pandemic. In Proceedings of the 2022 XII International Conference on Virtual Campus (JICV), Arequipa, Peru, 29–30 September 2022. [CrossRef]
37. García-Martín, J.; García-Sánchez, J.-N. The digital divide of Know-How and use of digital technologies in higher education: The case of a college in latin america in the COVID-19 era. *Int. J. Environ. Res. Public Health* **2022**, *19*, 3358. [CrossRef]

38. Quispe-Prieto, S.; Cavalcanti-Bandos, M.F.; Caipa-Ramos, M.; Paucar-Caceres, A.; Rojas-Jiménez, H.H. A systemic framework to evaluate student satisfaction in Latin American universities under the COVID-19 pandemic. *Systems* **2021**, *9*, 15. [CrossRef]
39. Antón-Sancho, Á.; Vergara, D.; Lamas-Álvarez, V.E.; Fernández-Arias, P. Digital content creation tools: American university teachers' perception. *Appl. Sci.* **2021**, *11*, 11649. [CrossRef]
40. Salas-Pilco, S.Z.; Yang, Y.; Zhang, Z. Student engagement in online learning in Latin American higher education during the COVID-19 pandemic: A systematic review. *Br. J. Educ. Technol.* **2022**, *53*, 593–619. [CrossRef]
41. Antón-Sancho, Á.; Vergara, D.; Fernández-Arias, P.; Ariza-Echeverri, E.A. Didactic use of virtual reality in colombian universities: Professors' perspective. *Multimodal Technol. Interact.* **2022**, *6*, 38. [CrossRef]
42. Vergara, D.; Antón-Sancho, Á.; Fernández-Arias, P. Variables influencing professors' adaptation to digital learning environments during the COVID-19 pandemic. *Int. J. Environ. Res. Public Health* **2022**, *19*, 3732. [CrossRef] [PubMed]
43. Prensky, M. Digital natives, digital immigrants part 1. *On the Horizon* **2001**, *9*, 1–6. [CrossRef]
44. Prensky, M. Digital natives, digital immigrants part 2: Do they really think differently? *On the Horizon* **2001**, *9*, 1–6. [CrossRef]
45. Creighton, T.B. Digital natives, digital immigrants, digital learners: An international empirical integrative review of the literature. *Educ. Leadersh. Rev.* **2018**, *19*, 132–140.
46. Autry, A.J.; Berge, Z. Digital natives and digital immigrants: Getting to know each other. *Ind. Commer. Train.* **2011**, *43*, 460–466. [CrossRef]
47. Helsper, E.J.; Eynon, R. Digital natives: Where is the evidence? *Br. Educ. Res. J.* **2010**, *36*, 503–520. [CrossRef]
48. Bennett, S.; Maton, K.; Kervin, L. The 'digital natives' debate: A critical review of the evidence. *Br. J. Educ. Technol.* **2008**, *39*, 775–786. [CrossRef]
49. Antón-Sancho, Á.; Fernández-Arias, P.; Vergara, D. Assessment of virtual reality among university professors: Influence of the digital generation. *Computers* **2022**, *11*, 92. [CrossRef]
50. Jukes, I.; McCain, T.; Crockett, L. *Understanding the Digital Generation: Teaching and Learning in the New Digital Landscape*; Corwin Press: Thousand Oaks, CA, USA, 2010.
51. Buckingham, D.; Willett, R. *Digital Generations: Children, Young People, and the New Media*; Routledge: Oxford, UK, 2013.
52. Erstad, O. Educating the digital generation. *Nord. J. Digit. Lit.* **2010**, *5*, 56–71. [CrossRef]
53. Hicks, S.D. Technology in today's classroom: Are you a Tech-Savvy teacher? *Clear. House J. Educ. Strateg. Issues Ideas* **2011**, *84*, 188–191. [CrossRef]
54. Kennedy, G.E.; Judd, T.S.; Churchward, A.; Gray, K.; Krause, K.-L. First year students' experiences with technology: Are they really digital natives? *Australas. J. Educ. Technol.* **2008**, *24*. [CrossRef]
55. Peres, P.; Pimenta, P. *Teorias e Práticas de B-Learning*; Edições Silabo: Lisabona, Portugal, 2011.
56. Boonmoh, A.; Jumpakate, T.; Karpklon, S. Teachers' perceptions and experience in using technology for the classroom. *Comput. Assist. Lang. Learn. Electron. J.* **2021**, *22*, 1–24.
57. Garrote Jurado, R.; Pettersson, T.; Regueiro Gomez, A.; Scheja, M. Classification of the features in learning management systems. In Proceedings of the XVII Scientific Convention on Engineering, Architecture, Havana, Cuba, 24–28 November 2014; pp. 1–12.
58. Vergara, D.; Antón-Sancho, Á.; Fernández-Arias, P. Engineering professors' habits: Didactic use of information and communication technologies (ICT). *Educ. Inf. Technol.* 2023, *in press*. [CrossRef]