

Appropriation of Information Technologies During Remote University Education in Latin America

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Abstract– *The use of new information and communication technologies (ICTs) has revolutionized not only how we live, but also how we teach and learn, even more so during the pandemic, when universities had to adopt a 100% virtual methodology due to lockdowns. The aim of this study is to collate the evidence on the use of ICTs for remote education in Latin American universities during the Covid-19 pandemic, through the systematic review of leading articles indexed in journals such as Scopus, Pro Quest, Redalyc, and others, published between March 2020 and March 2022. The method includes the use of the PRISMA statement, and an explicit flowchart for the selection of articles on inclusion and exclusion criteria, using a keyword search algorithm. The results showed that 36% of the study reported the use of virtual environments such as institutional platforms or Google Classroom to develop synchronous and asynchronous classes, 27% rolled out innovative educational technological tools with proposals ranging from chatbots, teaching telepresence to mass assessment tools, and 18.5% shared their experiences in the use of open educational resources, such as gamification tools, and mobile devices, in particular WhatsApp and Telegram for communication. The country that reported the largest number of experiences was Mexico. One can therefore conclude that faced with the unexpected change in modality, and despite situations of uncertainty, limited technology and coverage combined with lack of training, Latin American universities demonstrated the ability to appropriate technological tools for their pedagogical practice during remote education. Considering these findings, we decided to reflect on the challenges posed by virtual education, in the context of a new normality, in a region where the connectivity gap is still a limitation.*

Keywords- Higher Education, Systematic Review, Distance Learning, Pandemic, Information Technology

I. INTRODUCTION

The use of new information and communication technologies (ICTs) has revolutionized not just how we live, but also how we teach and learn, even more so during the pandemic, by the widespread use of remote education. Although the Internet access gap is a reality we cannot ignore, its ever-expanding role is also very real. It is known that prior to Covid 19, 35% of the world population (2,484,915,152 inhabitants) had access to the Internet [1], this percentage has now increased to 62.5%, that is, 7.9 billion people. In the case of Latin America, 67% of its total population has Internet access, and 60% has Internet at home; however, rural areas only have 37% connectivity (CEPAL [2]).

In this context, in Peru, in May 2020, Legislative Decree No. 1496 was enacted within the framework of the nation-wide State of Health Emergency to regulate continuity in providing

educational services in universities, the wake of similar situations worldwide. After the initial closure period due to the pandemic-related lockdowns, universities were able to roll out their study programs through remote means, in a totally virtual environment. This fact meant an unexpected change for students, teachers, and institutions, since they did not have enough technology, and, in addition, they lacked the operational knowledge required to rise to the challenge. However, the context is correlated with innovation, and in Education, the pandemic marks a before and after situation, impacting not just the present, but also the future of universities, their students, and society. Undoubtedly, technologies are drivers of pedagogical disruption and of great transformations in the life of humanity and society [3].

Trying to define the role of information and communication technologies (ICTs) in education is complex and probably impossible from a single perspective. There is common agreement that these are valuable tools in teaching since they promote the interaction of teachers and students through virtual platforms, institutional web pages, learning management systems, virtual forums, email, as well as collaborative work with online tools, videoconferences, and more [4]. All of these are materialized in the classroom work through synchronous activities, i.e., simultaneous interactivity between teachers and students in real time, or asynchronous activities (not in real time). Likewise, ICTs are instruments that allow students to develop and improve soft skills, such as autonomy and flexibility, since they face situations where they must show the ability to make decisions, such as, choosing how to access information, regulate the time allowed for the use of devices, and more importantly, taking responsibility for their own actions [5].

ICTs can be considered as a set of technologies that allow the acquisition, processing, storage, treatment, communication, recording and presentation of information, in the form of voice, images and data contained in signals of an acoustic, optical or electromagnetic nature. They include electronics as the basic technology underpinning the development of telecommunications, computing and audiovisual, but they also incorporate a whole series of innovative elements at the service of education and meaningful learning [6].

The appropriation of ICTs in education implies that teachers can harness technological tools to apply them in their pedagogical practice. In other words, ICTs constitute a means to carry out their teaching activity in order to generate learning, enhance skills and foster learning environments conducive to interaction between teachers and students, as well as between

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students themselves. ICTs become truly meaningful when this appropriation generates innovation, that is, when their use is tailored to meet the needs of students, and the environments in which they operate [7], resulting in innovative and useful products.

Addressing the educational demands raised by the pandemic not only required creativity, resilience, and flexibility from teachers and students, but also institutional conditions to promote educational innovation through ICTs that is, the extent to which universities were prepared to go in order to satisfy the technological demands required to deal with virtuality in their educational system. Although there is no single answer regarding the situation in Latin America from the teaching perspective, it is known that in countries like Mexico, Ecuador, and Peru, both private and public universities agree that the necessary conditions do exist for teachers to innovate by using technological tools in their pedagogical practice within universities [8].

Against this background, this systematic literature review (SRL) aims to answer the question: what is the evidence for the appropriation of ICTs for remote education in Latin American universities during the Covid-19 pandemic? It focuses on learning about the disruptive pedagogical tools, strategies and practices they used for synchronous and asynchronous activities during the pandemic, and which marked the beginning of a new normality, which undoubtedly goes beyond the space and time of Covid 19.

For purposes of transparency, the PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) was chosen as the rationale for structuring this review and recording the findings in a pertinent and truthful manner [9].

II. METHOD

This is a systematic review of the literature (SRL), with an observational and retrospective design. The population studied was made up of teachers and students from Latin American universities, our job was to inquire about the appropriation or use of ICTs for remote education during the pandemic. The purpose was to identify the ICT tools used in the development of educational activities during the pandemic period. Our work focuses on the analysis of articles indexed in academic databases such as Scopus, Google Scholar, ProQuest, Redalyc and others, using as search algorithm (technology or ICT) AND ("online teaching" or "remote education) and (university*or "higher education") and (Covid or pandemic). The selection process [for articles] followed the proposal of a five-phase analysis for a systematic review of the literature carried out by K. Khan, R. Kunz and J. &. A. G. Kleijnen [10].

Concerning the inclusion criteria, articles published between March 2020 and March 2022, in English or Spanish, related to the use of ICTs during remote education in public or private universities in Latin America, in their undergraduate or graduate programs were taken into consideration. Regarding the exclusion criteria, articles on Massive Line Open Courses

(MOOC), virtual, hybrid or blended courses, Webinars or Master Classes, and other programs promoted by universities or university departments at undergraduate or postgraduate levels for a non-university population (duly enrolled), were considered ineligible for the review. However, we decided to eliminate from the analysis the literature offering proposals for innovation unrelated to pedagogical practice, even if they are part of the academic research. Likewise, considering that a bias is an error that leads to deviation from the truth, in the results themselves or in their interpretation [11], it was considered as part of the protocol to avoid arbitrary search limiters, and, on the contrary, to include different databases, and publish all the findings on the topic under analysis. Similarly, it was decided to exclude from the review those articles that showed a high bias, either in the selection of the sample, in the execution, or in the measurement of results, as a strategy to avoid distortion in the results.

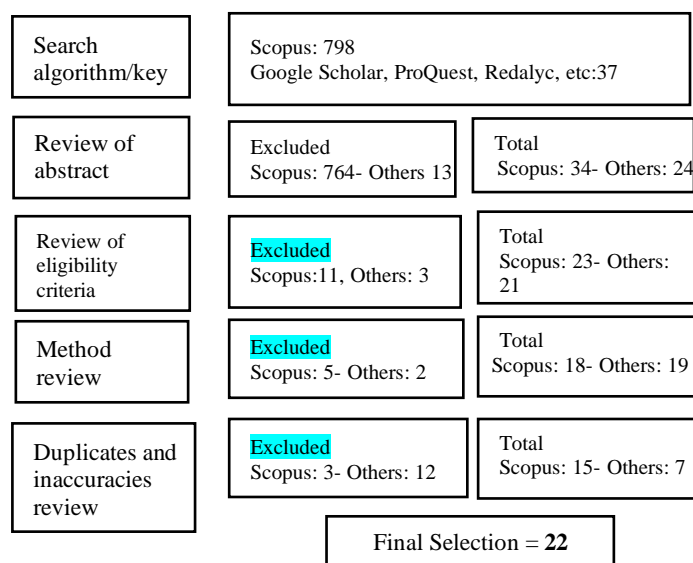


Fig. 1 Item selection flowchart

Note. The figure shows the five-phase process to select articles.

As shown in Figure 1, of a total of 798 articles initially accessed, after the review process, 776 articles were excluded because they did not meet the eligibility criteria, presented duplications or inaccuracies or probable biases, leaving 22 articles in the final selection.

Table 1 shows the selected articles extracted from Scopus (15), Google Scholar (02), Scielo (01), Dialnet (01), ProQuest (02), and Redalyc (01). The country with the highest production was Mexico (08), followed by Chile (04) and Colombia (03), Ecuador (02) and others (05). Most of the articles were published in 2021 (17 articles), four in 2020, and only one in 2022, at the time of closing the search.

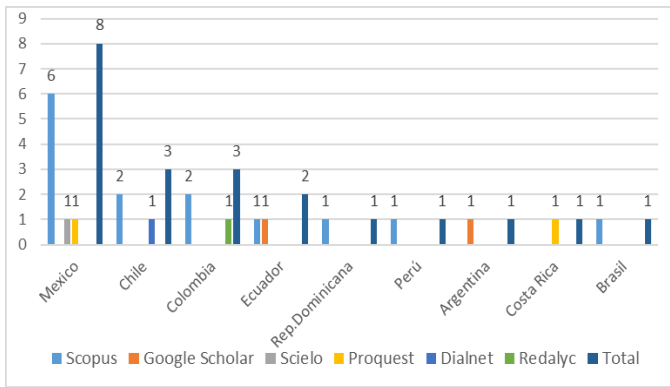


Fig. 2 Synthesis of selected articles

Note. The legend at the bottom of the chart shows the sources for each article.

III. RESULTS

The SLR made it possible to identify the tasks involved in teaching practice in which the appropriation of ICTs was proven in response to the unexpected demand for remote education. The data obtained were sorted into the following categories: Open Educational Resources, Virtual Learning Environment, Educational Innovation, and Use of Mobile Devices, as shown in Table 1.

TABLE I
ELEMENTS OF APPROPRIATION FOR TEACHING

Categories	Item No.	Quantity	%
Open Educational Resources (OER)	12, 17, 21, 18	04	18.5
Virtual environment for teaching	2, 3, 7, 8, 9, 14, 15, 20	08	36.0
Educational innovation	1, 4, 5, 11, 13, 22	06	27.0
Mobile devices	6, 10, 16, 19	04	18.5
Total		22	10.0

Table 1 shows the categories of analysis of the ICT tools used in remote university education.

There is increasing access to knowledge, and the Web offers many resources that can be used for research, teaching and learning, openly and free of charge, which are known as Open Educational Resources (OER). This English term coined in 2002 by UNESCO encompasses a full range of audiovisual resources, graphic material, videos, assessments, software, and any other tool, material, or technique used to support access to knowledge [12].

TABLE II
OER APPROPRIATION RESULTS

No. of art.	ICT tools	Practical utility
	Mentimeter	- Synchronous activities
12	Digital pen	Motivational environments
	Edpuzzle	Active participation

	Kahoot Socrative Other CRS, SRS or IRS	Interaction Assessment Feedback - Asynchronous activities
17	Google Drive	Contents generation
	YouTube Zoom	Collaborative work - Asynchronous activities Contents generation Publication of resources - Synchronous activities
18		Videoconferences Phone tracking - Synchronous activities
	Skype, Zoom, Meet, Drive, Email	Videoconference - Asynchronous activities
21		Communication Contents sharing Collaborative work Pedagogical and administrative management

The table shows the types of open educational resources used in remote university education.

In the review process, the appropriation of various open educational resources in remote education was found, with Hidalgo & Llanos (2021) [13] reporting the use of rapid response tools and gamification to carry out synchronous activities, which allowed engagement, active interaction, and facilitated learning. Rangel *et al.* (2021) [14], for their part, highlighted the use of Google Drive for contents generation, and the facilitation of collaborative work. Similarly, the use of platforms for videoconferences was highlighted, noting that open technological resources are needed for more effectiveness, as they allow a closer link with the student, an effective monitoring of their participation, and improve motivation in synchronous classes. [15] [16].

On the other hand, the Virtual Learning Environment (VLE) is a platform especially designed to develop the management of teaching-learning processes since it makes it possible to manage, distribute, and carry out teaching and learning activities tailored to the needs of each level and modality. These processes are known as Learning Management Systems (LMS), Virtual Learning Environments (VLEs) or Learning Content Management Systems (LCMS). Table 3 shows the magnitudes in the use of virtual environments.

TABLE III
VLE APPROPRIATION RESULTS

No. of art.	ICT tools	Practical utility
	Virtual platforms	- Synchronous activities
20, 15	Drive	. Videoconferences
	Institutional mail services	- Asynchronous activities
	Web	. Posting of student assignments
	Google Classroom,	. EFL teaching

2, 3, 7, 9, 14	Schoology	- Synchronous activities
	edmodo	. Videoconferences
	Zoom	- Asynchronous activities
	Skype	. Material publication
	E-mail	. Collaborative work
	Audio recordings	. Posting of student assignments
	Video	. Assessment
	Drive, and audiovisual material	
	Remote monitoring tools	- Assessment
	Automated Assessment Tool	. Minimization of unethical acts
8		. Facilitation of on-time assessment
		. Immediate feedback

The table shows VLEs and their respective utility in remote university education

Virtual environments were used for synchronous and asynchronous activities, with tools for videoconferences, forums, and publication of materials. Evidence showed that students were more favorably inclined with advantages including access to content and collaborative work, while connection difficulties were a recurring limitation [6]. In addition, previous studies (Díaz *et al.* (2021) [17]) showed evidence of required average knowledge on how to handle the different applications, concluding that although ICTs contribute to teaching in higher education, digital competency is required.

Furthermore, most of the articles in this category referred to the use of VLE for the teaching of English as a foreign language (EFL) and there is a common understanding about their potential to develop synchronous and asynchronous activities.

Finally, virtual learning environments were used in assessments. The analysis shows, firstly, that the use of a remote assessment system generated some anxiety in the participants, though it helped them to act more honestly, minimizing unethical acts, which contravene academic probity [18]. Secondly, the automated assessment model offered scopes to carry out the assessment not only more quickly, but also providing immediate feedback, thus facilitating the assessment process [19].

Regarding educational innovation, it is proven in pedagogical practice by the incorporation of relevant elements, which include novelty, added value, and improve the efficiency of the processes and the achievement of goals. Innovation in technological management is one of the pillars of educational innovation, which implies knowledge, creativity and expertise of teachers to generate innovative products aimed at satisfying needs in the educational environment. The etymology of innovation refers to the verbs innovate and renew, therefore innovating means change; but deliberate, intentional, voluntary, and goal-oriented change. Thus, one can conclude that "innovation is a concept originally related to the practical application and development of new ideas in the industrial world", which implies "the successful implementation of creative ideas within organizations [8].

TABLE IV
RESULTS OF EDUCATIONAL INNOVATION WITH ICTS

No. of art.	ICT tools	Practical utility
1	Chatbot	- Asynchronous activities . Automated targeting
13	Teacher telepresence with hologram effect	- Synchronous activities . Close presence of the teacher . Greater motivation . Improves participation
		- Asynchronous activities . Collaborative teacher work . Digitized practices
4	Mixed course design: T21 Model and DFM Strategy	- Synchronous activities . Videoconferences
5	Strategy of random networks of interaction	- Synchronous activities . Collaborative work . Peer interaction . Active participation
		- Asynchronous activities . Learning guides . Self-assessment
11	Video design and formative assessment tool	- Synchronous activities . Video design in class

The table shows innovative practices during remote education.

During the pandemic, the demand for solutions to challenges posed by remote education was the starting point for the generation of innovative products, and the articles reviewed report experiences that had a positive impact on students. Múnera & Salazar (2022) [20] share the experience of using a chatbot, in order to offer guidance for precise actions within the course.

Likewise, they report the design of a hologram effect system to improve the perception of the teacher's presence in the virtual classroom [21].

Both experiences injected novelty and promoted environments of greater participation and interest, thereby heightening the sense of community, as well as student performance. Innovation was also shown in strategies for class work; for example, the implementation of an interactive communication strategy through random speed dating in synchronous activities, which improved participation and collaborative work [22]. Delgado (2021) [23], for his part, presented a class model shared by physics, mathematics and computer science teachers, promoting the optimization of resources and collaborative work; while Madariaga *et al.* (2021) [24] developed a guide for the development of videos in synchronous classes, which includes timely and permanent feedback.

Finally, we live in a society based on access to global, instantaneous and interconnected knowledge, where the use of effective and synchronous communication strategies is predominant. For instance, using a laptop represents much more than a technological fact as its very accessibility modifies learning schedules, the narrative of contents and learning tools

[25]. At the sociocultural and educational level, mobile devices are increasingly gaining prominence since they are used to perform activities that can generate knowledge, students take advantage of their benefits and attractiveness, as well as of the possibility of digitally connecting to another space, real or virtual, through mobile devices.

TABLE V
MOBILE DEVICE RESULTS

No. of art.	ICT tools	Practical utility
6	WhatsApp	Teacher-student interaction . Accessibility . Better connectivity
	Telegram	
10	Mobile phones	Main technological equipment for learning . Low accessibility to computers . Low internet connectivity
		Main technological equipment for learning . Low accessibility to computers . Low internet connectivity
16	Smartphone	Immediate communication . Plugin to improve interaction and synchronous activities
	WhatsApp	
18	Phones	Main interaction tools . Learning environments and networks
	Mobile phones	

The table shows the different uses of the telephone in remote university education

Table 5 shows the use of the most widely used mobile technological tools in the teaching-learning process, highlighting in first place WhatsApp through smartphones. The table also highlights some limitations, such as low Internet connectivity, which makes it difficult to share several resources at the same time, such as audio, video, documents, among and more. However, mobile devices provide an immediately accessible and non-complex means of interaction and communication between teachers and students.

In the teaching practice, the use of telephones has facilitated synchronous interaction and connection to the Internet; clearly, some tools not originally designed for virtual education (telephone and messaging applications) are useful in supporting the process, but not in triggering it. Albarrello & Arri (2021) [26] also pointed out that the use of smart devices made it easier for students to develop complex study strategies in which they alternate between texts, audios and other applications that allow them to compensate for the physical absence of their classmates through collaborative work mediated by screens. García & Herrera (2021) [27] emphasize the importance of personal learning environments and personal learning networks, highlighting the importance of contacts and interaction with them in learning. Finally, Avendaño (2021) [16] adds that telephone calls and messaging, are useful complements to the work of the virtual classroom, since instructions can be extended, tasks monitored, and learning expanded through a more personalized interrelation.

IV. DISCUSSIONS AND CONCLUSIONS

The research shows clear appropriation of the use of online documents through "Drive" file sharing platforms, as well as instant (synchronous) meeting platforms such as Skype, Zoom, Meet, all of which allow a direct approach with students within the teaching-learning process, thus avoiding the potential perception of distance from the teacher that students might feel. The positive impact of using technological tools is that students actually use the materials intended for the learning process, even in a virtual context [28].

The use of multiple platforms such as Google Classroom, Edmodo, Schoology, among others, allows the sharing of academic information, which can be used asynchronously by students. However, these resources can produce a negative impact or negative perception due to the lack of synchronous interaction within the learning process, which could affect the social climate of the classroom [29]; therefore, it is important that teachers develop learning sessions that include digital tools for both synchronous and asynchronous use.

Innovative teaching practices based on the use of multiple educational platforms show that the chatbot and teacher telepresence with a hologram effect can mitigate the situation described by Juárez-Díaz (2021) [30], who reports that students complained about the little or no teacher mediation and connectivity difficulties. This situation frequently occurs in the teaching of a foreign language (English), where students show a negative perception of the online learning process [31]. This situation could be reversed by the implementation of a flipped classroom learning with an adequate use of ICTs which would result in a challenging experience for students [32] [33]. Regarding the use of ICTs in the teaching-learning process through smartphones, Telegram and WhatsApp were of great help in university education, since they became the preferred means for the interrelationship between teachers and students [34]. For their part, Santos et al. (2021) [35] stated that due to the low accessibility to computers, students used telephones as the main access tools and for carrying out assignments.

The present study concludes that, despite situations of uncertainty, technological coverage limitations and lack of training, university professors in Latin America have shown flexibility and resilience, demonstrating the ability to appropriate technological tools for remote education. There is a plethora of open educational resources (OER), which allows a closer connection with students, effective monitoring of their participation, and improve motivation, engagement and learning. However, their use is not widespread, only a few countries report using them, this is largely due to the low Internet connectivity in Latin America.

Virtual learning environments (VLE) have facilitated the teaching-learning process, bringing together teachers and students to develop synchronous and asynchronous activities. Teachers have managed to adapt their skills to virtual education, using virtual environments, and students have shown a good predisposition to participate in them. However,

including strategies to achieve better participation and interaction remains a challenge.

Similarly, the Covid-19 pandemic provided an opportunity to develop innovative educational solutions based on ICTs, with valuable experiences that enrich the educational practice, through the generation of new tools and innovative strategies.

Finally, despite the isolation that the Covid-19 Pandemic meant, the availability of information and ICTs enabled students to carry out collaborative work by using smartphones, tools such as WhatsApp, Telegram, and the multiple possibilities they offered, including Office tools and Google that allowed them to stay connected and participate in synchronous and asynchronous activities, including collaborative work. The role of these tools has been key to the development of remote university education, since they have been the most accessible tools for students.

Additionally, it should be noted that Mexico is the Latin American country that produced most of the research on the subject, in total eight countries published studies on the subject, with at least one research article. Also, the source that provided the largest number of articles is Scopus.

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