Availability and technological knowledge of university mathematics teachers in the time of covid-19

Disponibilidad y conocimientos tecnológicos de docentes universitarios de matemáticas en tiempos de la covid-19

Laura Lillian Acuña Michel*
Omar Cuevas Salazar**
Joel Angulo Armenta***

ABSTRACT

The purpose of the study was evaluating, in the face of the contingency caused by the Coronavirus Disease pandemic (covid-19), the mathematics teachers knowledge and availability of technological tools for teaching remote university courses. The research adopted the quantitative approach and the design is non-experimental, transactional and descriptive. Eighty-one teachers participated and the survey consisted of 38 items with dichotomous answers, Likert scale and multiple selection. The questions were related to the remote modality, the availability of technology devices and services, and the use of technological tools. According to the results, the mathematics teachers of one south Sonora university have internet access and technological devices to distance teaching, they know or have used virtual classroom platforms and applications that allow communication with students. The areas of opportunity that were detected are the distance courses design, the online exams and didactic material preparation, as well as the implementation of tools that promote collaborative work.

RESUMEN

El presente estudio tuvo la finalidad de evaluar la disponibilidad y los conocimientos de herramientas tecnológicas que poseen los docentes universitarios de matemáticas en la impartición de cursos a distancia ante la contingencia provocada por la pandemia de la covid-19. Se utilizó un enfoque cuantitativo descriptivo, no experimental, de corte transeccional, donde participaron 81 docentes, quienes respondieron una encuesta conformada por 38 ítems con diferentes tipos de opciones de respuesta: dicotómicas, tipo Likert y opción múltiple. Las preguntas se relacionaron con la modalidad a distancia, la disponibilidad de dispositivos y servicios de tecnología, así como con el uso de herramientas tecnológicas. Según los resultados obtenidos, los docentes de matemáticas de una universidad del sur de Sonora, México, tienen acceso a internet y dispositivos tecnológicos para enseñar a distancia, conocen o han utilizado plataformas de aula virtual y aplicaciones que permiten establecer comunicación con los alumnos. Las áreas de oportunidad que se detectaron se relacionan con el diseño de cursos a distancia, la elaboración de exámenes en línea y material didáctico, además de la implementación de herramientas que promueven el trabajo colaborativo.

* Master's degree in Educational Mathematics from the Instituto Tecnológico de Sonora. Assistant professor at the Instituto Tecnológico de Sonora, Mexico. ORCID: http://orcid.org/0000-0002-4514-1128

** PhD. in Education from the Nova Southeastern University. Research Professor at the Instituto Tecnológico de Sonora, Mexico. ORCID: http://orcid.org/0000-0003-0113-0475

*** PhD in Education from Nova Southeastern University. Research Professor at the Instituto Tecnológico de Sonora, Mexico. Sonora, Mexico. ORCID: http://orcid.org/0000-0003-4335-3167

INTRODUCTION

As a result of the confinement during the global pandemic caused by covid-19, which broke out in December 2019 in Wuhan City, China (Sorooshian, 2020; Yi, Lagniton, Ye, Li & Xu, 2020), most governments around the world ordered educational institutions to avoid face-to-face encounters aimed to prevent the spread of the virus (Sir John, 2020). By March 2020, 8.3% of the global student population was affected by school closures (approximately 144 million students), which left educational institutions with no alternative but to move to online education (United Nations Educational, Scientific and Cultural Organization, Unesco, 2021); consequently, the inclusion of information and communication technologies (ICT) in the educational system became vital (Sir John, 2020; Moreno-Correa, 2020).

It is worth considering that, as the quarantine was postponed, it was a commonly use to speak of online education, remote education, virtual education and digital education (Bustamante, 2020), since educational institutions worldwide moved from the face-to-face to the non-conventional mode in a disruptive manner. This brought with it the creation of distance teaching-learning environments that, due to lack of time, were improvised by teachers, which gave rise to uncertainty and stress among them because they were not trained to provide education mediated by digital technologies (Moreno-Correa, 2020; Oliva, 2020). Indeed, few institutions were prepared to make this move quickly and efficiently (Brown & Salmi, 2020; Murphy, 2020), which represented the greatest challenge that educational systems have ever faced (Moreno-Correa, 2020; Sir John, 2020). This change challenged serious constraints, difficulties and ethical questions, especially those related to equity and access to technology in society (Mishra & Warr, 2021; Lloyd, 2020).

Within this framework, educational institutions decided to continue the school year with distance classes and make use of digital platforms that allowed students to have reach of the subject contents (Sanchez, 2020). It should be mentioned that many teachers adapted to a distance mode without prior training or technological appropriation; both teachers and students had to develop digital skills to adapt to an emerging remote education generated during the pandemic caused by covid-19 (González-Fernández, 2021). From experience, it was shown that teaching with technology was complicated because it not only consisted of moving content or processes to the web (Mishra and Warr, 2021), in addition, the existence of gaps in knowledge and in the management of digital tools was observed, which led to rethink the way and manner in which schools should educate in times of crisis (Mentasti, 2021; Sanchez, 2020; Oliva, 2020).

In this perspective, the new educational scheme adopted during the last months of pandemic required teachers to be able to design, develop and implement technological strategies in their teaching practice (González-Fernández, 2021), which would help the development of capabilities to teach distance courses, since if it was previously considered as an educational option, at that time it was practically the only alternative to face the situation (Martínez-Garcés & Garcés-Fuenmayor, 2020; Moreno-Guerrero, Aznar-Díaz, Cáceres-Reche & Alonso-García, 2020). Therefore, teacher digital literacy was considered one of the keys to success in dealing with the pandemic caused by covid-19, as well as other situations that may arise in the future (Alea, Fabrea, Roldan & Farooqi, 2020; González-Fernández, 2021).

However, the inclusion of ICTs in the education system, in addition to being a necessity originated by the health crisis, has long been considered a challenge for education in the world. Past history refers to the 2015 World Education Forum in Incheon, South Korea, where the importance of ICT integration in education and teacher training was reaffirmed (Unesco, 2019).

Thus, incorporating ICT in education is considered a topic of interest from a research point of view. Therefore, numerous studies have been conducted to analyze their use and level of adoption, through their association with variables such as gender, age, demographic factors, academic background and seniority (Luzardo, Sandia, & Aguilar, 2020). However, the results found have been different; for example, in the studies of Espinosa, Betancur and Aranzazu (2014), as well as Vera, Torres and Martínez (2014), it was found that age is a variable that influences the use of ICTs, and they assure that the older the teacher's age, the lower his or her knowledge in relation to the use of technologies. On the contrary, Campos and Ramírez (2018) and Hidalgo-Cajo and Gisbert-Cervera (2021) found that there are no significant differences with respect to age and ICT use in university teachers. With this in mind, it becomes necessary to study the relationship of these variables from other educational environments.

In 2015, the Qingdao Declaration was published, where it was established that in order to successfully integrate ICT in teaching-learning, it was essential to rethink the role of teachers, modifying their training and improving their professional skills (Unesco, 2019). This is why it is necessary to inquire about the acquisition of knowledge of teachers to integrate digital technologies in the classroom and ensure academic continuity in the non-classroom space (George, 2021).

Unesco, along with industry leaders and international experts in the field, in 2018 created an international framework that defines teacher competencies for effective use of ICT in teaching. This framework contains 18 competencies organized into six aspects of teachers' professional

practice: 1) understanding the role of ICT in education policy, 2) curriculum and assessment, 3) pedagogy, 4) application of digital competencies, 5) organization and administration, and 6) teachers' professional learning. The framework is also organized into three levels of teacher development in terms of the pedagogical use of ICT: the first one refers to knowledge acquisition, the second one measures knowledge deepening, and the third one assesses knowledge creation; each represents different stages in the use of ICT in education. Consequently, each country, district or school should adopt a different approach depending on the degree of ICT integration in its community and its contextual parameters (Unesco, 2019).

If teachers possess competencies to use ICT in their professional practice, there is a greater possibility that quality education will be delivered, effectively guiding the development of students' ICT competencies, in addition to promoting competencies related to the knowledge society, including critical and innovative thinking, complex problem solving, collaborative skills, and socioemotional skills. Similarly, they will have skills to create new communicative scenography and abilities to adapt to the educational problems they wish to solve, with consideration towards the cognitive and social characteristics of their students (Corica, 2020; Unesco, 2019).

The challenge of university professors transcends the mastery of pedagogical tools to perform their activities, as they are also required to have humanistic training, to be strategic and able to innovate, create and design in the classroom; they must also be empathetic with their students, to the extent of stimulating the ability to learn to be, learn to learn and learn to live together (Campos, Ruiz and Rodríguez, 2021). In order to make students become collaborative, creative, problem-solving, innovative and committed members of society, teachers have to use didactic tools and applications from the web as a digital educational resource (Unesco, 2019).

In Mexico, distance education models implemented today as a result of the covid-19 pandemic must take the availability of technologies and internet access in the homes of Mexican families into account, since sometimes educational institutions and students do not have the technological or cognitive resources that are required to implement innovative strategies, which represents the greatest hindrance to a non-conventional education (Portillo, Castellanos, Reynoso, & Gavotto, 2020). Prior to the pandemic, Mexico was evaluated in terms of the use and availability of ICT positioning itself in 87th place out of 176 economies in the world and as one of the nine most dynamic economies in the Americas (Juarez, 2017). In contrast to the above, the Asociación de Internet MX (2021a), in its study on the habits of internet users (conducted in May 2021), found that there are 84.1 million internet users in Mexico, with a growth of 10.2%.

Considering the exponential increase of internet users, teachers and students were not prepared to implement technology-mediated distance education. Therefore, it was decided to assume the social, educational and moral commitment with the population to create improvised learning environments (Roa, 2020), such was the case of a university in southern Sonora, Mexico, where in March 2020, in response to the sanitary measures adopted by the contingency, suspended face-to-face classes, which led professors and students to resort to technological resources at their disposal to continue classes in distance mode (Drive, Zoom, Meet, Classroom, email, WhatsApp, and various applications that allowed consolidating the teaching-learning process). As a result of the pandemic, education underwent some changes with an impact upon people who studied under the face-to-face model to a greater extent, as they were forced to continue their studies through video calls or online platforms. In the future, there is a totally different scenario than before the pandemic, as there is greater interest in studying under mixed or 100% online models; this prospect is reinforced according to data from the Asociación de Internet MX (2021b), where 65% of the people who studied under the face-to-face or mixed mode continued their studies in the non-conventional mode.

As time went by and covid-19 infections increased, educational authorities assessed the health situation, and foresaw that returning to classes would not happen in the short time. This is why the university under study decided to use a version of Moodle platform called Ivirtual, which was designed to provide educators, administrators and students with an integrated, robust and secure system to create personalized learning environments, and has been used since 2014 to deliver distance education courses. Ivirtual allows students to access information about their subjects, consult documents and didactic material to support learning, and helps teachers to organize classes by day, post instructions for the development of activities, establish spaces for receiving assignments, design online tests and facilitate feedback, among other advantages.

In view of the need to offer distance courses, university authorities decided that they should be taught in a remote synchronous, virtual asynchronous or mixed manner. In the specific case of the Department of Mathematics, it was decided to offer the courses in a remote synchronous way, since the interaction in real time between students and teachers would be necessary to clear doubts and answer questions during the teaching-learning process. It is important to consider that teaching of mathematics courses in a traditional way already implied a challenge for teachers due to the difficulty of achieving significant learning in students, so in the context of the pandemic, distance education has been included as an obstacle because it represents a greater challenge which requires teachers, within their capabilities, to also possess digital skills; that is, to use creativity and pedagogy to design activities by means of using technological tools and,

therefore, to have the knowledge to teach through them (Hallman, 2017; Sanchez, 2020).

Consequently, it is essential to become aware of teachers' knowledge of ICT, but also to identify whether they have access to the platforms, the Internet and the devices needed to teach in non-conventional environments. Therefore, there is a need to conduct a study under a rigorous theoretical and methodological perspective to answer the following question: do mathematics teachers have availability and knowledge about the technological tools necessary to teach distance courses during the emergency caused by covid-19?

Therefore, the objective of the study was: to evaluate the availability and knowledge of technological tools acquired by mathematics teachers in the teaching of distance courses (remote synchronous) during the emergency caused by covid-19, in order to identify training needs.

METHOD

The study was conducted by following a descriptive quantitative approach, with a non-experimental, cross-sectional design, and was carried out in the Mathematics Department of a state public university based in Ciudad Obregón, Sonora, Mexico. The population of this study included all the teachers in the department (105 professors), who were sent the invitation by email to support the project by answering the instrument voluntarily; 81 teachers decided to participate, 37 (46%) were women and 44 (54%) were men. A non-probabilistic sample was considered using the criterion of inclusion by convenience of those teachers who were teaching in the area of mathematics.

To measure the availability and acquired knowledge of technological tools by mathematics teachers, an instrument already used by the university considered in this study was applied, whose content was validated through expert judgment, with the participation of six researchers from the same institution, who have experience in the development of reagents and the use of ICT. The comments received were used to modify the instrument, which consisted of 38 items with different types of response options (dichotomous and multiple choice) according to a Likert scale with the categories of 4 = Always, 3 = Almost always, 2 = Sometimes and 1 = Never. The items were distributed as follows: four attributive variables (gender, type of contract, age and level of studies), two related to the distance mode, nine related to the availability of technology devices and services, and 23 concerning the use of technological tools, including technological pedagogical aspects.

The procedure used in the development of this research is described below:

1) The instrument was developed for the teachers of the Mathematics Department in electronic format, using Google forms.

2) It was distributed via e-mail to each participant.

3) The data were exported to an Excel file.

4) Subsequently, they were transported to the SPSS data editor.

5) Finally, the data were analyzed using SPSS software.

Descriptive and inferential statistics were used in the data analysis. Specifically, graphs and frequency tables were made to show the response percentages of each of the survey items, and contingency tables were used to know the association between two variables; in addition, hypothesis tests were applied for the comparison of proportions.

RESULTS

Once the data from the survey, applied to the teachers of the Mathematics Department, were collected, the following results were obtained. Of the 81 participating teachers, 11 (14%) were full-time and 70 (86%) part-time; 21 (26%) have a bachelor's degree, 54 (67%) a master's degree and 6 (7%) a doctorate; with respect to age, four (5%) are 30 years old or younger, 23 (28%) are between 31 and 40 years old, 24 (30%) are between 41 and 50 years old, the same percentage are between 51 and 60 years old, and 6 (7%) are 61 years old or older.

Of the total sample (81 teachers), 80 (99%) reported having at least one technological device at home; 42 (52%) have a desktop computer, 73 (91%) a laptop, 68 (85%) a smart cell phone, 76 (95%) have a microphone and 79 (99%) have a webcam. Likewise, of the 81 teachers, 80 (99%) have Internet service at home and 49 (63%) have mobile data on their cell phone. With respect to the teachers' experience in distance learning, 23 (28%) stated that they had participated in the design of courses in this mode; likewise, 56 (69%) mentioned having taught courses also in this mode, a low percentage for the need to offer all courses in distance learning.

According to the results, 99% use e-mail regularly, which does not represent a major problem. Regarding the frequency of email use, only 1 (1%) said they use it once a week, 42 (52%) use it every day and 38 (47%)

mentioned using it several times a day. On the other hand, 63 (78%) of the teachers use the cloud to store and access their information, while 49 (60%) share files from the cloud.

Regarding digital technologies to communicate with students, Figure 1 shows those that are used by teachers in the Mathematics Department. It is possible to observe that among the main technologies used are email and WhatsApp.
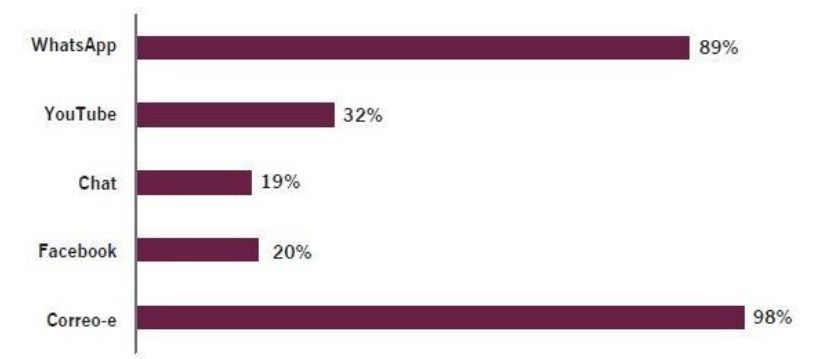

Figure 1. Technologies used for communication with students

Regarding the most used internet browsers, of the 81 teachers (100%) use Google Chrome, 49 (61%) Internet Explorer and 30 (37%) use Mozilla Firefox. In addition, they were asked whether they use the Internet on their cell phones, 62 (77%) answered that they use it almost always, 15 (18%) that they use it sometimes and 4 (5%) that they do not use it at all.

Regarding the platforms and systems used in the teaching of classes, 51 (63%) of the teachers of the Mathematics Department have used a learning management system (LMS), 41 (51%) have used the institutional platform, 30 (37%) Classroom and 13 (16%) Moodle. They were also asked if they have used any tool to take online tests to which 44 (54%) answered yes, 16 (20%) have done so through the institutional platform, 20 (25%) have used Quía, 41 (50%) Google Forms and 22 (27%) Kahoot.

Regarding virtual classroom platforms, 74 (93%) of the teachers reported having used at least one; of which 72 (97%) have used Zoom, 21 (28%) Google Meet and 5 (7%) Telmex Videoconference. Of the total number of teachers, 39 (48%) have used collaborative work tools; of which 27 (69%) have used Google Docs and 12 (31%) OneDrive. Of the 81 teachers, 54 (67%) reported using tools to create educational resources; of which 33 (61%) have used PowerPoint with audio, 14 (26%) Prezi and 16 (30%) Kahoot.

On the other hand, the chi-square test (Table 1) was performed to check whether the proportion of teachers with respect to the type of contract (full-time and part-time) differed with respect to whether they had designed a distance learning course, and the test was significant (Table 1).

Table 1. Chi-square test to test the difference between the type of contract and the design of distance learning courses

	Value	gl	Asymptotic sig. (bilateral)
Pearson chi-square	4.281	1	.039
N of valid cases	81		

Of the 11 full-time teachers, 6 (54.5%) had designed courses in distance mode, of the 70 part-time teachers, 17 (24.3%) had designed courses in this mode (see Table 2).

Table 2. Contingency table on the type of contract and participation in the design of distance courses by teachers

			Participation in the design of distance courses		Total
			No	Yes	
Type of contract	Auxiliary	Re-count	53	17	70
		% within Contract Type	75.7%	24.3%	100%
	PTC	Re-count	5	6	11
		% within Contract Type	45.5%	54.5%	100%
Total		Re-count	58	23	81

There was no substantial difference between full-time and part-time teachers with respect to teaching courses in the distance mode, nor was it significant with respect to having data on their cell phone, the use of LMS, or the use of tools to take online tests.

The chi-square test was also used to analyze whether the gender ratio (women and men) differed in relation to the design of distance learning courses, but no significant difference was found. Neither was the relationship between gender and the delivery of courses in distance mode considered relevant, nor between gender and whether they have data on the cell phone, the same happened between gender and the use of LMS. Where a significant difference was found (see Table 3) was between gender and the use of tools to take online tests.

Table 3. Chi-square test to test the difference between the type of gender and having used tools to take online exams

	Value	gl	Asymptotic sig. (bilateral)
Pearson chi-square	4.817	1	.028
N of valid cases	81		

Of the 37 female teachers, 25 (67.6%) had used online tests, while of the 44 male teachers, only 19 (43.2%) had used this type of tool (Table 4). Finally, chi-square tests were performed to test the independence between the level of study (bachelor's, master's and doctorate) of the teachers and the design of courses in distance mode, the teaching of courses in this mode, whether they have data on their cell phone, the use of LMS and the use of tools to take online tests; in all cases the result was not significant.

Table 4. Contingency table on the type of gender and use of tools to take online exams

			Use of online exam tools		Total
			No	Yes	
Gender	Feminine	Re-count	12	25	37
		% within Contract Type	32.4%	67.6%	100%
	Masculine	Re-count	25	19	44
		% within Contract Type	56.8%	43.2%	100%
Total		Re-count	37	44	81

DISCUSSION

Generally, it can be established that the percentage of teachers living in Sonora, Mexico, who have internet in their homes is high considering the data collected in the National Survey on Availability and Use of Information Technologies in Homes 2019 (ENDUTIH), which shows that only 56.4% of Mexican homes have internet access (Instituto Nacional de Estadística y Geografía, INEGI, 2020, p. 18). The results found in this research with 81 university mathematics teachers show that 99% have internet service at home, these data do not differ from the study by Portillo *et al.* (2020), which considered 32 university teachers, identifying that 87.5% of teachers have internet access.

Likewise, there is a high percentage of mathematics teachers in the university analyzed for the study, who have technological resources to teach at a distance, 99% of the teachers responded that they had at least one technological device at home; of these, 52% have a desktop computer, 91% have a laptop, 85% have a smart cell phone, 95% have a microphone and 99% have a webcam.

Hidalgo-Cajo and Gisbert-Cervera (2021) describe teachers as "multi-device" users, as they mostly own laptops and desktop computers, as well as tablets, digital book readers and smartphones; in this case, women have a greater number of devices and are the ones who use them most for educational purposes. This is consistent with the 2019 ENDUTIH data, which states that 44.3% of Mexicans have a computer (INEGI, 2020); likewise, the Asociación de Internet MX (2021a) mentions that few people had to acquire a device to adapt to the 100% online mode during the pandemic, due to the fact that most already had at least one.

Teachers say the computer and the smartphone are the mostly used devices, 96.9% use the computer as the main device and 3.1% use the smartphone as the first option (Portillo *et al.*, 2020); however, the Asociación de Internet MX (2021b) states that smartphones have positioned themselves as the connectivity device of greater adoption, displacing the computer, since although this is the most complete device to exploit Internet capabilities, the high costs inhibit its complete adoption in Mexico. Meanwhile, 63% of teachers have data on their smartphones, a low percentage compared to the data obtained in the ENDUTIH, which shows that 95.3% of Internet users in Mexico connect through a smartphone (INEGI, 2020).

Regarding the digital technologies used to communicate with students, among others, WhatsApp, chat (Messenger rooms), Facebook (wall) and email were mentioned, the latter being the mostly used followed by WhatsApp; this is contrary to what is established in the study by Portillo *et al.* (2020), where they state that 90.6% of teachers consider WhatsApp as their preferred means of communication.

In relation to the teachers' experience with distance learning courses, it was found that 69% had taught courses in this mode before the pandemic. Portillo *et al.* (2020) found that 65.6% of the teachers had already worked in this mode. In both studies, about 70% have had experience teaching in a distance mode; the reasons why this percentage is not higher are unknown. In this regard, Rizales-Semprum (2019) found that 75% of teachers consider this mode proper for the teaching-learning of mathematics.

An area of opportunity in the Department of Mathematics is the design of courses in distance mode, since few teachers have done so (28%). Another area of opportunity detected in this research is with respect to tools for devising online tests, since only 54% of teachers have used some tool (institutional platform, Quía, Google Forms and Kahoot). In a study conducted by Portillo et al. (2020) slightly more than 75% of the students rated as bad and regular the way in which teachers evaluated the activities developed during the pandemic. The development of online tests undoubtedly is an important part of the evaluation, but it is also necessary to learn how to evaluate the different activities carried out online, such as participation in forums and chat.

Although most of the teachers surveyed indicate that they have a basic command of computer use, they also mention that they do not know of programs that can help them carry out their pedagogical activity to develop distance classes (Rizales-Semprum, 2019). This is reflected in the percentage of use of tools to develop educational resources (67%) focusing mainly on PowerPoint, Prezi and Kahoot. As teachers are not trained to develop educational material they resort to the use of videos available on the network, this may be the cause of students rating the materials and resources used by teachers as bad and regular to support their distance classes during the pandemic (Portillo et al., 2020).

They were also questioned about the knowledge they have regarding the digital platforms used in the pandemic, to which 63% of the teachers of the Mathematics Department responded that they have used some LMS, of these 51% have used the institutional platform, 37% Classroom and 16% Moodle; even though the use of technological platforms began since 2003 in the institute. The Moodle platform is an LMS that promotes a social constructivist education, but teachers are partially unaware of how it works as they have not used it (Rizales-Semprum, 2019), so it is a low percentage of teachers who have used it.

It would be appropriate to evaluate student satisfaction with reference to the support received from teachers during the pandemic with respect to the materials and resources that were used as support in distance classes, how teachers evaluated the activities, whether the means used to answer questions were adequate and, generally, how they rate the teacher's use of technology.

CONCLUSIONS

From the results presented, and from their analysis and discussion, the following conclusions can be drawn: most of the teachers in the Mathematics Department have technological devices and internet at home to teach distance courses, and more than half of them have taught classes in this mode. To maintain communication with students, teachers use email as the first resource, followed by WhatsApp.

On the other hand, they use the cloud to store and access their information, and they use more than one Internet browser (Google Chrome is the most used). In addition, it was found that most teachers have used virtual classroom platforms for synchronous distance sessions (Zoom, Meet and Telmex Videoconferencing).

The proportion of teachers of the Department of Mathematics who have designed courses in distance mode is low, due to the fact that most of the courses are taught in face-to-face mode, only one of these courses is offered in distance mode. In order to increase the percentage of participation of professors in the design of distance courses, it could be established as a strategy to offer more courses in this mode. With regards the online test preparation tools, it was found that female teachers have used them more than male teachers.

Teachers should be encouraged to use tools to promote collaborative work, as well as the use of the cloud to share files. It is also necessary to train them in the design of distance courses, in the use of LMS and tools for tests, since few of them have experience in these areas. There is a need to expand educational resources to prepare didactic material, since they generally use PowerPoint presentations and only a few use other tools, such as Prezi and Kahoot.

It is important to mention that the results obtained in this study cannot be generalized to all mathematics teachers in the region, nor in other regions, because the sample was non-probabilistic and the behavior of the variables will depend on the educational environment where the research is conducted; however, the data obtained are a reference of the participating teachers.

It is a reality that the use of technological tools is part of current and future education, and that using them efficiently will allow the creation of new educational environments where learning can be more meaningful. In this sense, it is necessary to consider technology as a means to an end, not as an end in itself. Indeed, it is not enough to have technological resources and Internet access; it is necessary to start with a continuous training program that allows teachers to develop ICT skills.

REFERENCES ■

Alea, L.; Fabrea, M.; Roldan, R. & Farooqi, A. (2020). Teachers' Covid-19 awareness, distance learning education experiences and perceptions towards institutional readiness and challenges. *International Journal of Learning, Teaching and Educational Research, 19*(6), pp. 127-144. https://doi.org/10.26803/ijlter.19.6.8

Asociación de Internet MX. (2021a). 17° Estudio sobre los hábitos de los usuarios de internet en México 2021. https://onx.la/90047

Asociación de Internet MX. (2021b). Educación en línea en México 2021. https://onx.la/f44ac

Brown, C. & Salmi, J. (2020). Putting fairness at the heart of higher education. University World News. *The Global Window on Higher Education*. https://www.universityworldnews.com/post.php?story=20200417094 523729

Bustamante, R. (2020). Educación en cuarentena: cuando la emergencia se vuelve permanente. *Aportes para el diálogo y la acción, 1*(1), pp. 1-9. http://www.grade.org.pe/creer/archivos/articulo-4.pdf

Campos, R. A.; Ruiz, E. y Rodríguez, R. A. (2021). Re-pensando el perfil docente universitario: una mirada desde sus participantes. *Educando para educar*, (40), pp. 13-30. https://beceneslp.edu.mx/ojs2/index.php/epe/article/view/84/81

Córica, J. L. (2020). Resistencia docente al cambio: caracterización y estrategias para un problema no resuelto. *Revista Iberoamericana de Educación a Distancia, 23*(2), pp. 255-272. http://dx.doi.org/10.5944/ried.23.2.26578

Espinosa, H. R.; Betancur, L. F. R. y Aranzazu, D. (2014). Alfabetización informática y uso de sistemas de gestión del aprendizaje (LMS) en la docencia universitaria. *Revista de la Educación Superior, 43*(171), pp. 139-159. https://doi.org/10.1016/j.resu.2015.03.004

Juárez, C. (22 de noviembre de 2017). México ocupa el lugar 16 en el Índice de Desarrollo TIC. *El economista*. https://www.eleconomista.com.mx/empresas/Mexico-ocupa-el-lugar-16-en-el-Indice-de-Desarrollo-TIC--20171122-0063.html

George, C. E. (2021). Competencias digitales básicas para garantizar la continuidad académica provocada por el covid-19. *Apertura, 13*(1), pp. 36-51. http://doi.org/10.32870/Ap.v13n1.1942

González-Fernández, M. O. (2021). Competencias digitales del docente de bachillerato ante la enseñanza remota de emergencia. *Apertura, 13*(1), pp. 6-19. http://dx.doi.org/10.32870/Ap.v13n1.1991

Hallman, H. (2017). *Millennial Teachers: Learning to Teach in Uncertain Times* (1st ed.). Routledge. https://doi.org/10.4324/9781315562582

Hidalgo-Cajo, B. G. y Gisbert-Cervera, M. (2021). La adopción y el uso de las tecnologías digitales en el profesorado universitario: un análisis desde la perspectiva del género y la edad. *RED. Revista de Educación a Distancia, 67*(21), pp. 1-19. https://revistas.um.es/red/article/view/481161/311221

Instituto Nacional de Estadística y Geografía (INEGI). (2020). Comunicado de prensa núm. 103/20. Encuesta nacional sobre disponibilidad y uso de tecnologías de la información en los hogares, 2019. https://www.inegi.org.mx/contenidos/saladeprensa/boletines/2020/OtrTemEcon/ ENDUTIH_2019.pdf

Lloyd, M. (2020). Desigualdades educativas y la brecha digital en tiempos de covid-19. En H. Casanova Cardiel (coord.), *Educación y pandemia: una visión académica* (pp. 115-121). Ciudad de México: Universidad Nacional Autónoma de México, Instituto de Investigaciones sobre la Universidad y la Educación.

Luzardo, M.; Sandía, B. E. y Aguilar, A. S. (2020). Conocimiento y frecuencia del uso de las tecnologías de información y comunicación en la práctica educativa. Variables sociodemográficas de los docentes en la Universidad de Los Andes. *Revista cubana de educación superior, 39*(1). http://scielo.sld.cu/pdf/rces/v39n1/0257-4314-rces-39-01-e3.pdf

Martínez-Garcés, J. y Garcés-Fuenmayor, J. (2020). Competencias digitales docentes y el reto de la educación virtual derivado de la covid-19. *Educación y Humanismo, 22*(39), pp. 1-16. https://doi.org/10.17081/eduhum.22.39.4114

Mentasti, S. (2021). Enseñar en tiempos de pandemia: reflexiones para repensar la escuela en la era digital. *Revista Iberoamericana de Tecnología en Educación y Educación en Tecnología, 28*, pp. 303-309. http://sedici.unlp.edu.ar/handle/10915/117113

Mishra, P. & Warr, M. (2021). Contextualizing TPACK within systems and cultures of practice. *Computers in Human Behavior, 117*. https://doi.org/10.1016/j.chb.2020.106673

Moreno-Correa, S. (2020). La innovación educativa en los tiempos del coronavirus. *Salutem Scientia Spiritus, 6*(1), pp. 14-26.

https://revistas.javerianacali.edu.co/index.php/salutemscientiaspiritus/article/view/2290

Moreno-Guerrero, A. J.; Aznar-Díaz, I.; Cáceres-Reche, P. y Alonso- García, S. E. (2020). Learning in the Teaching of Mathematics: An Educational Experience in Adult High School. *Mathematics 2020, 8*(5), p. 840. https://doi.org/10.3390/math8050840

Murphy, M. (2020). Covid-19 and emergency eLearning: Consequences of the securitization of higher education for post-pandemic pedagogy. *Contemporary Security Policy, 41*(3), pp. 492-505. https://doi.org/10.1080/13523260.2020.1761749

Oliva, H. A. (2020). La educación en tiempos de pandemias: visión desde la gestión de la educación superior. *Researchgate.net, 3,* pp. 1-16. https://doi.org/10.13140/RG.2.2.27595.54568

Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura (Unesco). (2019). Marco de competencias de los docentes en materia de TIC. Unesco. https://unesdoc.unesco.org/ark:/48223/pf0000371024

Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura (Unesco). (01 de marzo 2021). Coalición Mundial para la Educación covid-19. https://es.unesco.org/covid19/globaleducationcoalition

Portillo, S.; Castellanos, L.; Reynoso, O. y Gavotto, O. (2020). Enseñanza remota de emergencia ante la pandemia covid-19 en educación media superior y educación superior. *Propósitos y Representaciones, 8*(3), pp. 1-17. http://revistas.usil.edu.pe/index.php/pyr/article/view/589

Rizales-Semprum, M. J.; Gómez-Valderrama, C. L. y Hernández-Suarez, C. A. (2019). Uso de herramientas tecnológicas para la enseñanza de las ciencias en educación media diversificada de acuerdo a la modalidad de estudio a distancia. *Eco Matemático, 10*(2), pp. 35-46. https://doi.org/10.22463/17948231.2591

Roa, J. C. (2020). La educación superior y el covid-19: experiencias desde mi perspectiva como docente. *Revista Multi-ensayos, 7*(13), pp. 26-32. https://www.camjol.info/index.php/multiensayos/article/view/10749/12501

Sánchez, C. (2020). Herramientas tecnológicas en la enseñanza de las matemáticas durante la pandemia covid-19. *Hamut´ay, 7*(2), pp. 46-57. http://dx.doi.org/10.21503/hamu.v7i2.2132

Sir John, D. (2020) Education and the Covid-19 pandemic. *Prospects, 49*(1), pp. 91-96. https://doi.org/10.1007/s11125-020-09464-3

Sorooshian, S. (2020). Quarantine decision due to coronavirus pandemic. *Electronic Journal of General Medicine,* *17*(4). https://doi.org/10.29333/ejgm/7862

Vera, J.; Torres, L. y Martínez, E. (2014). Evaluación de competencias básicas en TIC en docentes de educación superior en México. *Pixel- Bit. Revista de Medios y Educación,* *44*, pp. 143-155. http://www.redalyc.org/articulo.oa?id=36829340010

Yi, Y.; Lagniton, P.; Ye, S.; Li, E. & Xu, R. (2020). Covid-19: what has been learned and to be learned about the novel coronavirus disease. *International Journal of Biological Sciences,* *16*(10), pp. 1753-1766. https://doi.org/10.7150/ijbs.45134

■■ ■■

HOW TO CITE

Acuña Michel, Laura Lillian; Cuevas Salazar, Omar y Angulo Armenta, Joel. (2022). Disponibilidad y conocimientos tecnológicos de docentes universitarios de matemáticas en tiempos de la covid-19. *Apertura, 14*(1), pp. 52-65. http://dx.doi.org/10.32870/Ap.v14n1.2136

■■ ■■