The technological gap of undergraduate education in Mexico and its impact on e-learning

Raúl Villarreal-Lara[1]*; Alejandra Guadalupe Hernández-Morales[1]
[1]Tecnologico de Monterrey, Escuela de Ingeniería y Ciencias, Ave. Eugenio Garza Sada 2501, Monterrey 64849, NL, Mexico
aghernandez@tec.mx, *email corresponding author: raulvl@tec.mx

Abstract*– Education in Mexico has faced several limitations that have created a barrier to optimize its academic quality and experience. The technological gap, also known as the digital gap, has been an important opportunity area in the country, which has been evidenced by the COVID-19 pandemic. Although Mexico does not have enough experience and technological capacity for digital or remote education, like other countries, different strategies, and educational innovation efforts have been assessed to solve this problem. This research aimed to document the different innovations and strategies that have been attempted by the academic sector (both public and private) against the technological gap that currently exists in Mexican higher education institutions. For this purpose, an exploration on the perception between remote learning and face-to-face learning among students and teachers was performed according to literature review and surveys. Results indicated that educators preferred face-to-face learning (64%) but believed that a positive aspect of e-learning is the fast adaptation of the courses through time. Similarly, students preferred face-to-face learning (48%), followed by a hybrid scheme (41%) and perceived that e-learning did not require more time and effort. Furthermore, e-learning is a relevant strategy to promote international collaboration, share experiences, knowledge, as well as a valuable resource to generate a virtual and global education network.

***Keywords* - e-learning, Higher Education, e-teaching, Technological gap, Educational innovation, Face-to-face learning,**

II. Introduction

In Mexico, educational quality is ranked 102 out of 137 countries evaluated in the Global Competitiveness Report in 2018 [1]. This is unsurprising since Mexico has faced an educational gap for many years. These educational gaps are related to an academic system that does not have sufficient infrastructure, trained personnel, technology, availability, and/or even sanitary conditions [2].

According to Ortega [3], in most countries associated with the OECD (Organization for Economic Cooperation and Development), the proportion of young people between 18 and 24 years old who are neither studying nor working increased on average 1.7% (14.4% in 2019 versus 16.1% in 2020), while in Mexico the increase was 1.8% (21.5% in 2019 versus 23.3% in 2020).

On the other hand, the COVID-19 pandemic has affected billions of people worldwide, generating immeasurable health, economic, social, and educational consequences, not to mention a high number of losses of human life [4]. A very evident change occurs in teleworking as an effect of adaptability and survival. It can be defined as a new work scheme using ICT (Information and Communication Technologies) and making it possible to work and study from home [5].

Specifically derived from the COVID-19 contingency, the decision was made worldwide to carry out strict confinement, including the educational sector, leading them to search for solutions in methodologies, pedagogies, and didactics specific to distance and virtual education with the purpose of not canceling academic and research activity at all levels [4]. This health threat has left the education system faced with making decisions about how to continue teaching and learning while keeping its teachers, staff, and students safe from this public health emergency, the impact of which needs to be better understood [6]. Added to this problem is the fact that one of the most critical educational gaps that Mexico suffers from is the technological gap [7].

E-learning, also referred to as online learning or electronic learning, is the process of acquiring knowledge through electronic technologies and media [8]. It is a method of learning that is enabled by electronic means. Usually, e-learning takes place on the Internet, allowing students to access their learning materials from anywhere and at any time.

In Mexico, as in other countries, the technological limitations in education were exacerbated during the COVID19 contingency. This work aimed to document the different action strategies and innovations that have been attempted to implement against the educational technological gap that currently exists in Mexico and to explore, the perception between remote learning and face-to-face learning among students and professors from a Mexican private higher education institution.

Digital Object Identifier: (only for full papers, inserted by LACCEI).
ISSN, ISBN: (to be inserted by LACCEI).
DO NOT REMOVE

II. Methodology

Besides previous reported literature, exploratory data was collected through anonymous online surveys, composed of specific questions to quantify different perspectives on learning for both students and teachers, respectively. This study was carried in 2021, where a total of 162 individuals (137 students and 25 professors) who are part of the university community of Tecnologico de Monterrey, Campus Monterrey were surveyed.

Data was collected by Google Forms and frequency graphs were developed in Excel (version 365).

Clustering analysis and a dendrogram were performed using Minitab (version 19.2020.1.0) to generate a total of 4 different clusters using the complete linkage method and the Euclidean method, to measure the distance between all observations.

III. Results and discussion

A. The quality of education in Mexico and strategies to reduce the technological gap.

Educational quality in Mexico has faced different barriers. The technological gap, also called the digital gap, is one of the most relevant opportunity areas in education. Unfortunately, the crisis generated by the COVID-19 pandemic only made these barriers more evident [2].

According to the Organization for Economic Cooperation and Development [9], the concept of technological gap refers to having access to computers (ICT) and the Internet and skills to use these technologies. However, according to González [10], the problem of the digital gap does not only lie in having a computer, a cable, or a technological device to access information through an Internet connection, but it is also a social problem in which those in charge of establishing and promoting public policies have a significant challenge since these policies must have the objective of reducing inequalities and social injustices, because this gap is directly related to public policies related to information access and should not be misinterpreted with the simple fact of the availability or lack of technological resources.

Unfortunately, in Mexico, rural schools represent almost 50% of all schools and most of them are without internet access. In fact, only 43% of public schools in Mexico have technological infrastructure and internet [11]. According to the National Institute of Statistics and Geography (INEGI) cited by [12], 76.6% of the urban population is an internet user, while in rural areas, 47.7% of the population use internet. Additionally, only 44.3% have a computer. For this reason, the Mexican Government resorted to the implementation of the National Distance Education Strategy (Aprende en Casa, in English, Learn from Home) for basic-level education, which was based on the transmission of educational programs in open television; since, according to the Secretaria de Educacion Publica [13], 94% of Mexicans have a television in their home; likewise, radio is another medium that allows us to reach marginalized areas [7].

However, according to Ponce *et al.* [14], the generation of educational content for television has many limitations, as well as the instructional designs of e-learning systems in Mexico, in addition to the lack of feedback to guarantee the correct understanding. Although tele-education systems are based on the development of subject content to be projected on television or computers, there is no feedback that is effective, nor dynamic. Additionally, at the primary level, students cannot be autonomous in learning. The most concerning are the first and second grades because the teaching of the reading and writing process is a problem that arises in the next school year.

At the higher education level, it was decided to migrate the academic system to remote and virtual education. Despite Mexico had not had much previous experience in virtual education, according to Ponce *et al.* [14] it is considered that at higher levels of education (High school and University Education), the possibility of 100% online education is feasible. The reality is that, in this virtual modality, we have faced different limitations, difficulties, and questions related to the execution and performance of this strategy, because even with the technological infrastructure, the requirements to perform it correctly depend on more variables, such as preparation of students and even teachers in the use of technological tools, among others.

B. Evaluation of emerging teaching in remote learning modality.

As part of this adaptability, migrating the educational strategy to an online version can allow the flexibility of teaching and learning anywhere and at any time; however, the speed with which this shift to education is expected to happen in remote learning is complex and unprecedented. Not only for students, but for educators as well.

Although staff and support teams at universities or educational entities are often available to help teachers learn and implement remote learning, these teams typically support a small group of teachers interested in online teaching. Moreover, because of the situation during the COVID-19 pandemic, these individuals and teams cannot offer the same level of support to all teachers in such a narrow preparation window [6].

Interestingly, according to the surveys, it was observed (Figure 1) that most teachers currently preferred to teach their

courses in face-to-face format (64%), while only 24% enjoy teaching classes online.

On the other hand, the surveyed students were asked what educational format they enjoyed and preferred, giving an additional option of a hybrid modality (which consists of both, virtual and face-to-face classes). Similarly, it can be observed in Figure 1B that students enjoy more face-to-face teaching (48%), followed by hybrid modality (41%). Clearly, 89% of the students preferred and enjoyed more classes with an in-person concept (sum of face-to-face and hybrid modality) (Figure 1B).

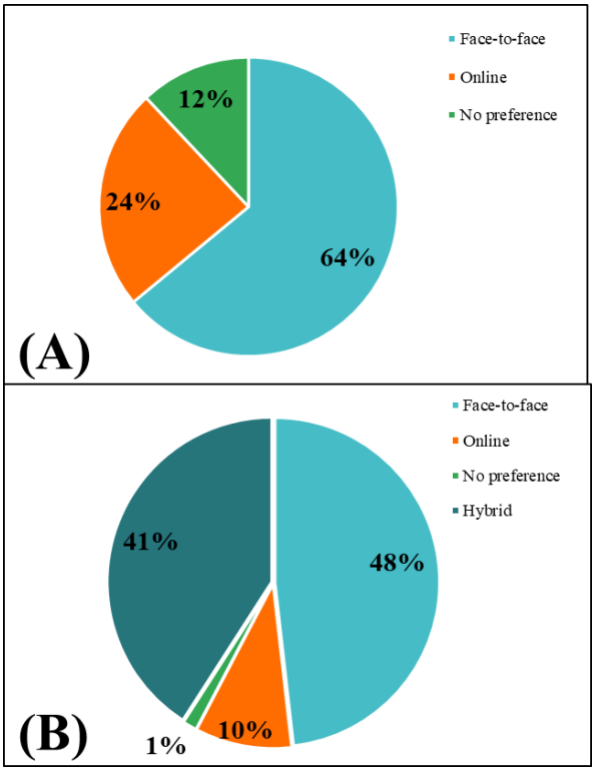

Figure 1 Results on the preference of the educational modality according to (A) educators and (B) students, according to the question: Which academic scheme do you prefer the most?

Furthermore, regarding the perception of investment of time and effort with the change to remote modality, a significant difference was observed since most teachers (64%) consider that there is a more significant investment of time and effort. In comparison, most students (40.1%) consider that they invest more time and effort in the face-to-face modality, followed by the online modality (35.8%). The interpretation of this data is consistent because, in most cases, the teacher invests a more significant amount of time and work in redesigning the course so that the content, activities, exams, and tasks are developed virtually, giving breaks between classes. In contrast, the students invest relatively the same time assigned to the class, so it does not generate an additional ailment.

Concerning the previous results, teachers and students were asked if they considered that changing a face-to-face course to a remote scheme would eventually be easier and more practical, and interestingly, it was observed that 100% of the teachers answered affirmatively. However, 65.7% of the students stated that this adaptation would make the learning experience easier and more practical. This response was evident in the case of teachers since the most outstanding effort and time investment is focused on restructuring the course from face-to-face to virtual, which is carried out, particularly at the beginning of this transfer, and over time, it becomes systematic.

Although the COVID-19 pandemic has severely impacted average educational progress, universities can exploit this unforeseen opportunity to detect gaps and accelerate online education reform through innovative course content, cutting-edge technology, and efficient time administration. This emergency is an opportunity to promote further international collaboration and share knowledge and resources to build a global online education network [15].

Another aspect that was evaluated between teachers and students was to identify which barriers they faced most in teaching or taking classes. According to the surveyed teachers, the most critical barriers continue to be technological issues (40%), followed by the extra investment of time (28%) and the lack of a workspace (20%) (Figure 2A). In a very similar way, students perceive technological failures as their most significant barriers (36%), followed by a lack of adequate space (24%), and 21% indicated that it is necessary to invest more time (Figure 2B). Interestingly, both teachers and students identified technological failures, lack of adequate workspace, and extra investment of time as their most critical needs.

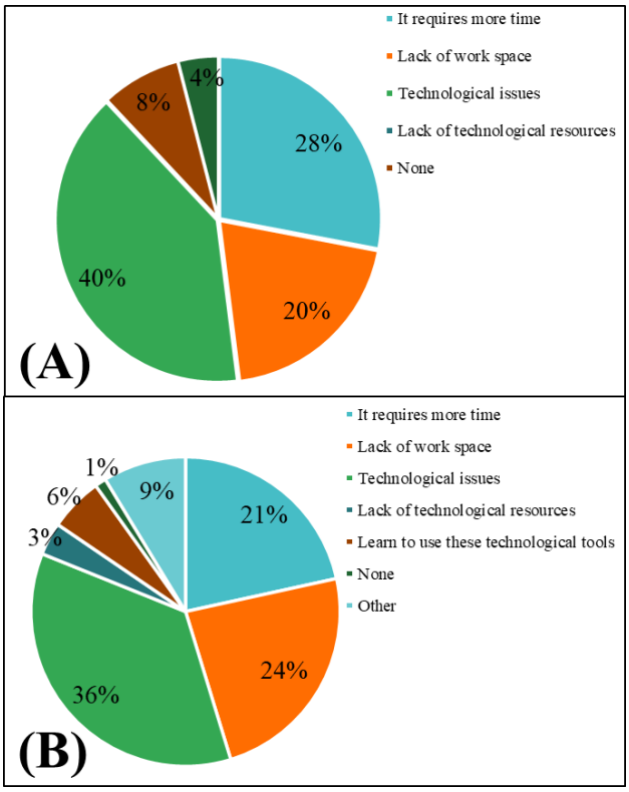

Figure 2 Results on the main problems that have occurred during a remote educational modality according to (A) educators and (B) students.

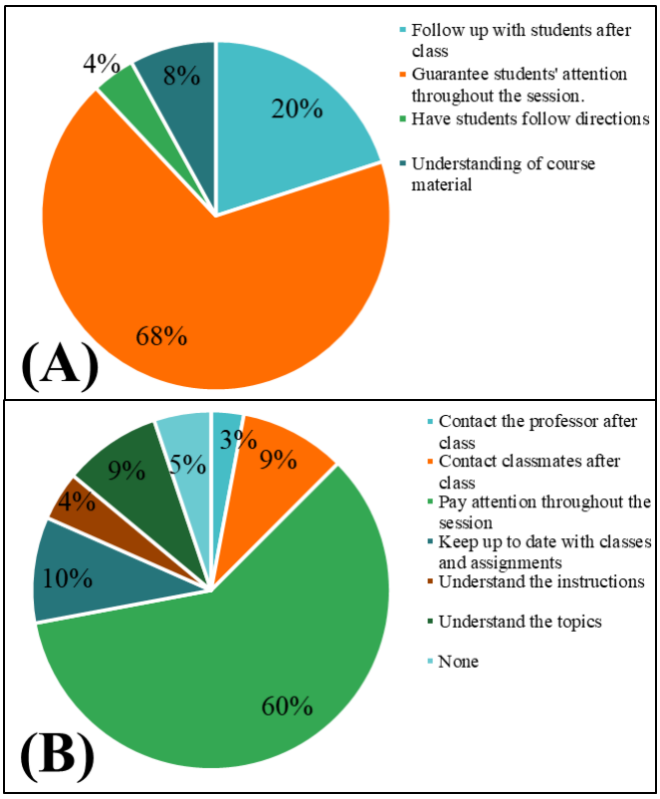

Figure 3 Results on the perception of the main challenges when being in a virtual educational course according to (A) educators and (B) students.

Finally, teachers and students were asked about the most relevant challenge or problem they have faced when teaching or taking a virtual course (Figure 3). On one hand, educators answered that the most crucial challenge or problem was to maintain the student's attention throughout the session, with 68%, followed by being able to follow up with the students after class, with 20% (Figure 3A). As for the students, remarkably they agreed that the most important challenge for them is being able to pay attention throughout the session, with 60%, followed by being able to keep up (10%) and being able to contact their classmates after class (9%) (Figure 3B). In line with this last response, the students were asked if contact or interaction with the rest of the students or the professor was easier when being in a remote modality, and 89.1% of the students answered that it was more challenging to contact their classmates and 70.1% of students consider that it is more difficult to contact the teacher in remote classes.

Likewise, consistent with these results and according to Vnoučková [16], the perception of teaching and everything that the videoconferencing process involves is slightly less effective in person.

These ravages have significantly affected the economic situation of universities. Although there is still no data to visualize this impact in Mexico, universities in the United States have made an estimate and prediction of these losses. According to Korn *et al.* [17], for universities, all funding sources are in doubt, and in addition to this, they are also facing a drop in enrollment due to unpredictable student registration, estimated at 15%, and the loss or lack of donations from private organizations. For instance, Hamilton College in New York lost 1 billion dollars in just one month.
Johns Hopkins University also went from projecting profits of $72 million this fiscal year to expecting a net loss of more than $100 million, forecasting a loss of $375 million in fiscal year 2021.

According to Sun *et al.* [15], this goes beyond online courses; graduate and senior students must complete their thesis projects, which is even more challenging. Except for research directly related to pandemic prevention and control, all other activities requiring laboratory data collection, field sampling, or site investigation have been suspended or largely limited. On the other hand, theoretical studies and research in social sciences are less affected, thanks to the availability of many online libraries, archives, and databases.

Finally, a cluster analysis was performed to understand the categorization of the exploratory data, where 4 main clusters were constructed using the 162 observations. According to Figure 4, Cluster 1, in blue color, is represented by 22 observations, Cluster 2, in red color, is represented by only 4 observations, Cluster 3, in green color, is represented by 89 observations, and finally Cluster 4, in purple color, by 47 observations.

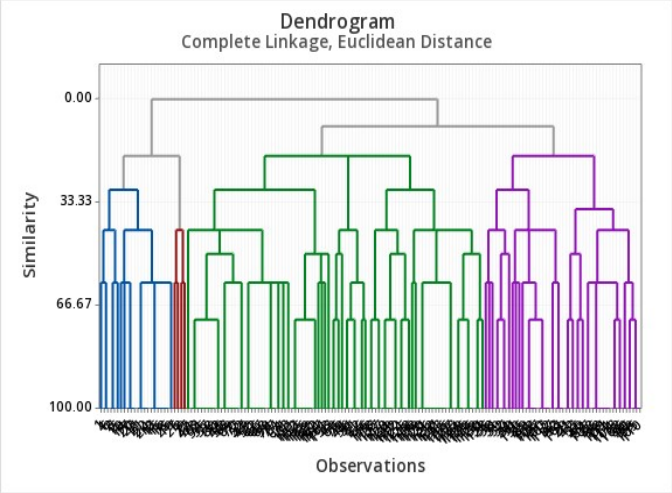

Figure 4 Dendrogram of clustering results from surveys answered by educators and students (n=162).

Interestingly, Table 1 shows that Cluster 1 represented most of the surveyed educators and preferred face-to-face learning (73%) but believed that a positive aspect of e-learning is the fast adaptation of the courses through time (100%). Furthermore, Cluster 2 represents the smallest cluster with both educators (75%) and students (25%) who believe E-Learning requires more time and effort (100%). Cluster 3 was the biggest cluster that represented students (100%) who perceived that E-Learning don't require more time and effort and has an easy adaptation (100%) and believe the biggest e-learning problem is technology failure (58%). Finally, Cluster 4 represents students (100%) who preferred face-to-face learning scheme (66%), believe that adaptation to e-learning is difficult (100%), and perceived that technology failure is the biggest e-learning problem (66%).

Table 1. Centroid of cluster analysis for the seventeen (17) variables of the e-learning survey for educators and students (n=162).

Variable	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Grand centroid
Educator	1.00	0.75	0.00	0.00	0.154
Student	0.00	0.25	1.00	1.00	0.846
E-learning require more time and effort	0.59	1.00	0.28	0.49	0.401
E-learning don't require more time and effort	0.41	0.00	0.72	0.51	0.599
Time consuming (E-learning problems)	0.27	0.50	0.30	0.51	0.364
Technology failure (E-learning problems)	0.45	0.00	0.58	0.66	0.574
Lack of working space (E-learning problems)	0.18	0.25	0.37	0.53	0.389
None (E-learning problems)	0.05	0.25	0.01	0.02	0.025
Lack of concentration (E-learning problems)	0.05	0.00	0.08	0.06	0.068
Lack of technological software knowledge (E-learning problems)	0.00	0.00	0.07	0.04	0.049
Others (E-learning problems)	0.00	0.00	0.01	0.02	0.012
Easy Adaptation to E-learning	1.00	1.00	1.00	0.00	0.710
Difficult adaptation to E-learning	0.00	0.00	0.00	1.00	0.290
Prefer E-learning	0.27	0.00	0.13	0.02	0.117
Prefer Face-to-face learning	0.73	0.00	0.39	0.66	0.506
Prefer hybrid learning	0.00	0.00	0.46	0.32	0.346
No preference in learning model	0.00	1.00	0.01	0.00	0.031

IV. Conclusion

Mexico is a country that has suffered different limitations in the quality of its education, the technological gap being one of the most relevant and which has been evidenced by the COVID-19 pandemic. Although Mexico needs more technological capacity or previous experience in digital or remote education issues, different innovations and strategies have been taken to solve the problem at different educational levels (e-learning). The most important advantage of implementing a technological educational model is undoubtedly the flexibility and ease of adapting to any other situation and/or condition.

However, to better understand this impact, it would be relevant to conduct a more in-depth study among different public and private higher education institutions, including students and educators, to visualize how these teaching methods have affected the academic efficiency. Through this research, it was possible to observe some of the barriers and challenges teachers and students face when migrating from a traditional (face-to-face learning) to a remote (e-learning) scheme. Among the most relevant, it was observed that a significant value proposition as an educational model is the development of courses in hybrid mode, contemplating the face-to-face and virtual model. In addition, this change in the educational scenario allows the exploration and integration of innovative strategies such as AI platforms and technological developments. Finally, we must take advantage of such advanced educational technology and educational innovation tools as an opportunity to promote international collaboration and facilitate to share experiences, knowledge, and as a resource to build a virtual and global education network.

V. Acknowledgment

The authors would like to acknowledge the financial support of Writing Lab, Institute for the Future of Education, Tecnologico de Monterrey, Mexico, in the production of this work.

VI. Reference

[1] V. Moy, "Lugar 102," El Financiero. https://www.elfinanciero.com.mx/opinion/valeria-moy/lugar-102/.

[2] Casado, "Las brechas educativas condenan a la pobreza," Ayuda en Acción. https://ayudaenaccion.org/ong/blog/educacion/brechaseducativas-pobreza/.

[3] Ortega, "Durante la pandemia, el número de jóvenes que no estudian ni trabajan subió 1.8%," Expansión Política. https://politica.expansion.mx/mexico/2021/09/17/durante-la-pandemiael-numero-de-jovenes-que-no-estudian-ni-trabajan-subio-1-8.

[4] V. M. Burbano, V. Miranda, A. Margoth, and Á. S. Burbano Valdivieso, "Teletrabajo académico afectado por el coronavirus: una mirada desde un grupo focal de profesores universitarios," Revista Espacios, vol. 41, no. 42, pp. 335-348, 2020.

[5] W. Santillan, "El teletrabajo en el COVID-19," CienciAmérica: Revista de divulgación científica de la Universidad Tecnológica Indoamérica, vol. 9, no. 2, pp. 65-76, 2020.

[6] Hodges, S. Moore, B. Lockee, T. Trust, and A. Bond, "The difference between emergency remote teaching and online learning," Educause review, vol. 27, pp. 1-12, 2020.

[7] J. M. González, "La brecha digital en la educación básica en México," Organización de los Estados Americanos. 2020. https://recursos.educoas.org/sites/default/files/VE14.381.pdf.

[8] A. M. Maatuk et al., "The COVID-19 pandemic and E-learning: challenges and opportunities from the perspective of students and instructors," Journal of computing in higher education, vol. 34, no. 1, pp. 21-38, 2022.

[9] Organización para la Cooperación y el Desarrollo Económicos, "Avances en las reformas de la educación básica en México: Una Perspectiva de la OCDE." 2012. https://docplayer.es/7858303-Avancesen-las-reformas-de-la-educacion-basica-en-mexico-una-perspectivadesde-la-ocde.html.

[10] M. Gonzalez, "La desigualdad educativa como producto de una brecha digital," Educación Futura. 2010. https://sid.usal.es/idocs/F8/FDO22178/reflexiones.pdf.

[11] INOMA, "El resago tecnologico en las escuelas rurales de mexico" 2020. Available: https://inoma.mx/index.php/2019/10/08/el-rezagotecnologico-en-las-escuelas-rurales-de-mexico/

[12] L. Mendoza, "La educación en México en tiempos de COVID-19," Educación Futura. https://www.educacionfutura.org/la-educacion-enmexico-en-tiempos-de-covid-19/.

[13] Secretaría de Educación Pública, "Boletín No. 271 Trabaja el Sistema Educativo Nacional para transitar a un modelo de aprendizaje mixto." https://www.gob.mx/sep/articulos/boletin-no-271-trabaja-el-sistemaeducativo-nacional-para-transitar-a-un-modelo-de-aprendizaje-mixtoesteban-moctezuma-barragan?idiom=es.

[14] R. Ponce, H. A. Hernández, A. Díaz, and R. Díaz, "Retos de la educación en línea para las escuelas públicas en México," Observatorio, Instituto para el Futuro de la Educación. https://observatorio.tec.mx/edubits-blog/retos-de-la-educacion-en-linea-en-escuelas-publicas-enmexico.

[15] L. Sun, Y. Tang, and W. Zuo, "Coronavirus pushes education online," Nature Materials, vol. 19, no. 6, p. 687, 2020.

[16] L. Vnoučková, "Impact of COVID-19 on human resource management," Revista Latinoamericana de Investigación Social, vol. 3, no. 1, pp. 1821, 2020.

[17] M. Korn, D. Belkin, and J. Chung, "Coronavirus pushes colleges to the breaking point, forcing 'hard choices' about education," The Wall Street Journal, 2020.