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Technological Devices and Digital Competences: A Look into the Digital Divides for University Continuity during the COVID-19 Pandemic

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Abstract: Virtual education has gained great relevance in recent years, due to the pandemic. The access to electronic devices and services represents an urgent necessity and thus the concern for acquiring digital competences, which allow a proper interaction within the teaching–learning process. Recent studies have demonstrated the importance of having digital resources and the adaptability of their use from the university students' homes during the pandemic crisis. This research intends to identify the relevant challenges regarding the accessibility to technological devices and digital competences that university students had to face to obtain suitable learning during the lockdown, due to the pandemic. The sample information consisted of 9326 Peruvian university students. The data was obtained from the National Homes Survey from the Statistics and Information National Institute, and it was distributed in twenty-five regions (in groups of five macro-regions) over a period of three years (2019–2021). The results showed significant differences in the number of students with internet access from home: between 40% and 60% access classes with a desktop or laptop, and digital competences have improved in the last year. This is evidence that digital divides set limits on the opportunities for a quality education.

Keywords: education resources; digital divides; information technology; online learning

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1. Introduction

The pandemic has impacted all areas of society, including higher education. In the face of the need to maintain educational continuity, educational institutions were forced to adapt to the new digital reality and offer an online educational model (or virtual education). The achievement of this adaptability has depended on the responsiveness of each country, considering different important factors such as access to technology, economic resources, the technological and pedagogical capacity of the educational personnel, the infrastructure related to connectivity, and the educational policies, among others. As a result, many countries have shown some degree of deficiency in one or more of these factors, thus affecting educational quality [1–3]. In this regard, the significant digital disparity worldwide has revealed the existence of digital divides between countries with limited access to information and communication technologies (ICT) and those with greater access opportunities [4,5].

The digital divides in higher education refer to the inequalities that exist in the access to and use of ICT among university students (and the education system in general), and can manifest themselves in different forms, such as access to digital devices, internet connectivity, and digital skills and competencies, among others. Several studies focus on digital divides as an important factor in evaluating outcomes in virtual education.

According to the National Statistics Institute (2020) in Spain, 70.4% of university students indicated that they had a computer, tablet, or mobile phone for exclusive use, while another 24.6% said they had access to one of these devices for shared use. Only 2.4% reported not having access to any of them. Regarding internet access, 71.1% claimed to have good access, 24.6% regular access, only 3% reported occasional access, and 1.2% stated they had no access. [3]

A study conducted in India showed that students, from school to university level, face significant challenges in their educational activities. The lack of resources and the adoption of new digital teaching–learning methods during the pandemic have had a negative impact on the educational process of these students. [6]. Similarly, France has concluded that the inappropriate use of ICT affects the results of its students, and that universities were not prepared to train their teachers and students in the use of ICT, due to the digital divide present in the country [7].

During the pandemic, an increase in digital gaps and deficiencies in the training process of students became evident in Latin America [8]. In 12 Latin American countries, 81% of people in the highest income quintile have access to the internet at home, while only 38% of people in the lowest quintile have this vital tool. This problem is particularly severe in countries such as Bolivia, El Salvador, Paraguay, and Peru, where over 90% of students from the most vulnerable sectors lack access to the internet at home. On the other hand, in middle-income and upper-middle-income countries, this figure drops to 30%. Likewise, access to devices such as computers, cell phones, and tablets is also a problem for those coming from more disadvantaged sectors. [4].

Virtual education has, as a consequence, experienced an adaptation process in every educational aspect: teaching–learning methodologies; information and communication technologies (virtual environments, video conference); virtual learning materials; devices (desktops, laptops, etc.) and digital competences. The first three depend on the institution, while the others, that is the devices and the digital competences relate to a shared responsibility between the institutions and the students; however, the ones relating to the student can be cause enough for a student to drop out [9].

Regarding this, studies show that in order to face these challenges, it is necessary for the strategic plans of universities to be linked to regional public policies. This would allow for interaction between the universities' own resources, regional government financing, and the economic conditions of the population involved [10]. Achieving this interaction would allow the narrowing of the digital gaps related to access to technological devices and the internet, which are necessary resources in the educational system. On the other hand, the term "digital divide" is also aimed at measuring limitations or deficiencies in the proper handling of technological devices and information and communication technology (ICT) [11]. It is known that during the pandemic, the most commonly used technological devices were laptops and smartphones (among others), as well as access to the internet, and this is evidenced in research studies that seek to relate it to the continuity of university studies. Research studies have also been identified that seek comparisons with other factors (demographic, social, etc.) and even propose statistical modeling that allows for the prediction of certain levels of the digital divide [12–14]. Consequently, ensuring access to technological devices enables the development of key digital competencies for lifelong learning, thus enhancing other necessary competencies throughout the entire university education process.

According to the previous information, it is inferred that the continuity of university students during virtual education can be affected by the lack of access to the above-named resources [15]. As an example, the number of enrolled students during the first year of the pandemic reduced significantly among all the regions of Peru, as a reaction to the challenges of virtuality [16,17].

We can see in Figure 1 the effect of the pandemic in its first year (2020). In the macro-region North, five regions (Ancash, Cajamarca, La Libertad, Lambayeque and Piura) show a decrease in the number of enrolled students in comparison to the year 2019; this is the same as in the macro-region South, with six regions (Apurímac, Arequipa, Cusco, Ica, Puno and Tacna), the macro-region Center, with two regions (Huánuco and Junín), and the macro-region West, with one region (San Martín); all the macro-regions Callao/Lima showed a decrease in their number of unenrolled students. These characteristics match the rate of unenrolled university students shown in Table 1; in the macro-region North, the rate of unenrolled university students for 2019 was twenty-one out of one thousand university students, but for 2020 the rate was approximately fifty-six out of every one thousand university students. Therefore, it is necessary to assess the conditions in which university students face virtual education [18].

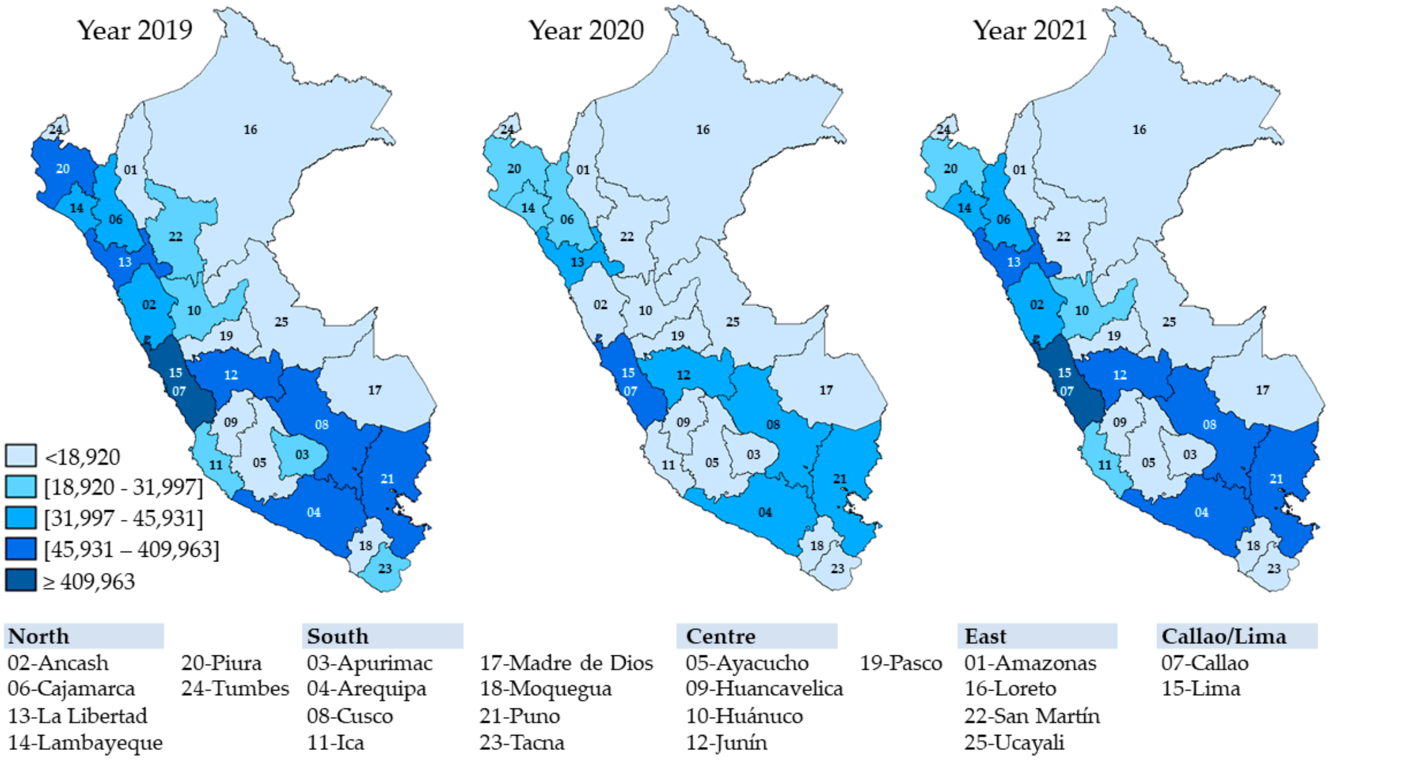


Figure 1. Distribution of enrolled university students during 2019–2020. **Note:** Our own elaboration using data from the National Institute of Statistics and Informatics—National Homes Survey.

Table 1. Mean and Standard deviation of the unenrolled rate per macro-region.

Macro-Region	Unenrolled Rate (Per 1000 University Students)					
	2019		2020		2021	
	Mean	Sd	Mean	Sd	Mean	Sd
North	21.3	21.7	56.9	38.4	38.2	22.6
East	41.4	21.2	54.9	66.0	25.6	25.6
Centre	31.9	28.1	14.6	9.7	22.9	24.3
South	32.6	14.4	26.2	17.6	31.5	25.5
Callao/Lima	63.5	14.9	58.4	8.2	37.6	1.7

Sd: Standard deviation.

By 2021, it can be seen oi Figure 1 that most of the regions show an increase in the number of university-enrolled students and an important decrease in the unenrolled rate. The evident decreases and increases in these indicators due to the pandemic raise issues about the conditions that university students face with virtual education. The digital divides reflected in the availability of the necessary technological devices for virtual classes can be a great challenge for the quality of the professional training. The proper use of the virtual platforms made by the institutions might be a limiting factor in teacher–student interaction; the use of the computer tools oriented to accomplish academic tasks demands a level of digital competence which is not covered completely [18]. Studies have shown that the low ability in digitally mediated educational environments affects the pedagogic scope; for this reason, the boost in digital training as a strength of an excellent education provision is recommended [19].

On the other hand, it is important to mention that, although minimizing digital gaps may mean a series of advantages (economic, time flexibility, etc.) or disadvantages (distraction or bad study habits) for the student, the greater concern is the growth of educational supply and demand with the "facilities" of virtual education, as this does not guarantee the quality of university education [20,21]. Some critics argue that graduates from virtual higher education are still not prepared for fieldwork [22]. Higher education during the pandemic created a strong dependence on technology, managing to overcome the "diploma disease" crisis, but also bringing the threat of not producing quality graduates, a problem that in the long run may be impossible to remedy [23]. Research has shown that so-called "virtual graduates" still do not possess the required skills in their job positions, since they are not being adequately trained [24].

The objective of this research is to identify challenges in the accessibility gaps of technological devices and digital competences faced by university students during the lockdown period due to the pandemic, considering a possible reduction of these gaps as an indirect consequence of the economic measures implemented by the Peruvian government to guarantee the continuity of the education system in line with the Sustainable Development Goals [25].

Considering these objectives, we pose the following research questions: RQ1: Are there differences in internet access for virtual learning among university students enrolled in the period of 2019–2021? RQ2: What is the most commonly used technological device for virtual learning among university students enrolled during the period 2020–2021? RQ3: What are the improvements in digital competences acquired for virtual learning among university students enrolled during the period 2019–2021? RQ4: Is there a relationship between internet access and the use of digital devices and the number of university students enrolled during the period of 2020–2021? Due to the adverse conditions generated by the pandemic, the following hypotheses are proposed: H1: There are significant differences in internet access for virtual learning among university students enrolled in the period 2019–2021. H2: The desktop/laptop is the most commonly used technological device for virtual learning among university students enrolled during the period 2020–2021. H3: There are improvements in the digital competences acquired for virtual learning in university students enrolled during the period 2019–2021. H4: There is a relationship between internet access and the use of digital devices and the number of university students enrolled in the period 2020–2021.

2. Materials and Methods

The research is quantitative, with a non-experimental design, and the scope is descriptive, comparative and correlational. The data collection technique is documentary analysis; the variables and analysis procedures are detailed in the following sub-sections.

2.1. Data Collection

The sample was the students enrolled in university in the Peruvian education system during the years 2019, 2020 and 2021. The data comes from the data base of the National Homes Survey (Table 2), known as ENAHO (due to its name in Spanish) from the Statistics and Informatic National Institute (INEI, from its name in Spanish), specifically from the "ENAHO—updated methodology", "living conditions and poverty", Module 3 (Education); the dataset can be accessed in the *Data Availability Statement*. The data was pre-processed as

SPSS 25 software syntax, screening the university students enrolled in the before-mentioned years (Table A1).

Table 2. Distribution of student sample by academic year.

Year	Module	Archive	Sample Size
2019	687-Modulo03	Enaho01A-2019-300.sav	3505
2020	737-Modulo03	Enaho01A-2020-300.sav	2721
2021	759-Modulo03	Enaho01A-2021-300.sav	3100

2.2. Technologialc Device

In the educational context, educational technology refers to any tool or device designed to support the teaching and learning process through the use of technology. These tools can include both hardware and software, and are used to improve the effectiveness, efficiency, and quality of learning, as well as to facilitate the management and organization of educational resources. Educational technology can also help personalize the learning process and adapt it to the needs and preferences of each student, promoting more effective and meaningful learning.

2.2.1. Access to Technological Devices

Refers to the possession of devices such as desktops or laptops (computers), tablets and smartphones at home, and its use is intended for higher education activities. This characteristic was identified in Module 3 of the National Household Survey, and selected through the corresponding filter (Table A1).

2.2.2. Internet Access

Refers to the possession of the internet service at home, the use of which is intended for the development of university higher education activities. This characteristic was identified in Module 3 of the National Household Survey, and selected through the corresponding filter (Table A1).

2.3. Digital Competences

These are a set of abilities, knowledge and competences that allow university students to understand, use and take advantage of technological devices effectively and efficiently. These competences include technical competences, such as the use of software and hardware, programming, and data management, as well as competences related to communication and collaboration in the digital context.

2.4. Macro-Regions

The macro-regions are territorial divisions that group together different departments (also called regions) or provinces of a country, following geographical, cultural, economic, and social criteria. The main purpose of creating these macro-regions is to facilitate the management and planning of the development in different areas of the country, allowing greater effectiveness and efficiency in decision-making and in the implementation of public policies. In addition, the formation of macro-regions helps improve coordination and cooperation among different levels of government and among the various actors and sectors involved in regional development. This is of great importance for achieving balanced and sustainable growth throughout the national territory and for reducing gaps and inequalities among different regions.

2.5. Statistical Analysis Method

Descriptive statistics (mean and standard deviation) and inferential statistics were calculated for the internet access variable, considering the annual macro-regional and territorial level. For the inferential statistics, the compliance of the normality assumption was first reviewed to determine in which macro-region to use the F-test (analysis of variance—ANOVA) and the Friedman test. To identify the most accessible technological devices, descriptive statistics were calculated, and the comparisons were made, taking into account the annual macro-regional and territorial level. The different characteristics of digital competences were conveniently compared on an annual basis, regardless of region. Finally, a statistical analysis with a multivariate approach was carried out, evaluating the relationship of the variables "internet access" and "access to technological devices (computers)" with the number of university students enrolled in the 25 regions, in order to obtain a global vision of the variables in the years 2020 and 2021, using principal component analysis. This analysis was complemented by comparing box-plot graphs for each variable in the years 2020 and 2021.

3. Results

3.1. Regarding Internet Access for Virtual Learning

These results aim to assess the changes in the digital divides, through the access to the necessary resources for virtual academic activities during the pandemic. As seen in Table 3, the macro-regions North, West, Center and South have a mean proportion of internet access from home of 50%; in 2020 this proportion remains the same, and in 2021 all the macro-regions increase the mean proportion of internet access. Nevertheless, there is still another proportion of enrolled students with no internet access.

Table 3. Mean proportions, standard deviation, and the effects of the periods regarding internet access.

Macro-Regions	2019		2020		2021		F-Test Stats *		Friedman Test	
	Mean	Sd	Mean	Sd	Mean	Sd	F	*p*-Value	Chi-Squared	*p*-Value
North	0.46	0.12	0.42	0.11	0.65	0.09	-	-	10.33	0.006
East	0.33	0.06	0.30	0.07	0.53	0.08	8.85	0.007	-	-
Centre	0.27	0.05	0.25	0.04	0.50	0.04	-	-	7.60	0.022
South	0.46	0.15	0.41	0.14	0.66	0.12	-	-	14.25	0.001
Callao/Lima **	0.67	0.01	0.63	0.00	0.80	0.01	-	-	-	-

Sd: Standard deviation. * *p*-Value > 0.05 (normality test per period). ** not enough information.

3.2. Regarding Technological Devices Used for Virtual Learning

Regarding the technological devices that students have for their academic activities, there is a balance between the use of a desktop/laptop and smartphone (Table 4); in addition, a small proportion use tablets for academic activities. It can be seen that around 50% of students between 2020 and 2021 did not have access to proper technological devices, since smartphones and tablets do not allow the development of competences and digital abilities which now are part of professional training. The use of tablets is limited to certain software for specific actions (documents, Excel worksheets and presentations), and it is not possible to install complementary tools that broaden the operational capacities of these types of software. On the other hand, it is quite difficult to install specialized software oriented to the use of databases, statistical analysis, and geographical information systems, among others. As to the use of smartphones, the limitations are more noticeable, as students could only use some office technology software for video conferences (Zoom, Meet, etc.) and there would be a total restriction on installing other specialized software.

3.3. Regarding the Acquired Digital Competences for Virtual Learning

The digital competences that university students obtained (Table 5) are grouped according to these characteristics: office technology (items 1, 2, 4 and 7), communication (item 3) and extension of informatics tools (items 5, 6 and 8). The results are compared to the previous year and the two years during the pandemic.

Table 4. Mean proportions and standard deviation for access to technological devices.

Macro-Region	Technological Devices Used											
	Desktop/Laptop				Tablet				Smartphone			
	2020		2021		2020		2021		2020		2021	
	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd
North	0.582	0.065	0.581	0.054	0.007	0.008	0.013	0.014	0.411	0.064	0.407	0.049
East	0.494	0.035	0.579	0.055	0.034	0.025	0.021	0.029	0.472	0.017	0.4	0.04
Centre	0.43	0.05	0.557	0.074	0.008	0.01	0.007	0.007	0.563	0.054	0.436	0.079
South	0.47	0.085	0.538	0.063	0.011	0.013	0.009	0.012	0.519	0.08	0.453	0.062
Callao/Lima	0.623	0.002	0.617	0.016	0.01	0.001	0.029	0.011	0.367	0.003	0.354	0.027

Sd: Standard deviation.

Table 5. Acquired digital competences.

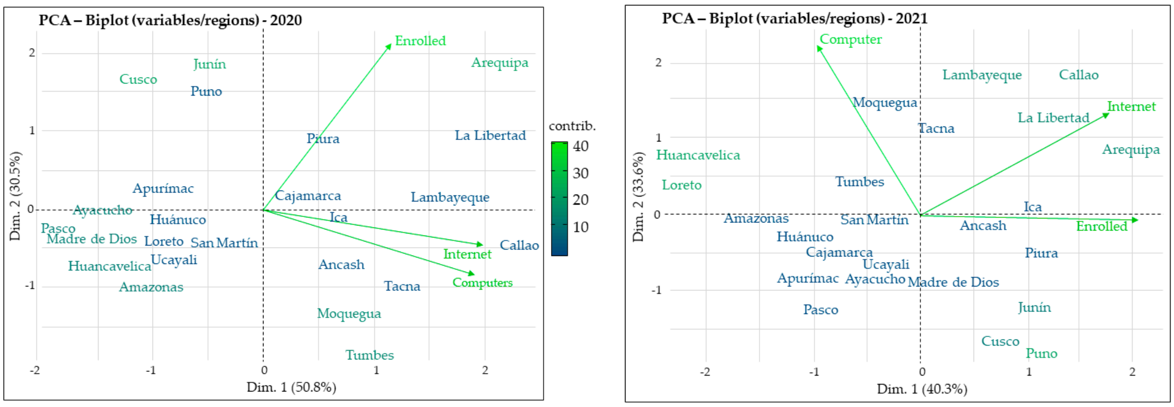
Digital Competences	Proportion by Period			Friedman Test	
	2019	2020	2021	Chi-Squared	*p*-Value
1. Copy or move a file or folder.	0.985	0.981	0.998	19.05	0.000
2. Use the copy/paste tool to duplicate or move information in a document.	0.961	0.974	0.997	25.39	0.000
3. Send e-mails with attached files, e.g., documents, photos, videos.	0.915	0.963	0.996	38.52	0.000
4. Use formulas in an Excel worksheet.	0.726	0.760	0.976	40.33	0.000
5. Connect and install new devices, e.g., a modem, a camera, a printer.	0.556	0.576	0.543	3.69	0.158
6. Find, download, install and set up software.	0.444	0.477	0.465	2.08	0.354
7. Create electronic presentations with programs (Power Point, Prezi, etc.) including text, pictures, sound, videos or tables.	0.846	0.840	0.985	30.08	0.000
8. Transfer files between computer and other devices.	0.731	0.777	0.979	31.46	0.000

In Table 5, we observe that in the year 2019 (prior to the pandemic), there is a higher proportion, 0.90, of students from different regions who have digital competences 1, 2, and 3, which refer to basic office skills and sending various files by email. Moreover, these competences increase steadily, to the point of identifying significant differences in 2021. On the other hand, we see a proportion of students, 0.556, who have digital competence 5, referring to connecting and installing devices and in the case of digital competence 6, 0.444 of students can search, download, install, and configure software; in both these competences, the proportions have not increased significantly up to 2021. Finally, competences 4, 7, and 8 are the ones that have increased (as of 2021) in a more noticeable way, regarding the proportion of students who have those competences related to spreadsheet management, presentations, and file transfer.

3.4. Regarding the Relationship between Internet Access and Digital Devices and Students Enrolled

Figure 2 shows that access to technology, i.e., access to the internet and the computer (technological device), presents a different relationship with respect to the number of university students enrolled in the two years analyzed. In 2021, a weak correlation is identified between access to digital devices (internet and computers) and the number of university students enrolled (Table 6), whereas in 2021 this weak correlation is maintained only with access to the internet. In the case of computers, their correlation has a negative coefficient that is decreasing over time (approaching zero), so we can deduce that there is a tendency towards zero correlation.

Figure 3, section (a) shows the skewness on the number of enrolled university students for both years; in 2020, 75% (quartile 2) of the regions accomplish 35,000 students attending university; for 2021, quartile 2 exceeds 40,000 enrolled university students. In section (b), for 2020 a great dispersion is shown in the distribution of the computer-access proportion for the 24 regions. Then, in 2021, the dispersion becomes more symmetrical; in other words, its index is more homogeneous. The same phenomenon happens in section (c), where the internet-access proportion in all the 24 regions is more homogeneous. It is also shown that Junín, Cusco and Puno are amongst the five regions with the highest record of enrolled university students in the country, despite their low internet and computer access indicators during the years 2020 and 2021.

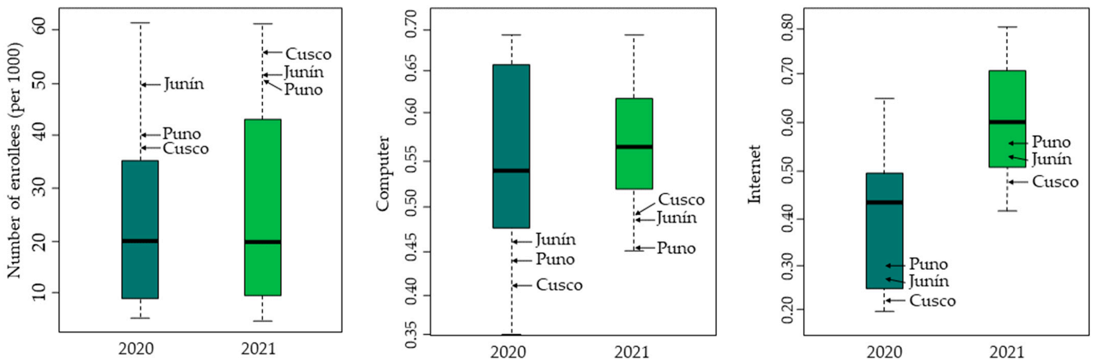


(**a**) (**b**)

Figure 2. Identification of the influence on technology access on the number of enrolled university students during the pandemic: (**a**) year 2020, Dimension 1: internet and computers, Dimension 2: enrolled; (**b**) year 2021, Dimension 1: enrolled and internet, Dimension 2: computers. The Lima region was excluded because it was an outlier region. **Note 1:** Computer: access to desktop/laptop, Internet: internet access, Enrolled: number of university students enrolled. **Note 2:** PCA (Principal Component Analysis).

Table 6. Correlation between internet access and computer usage with the number of university students enrolled in 2020 and 2021.

Technological Device	Enrolled at University			
	2020		2021	
	Pearson Correlation's	*p*-Value	Pearson Correlation's	*p*-Value
Internet access	0.186	0.383	0.185	0.386
Computers	0.122	0.570	−0.109	0.613



(**a**) (**b**) (**c**)

Figure 3. Distribution of the 24 regions according to these indicators: (**a**) number of enrolled university students; (**b**) computer-access proportion; (**c**) internet- access proportion.

4. Discussion

According to the previous sections, there is a decrease in the number of enrolled university students in the first year of the pandemic, in comparison to the previous year. Looking at Figure 1, we can estimate that 64% of all regions have suffered a significant reduction in the number of university students enrolled in 2020. On the other hand, at the level of the macro-regions, (whose design is oriented to the best use of resources for joint development and problem solving) they have not been able to mitigate this phenomenon. For example, 83% (five out of six regions) of the Northern macro-region have reduced the number of university students enrolled, compared with 75% of the Southern macro-region, 40% of the Central macro-region, 25% of the Western macro-region and 100% of the Callao/Lima Macro-region. In turn, we note that in 2021 there is a significant recovery in the number of enrollees, but this is due to the economic measures of the Peruvian government, which we will detail below. On the other hand, Table 1 shows the variations in the non-enrollment rate by macro-region; in particular, the Northern macro-region has a large increase compared to the 2019 rate. For the year 2021, the rate reduces to 38.2, this value being even higher than the 2019 rate. On the other hand, the other macro-regions did manage to reduce their non-enrollment rate compared to 2019. All the variations in the indicators discussed so far are a reflection of a series of extrinsic factors derived from the pandemic: economic, social, health, etc. In this research we focus on the difficulties of access to the necessary and mandatory resources for the development of virtual academic activities during the pandemic period, which we interpret as a digital divide in the midst of a growing technological revolution.

Given the social confinement due to the pandemic, the development of virtual academic activities depends on access to the internet and digital devices. For this reason, in 2020 the Peruvian government was especially interested in guaranteeing internet access to the university community. The Peruvian government decided to take action in order to close the gaps regarding internet access, and to allow the continuity of distance education. That year, in April, a transfer of PEN 31 million was authorized to sign a contract of internet services using external modems, flash drives and SIM cards, and as a result 23,3000 students from public universities were beneficiaries; in September, an additional PEN 30.5 million were authorized, benefitting 147,000 students. In both situations the students were in the limited-resources sector, according to the Household Targeting System, known as SISFOH (from its name in Spanish) [19,25,26]. As a result of these measures, we can observe in Table 3 some important variations with respect to internet access in each year. First, we can see that the average proportion of students enrolled in 2020 in the Northern, Western, Central and Southern macro-regions with internet access at home is below 50%, which, compared to the 2019 indicators, is very similar. Later on, in the year 2021, access to this resource increases in all macro-regions; the Western and Central macro-regions achieve a percentage close to 50%, the Northern and Southern macro-regions exceed 60% and the Callao/Lima macro-region reaches 80%. Within each Macro-region, statistical comparisons (the f-test statistics and the Friedman test) were performed, to test for significant improvements in access to this resource. For the data from the Western macro-region, a parametric test (f-test statistics) was used, finding significant changes (p-value < 0.01) in the average proportion of internet access; in the Northern, Central and Southern macro-regions, a non-parametric test (the Friedman test) was used, also finding significant changes in internet access. A study conducted in Colombia [27] identified the fact that 45.7% had access to the internet in the year 2022, while only 49.6% had daily access to this service. This gives us an indications that in the early years of the pandemic, the percentage of access to this resource could have been lower. Another study conducted in Spain [28] showed that access to the internet is at 100%, but through different modalities: ADSL, fiber optic, and variants of mobile internet (smartphone, USB modem, etc.).

Additionally, the access to internet services must go together with the access to proper digital devices for the development of academic activities as part of a university education of quality. Other investigations have shown the relevance of digital transformation for an education of quality, and the access to technology is a support for the future generation of professionals, who are nowadays trained within the skills-based approach in the teaching–learning process [26,29,30].

At the beginning of 2021, the Peruvian government promoted the acquisition of digital devices such as laptops and tablets, to decrease the access gap to these resources [29,30]; however, as explained before, desktops and laptops are the only suitable devices for the development of academic activities, and even the students' perspective on quality education is relevant in order to assure that they continue at university [31–33]. At the beginning of 2021, the Peruvian government also promoted the purchase of digital devices such as laptops and tablets, in order to minimize the gap in access to these resources [34,35]. However, as already specified in the previous chapter, computers or laptops are the only adequate devices for the development of academic activities; this could be a relevant factor that affects the students' perception of good educational quality and their continuity at university [31–33].

Table 4 shows that all the macro-regions report a balanced proportion of desktop/laptop and smartphone use, whereas tablet use is very low. If we look at the West and Central macro-regions and contrast the data in Tables 3 and 4, we notice that there is no consistency in the levels of number of enrollments observed in Figure 1. This deserves a detailed verification of the statistics reported by each region or the execution of audits focused on ensuring the correct administration of regional public expenditure. On the other hand, we see that the measures adopted by the Peruvian government have not minimized to any great extent the use of smartphones as a technological device to support the academic activities of university students. This leads to a series of situations related to the adaptability to virtual education: the effective participation in the teaching strategies of the teaching and learning, the use and management of virtual platforms to access the teaching material, the delivery of academic homework as a learning evidence, the sitting of virtual exams, the teacher–student interaction, and the classmates' interaction, as well as the impact on the skills and competences, starting with objective and subjective tests by the teacher, including the students' perception of the learning [36–38]. Research shows that digital competences, such as digital literacy, collaborative communication, digital-content creation, informatics security and problem solving can be greatly affected by students who lack, or have temporary availability, of the technological resources during the academic period [39]. The study [27] previously mentioned provides a characterization of digital divides by infrastructure, listing the following conditions: scarce or no access to digital devices, low quality of internet bandwidth, and use of inadequate devices to access virtual environments. Likewise, in the previously cited Pakistan study [13], a Heckman regression model of the treatment effect was estimated, and managed to identify the fact that the use of smartphones and iPads is inversely related to academic performance, which agrees with our position that these are inadequate digital devices within the educational system.

Another important aspect of virtual education is digital competencies, which is directly linked to the professional skills training required in the workplace and academic environments [39,40]. It is proven that the development of digital competences is one of the great strengths in a university student [41]; however, this development can have some limitations in some elements. Basic issues such as handling a file, editing a document, using basic formulas on an Excel worksheet, making presentations, or even sending e-mails, might not be a problem for current university students, but, depending on the circumstances, communication competences can be affected due to not knowing how to connect or set up a device (a camera, modem, printer, etc.) or how to install/setup the specialized software needed for almost every professional academic program [42,43]. None of these difficulties will occur provided students have the necessary devices [44], but, as we can see on Table 5, the number of university students who acquired the competence called installing or setting up software decreased in 2021 in comparison to 2020; therefore, we face two important characteristics: the access gap to technological devices and the weaknesses in the development of digital competences. A study by the University of Extremadura (Spain) [45] in 2017 already highlighted the need for better integration of ICTs to improve their use, that is, the improvement of digital competences. Subsequently, research conducted at the University of Zagreb (Croatia) [46] identified the fact that that the least-developed competences (with scores from 1 to 3) are: programming (1.37), creation and problem-solving (1.53), and searching, downloading, and filtering digital information and data (1.71). Finally, the study by the University of Guajira (Colombia) [27] in 2022 showed that constant table and chart creation is carried out by only 46.4%, presentation development by 62.9%, and collaborative work by 67.5%; all of this through the use of digital devices. All these features can lead to a series of misperceptions on the part of the student regarding their training, their abilities, and even the conditions provided by the university in their training process [47–49]. Therefore, it is necessary that the policies and government actions have a deeper vision about the implications of shortages and the real effect and/or harnessing of the money transfers, to minimize the educational gaps [50]. Evidently, there must be an assessment of the tangible positive (or negative) impact that the money transfer from the Peruvian government may have, and of how it was perceived by the beneficiary population [51].

In Figure 2 we have a view of the joint relationship between the number of university students enrolled and access to the internet and access to computers (desktop/laptop), and of how this varied in the first two years of the pandemic, as well as the economic measures of the Peruvian government. In section (a) of Figure 2, we observe the correlation of the Enrolled variable with the other variables in the 24 regions (except for the Lima region, as it is an outlier case); Dimension 2 allows the regions of Cusco, Junín, Puno, Piura, Arequipa and La Libertad to be identified as regions with the highest number of enrolled university students. In addition, the opening angle, with the vectors of the Internet and Computers variable, shows that there were possibly other variables not considered in this research that conditioned the number of university enrollments in the regions. On the other hand, a cluster of regions with low enrollment and low access to the internet and computers was identified (Amazonas, Huancavelica, Madre de Dios, Pasco, Ucayali, Loreto, San Martín, Huánuco, Apurimac and Ayacucho). Now, in section (b) we can notice the effect generated by the Peruvian government's economic measures. The vector of the Internet variable has a very close angle to the vector of the Enrolled variable, and, therefore, a considerable positive correlation (regions with a greater number of university students with internet access also have a greater number of university students enrolled). We can also see that Callao, Ica, Lambayeque and Ancash are among the regions that are increasing the number of enrollees, while the cluster identified as having a low number of enrollees remains the same.

It was stated above that Figure 3 shows a singular occurrence in Junín, Cusco and Puno, since during the years 2020 and 2021 these regions were positioned amongst the ones with the highest number of enrolled university students, as well as being at the bottom in terms of having the least computer and internet access. When the public spending indicators on education per university student [50] were reviewed, these three regions reported an average spending of PEN/.7458 per student in 2020, and PEN/.7566 in 2021; therefore, they are the regions with the least public spending per student in comparison with other regions. In relation to this, and from a social perspective, there is an attitude of resilience to continuing with university studies from the university students of these regions. In addition, these regions are part of the macro-regions Center (Junín) and South (Puno y Cusco), with the highest average proportions of smartphone use (Table 4) as a result of the greater difficulties in developing better digital competences.

Finally, the economic contingency plans adopted by the Peruvian government were necessary and have avoided more serious consequences in the university higher education sector, but have also made it possible to visualize a scenario of educational challenges and opportunities typical of any developing country [52,53]. The educational perspectives of students, teachers and university institutions have expanded to such an extent that virtuality can now be a new way of studying a professional career, eliminating the barriers of distance and access to an international university education [54–56]. Therefore, some of the opportunities that are opening up for the university higher education sector are: the internationalization of universities, through the offer of their own professional courses or through agreements with universities in other countries; the assimilation of teachers with extensive experience and of academic quality; the formation of international research groups in science and technology that promote the attraction of young talent from developed countries to developing Latin American countries; academic exchanges and training internships for both students and teachers, and many other opportunities.

5. Limitations

The statistical results related to digital competencies are limited to the list included in ENAHO (Table 5); for example, the competence of "critical thinking" necessary to evaluate and analyze digital information critically and make informed decisions, is not considered. Neither is the "digital citizenship", which refers to awareness and practice of ethical and legal norms in the use of technology, including respect for privacy and intellectual property. It has been indirectly assumed that item 5 is part of the "digital communication" competency that encompasses the use of video conferencing.

A comparative analysis between urban and rural areas was not planned, due to changes in the data collection procedures of ENAHO caused by the "mandatory social isolation" decree under the Supreme Decree No. 044-2020-PCM of the Peruvian government [57]. Both the application of data collection instruments and access to survey areas were reduced and limited to phone communication. From October to December, the usual procedures at the national level were gradually executed in person.

We also do not consider an orientation towards educational quality (or similar), because INEI does not collect this type of information. However, future research may consider this orientation if some governmental institution has relevant and publicly accessible information.

6. Conclusions

The results revealed a clear digital divide, due to the lack of internet access in various regions of the country. It is essential to implement public policies and educational strategies that reduce this divide, prioritizing regions with limited access and ensuring equitable internet access for university education. This will guarantee inclusion and promote sustainable development in the university education sector.

The most commonly used devices by university students are desktop computers, laptops, and smartphones. However, it is crucial to reduce the use of smartphones, as their usage restricts interaction between teachers and students, due to the inherent limitations of this type of device. Additionally, in situations where specialized software is required, the use of smartphones clearly hinders students from acquiring the necessary competencies.

Digital competencies have shown significant improvement, surpassing previous years' results proportionally, which is encouraging and should continue to be encouraged. This improvement is beneficial, as it provides students with the opportunity to access education beyond their communities and to consider educational and job opportunities at both national and international levels. It also allows them to explore employment options outside their region and country in the future.

Internet access and technological devices (specifically desktop computers/laptops) do not show a significant relationship with the number of enrolled university students in 2020 and 2021. This confirms the fact that digital divides pose an obstacle to university continuity.

There is a significant digital divide in different regions that requires action by government authorities, with priority given to those regions where there is a higher proportion of students facing difficulties in accessing the internet. Access to technological devices also needs to be addressed, as although students mostly use desktop computers, laptops and smartphones, the frequent use of smartphones is not ideal, as it can affect the level of learning. Another relevant aspect is digital competences, where an improvement is observed in most students. However, it is necessary to continue to foster these skills so that students have the ability to access education beyond their communities, including the possibility of seeking education abroad. Finally, it is crucial to guarantee digital conditions that ensure educational continuity in crisis situations such as the pandemic, designing educational policies and strategies that reduce digital divides and promote equitable access to virtual environments, with the aim of achieving sustainable development in higher education.

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Appendix A

Listed below are the pre-processing codes which are needed to replicate the results in the IBM SPSS Statistics 25 software. This is mainly the screening and variables creation which are necessary for the statistical analysis count of subjects from different professional programs.

Table A1. Pre-processing codes.

Codes and Descriptions

Code 1: selection of first two digits of UBIGEO code
STRING regions (A8).
COMPUTE regions = CHAR.SUBSTR(UBIGEO,1,2).
Code 2: university students enrolled in a specific year
COMPUTE filter_$ = ((P306 = 1 & P308A = 5)).
VARIABLE LABELS filter_$ ‘(P306 = 1 & P308A = 5) (FILTER)’.
VALUE LABELS filter_$ 0 ‘Not Selected’ 1 ‘Selected’.
FORMATS filter_$ (f1.0).
FILTER BY filter_$.
Code 3: university students enrolled in a specific year with internet access.
IF (P314B$1 = 1 | P314B$7 = 7) inter_access_YEAR = 1.
Code 4: university students enrolled in a specific year with computer/laptop access
IF (P306 = 1 & P308A = 5 & (P314B1_1 = 1 | P314B1_2 = 2)) comp_access_YEAR = 1.
Code 5: university students enrolled in a specific year with tablet access
IF (P306 = 1 & P308A = 5 & P314B1_6 = 6) tab_access_YEAR = 1.
Code 6: university students enrolled in a specific year with smartphone access
IF (P306 = 1 & P308A = 5 & (P314B1_8 = 8 | P314B1_9 = 0)) smart_access_YEAR = 1.

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