Revista Iberoamericana para la Investigación y el Desarrollo Educativo
ISSN 2007 - 7467

https://doi.org/10.23913/ride.v13i26.1512

Artículos científicos

El uso de las Tic en las matemáticas. Una revisión sistemática de la literatura

The use of ICT in mathematics. A systematic review of the literature

O uso das TIC na matemática. Uma revisão sistemática da literatura

Jenny Isabel Calero-Cerna
Universidad César Vallejo, Perú
jennyca_1@hotmail.com; jcaleroc@ucvvirtual.edu.pe
http://orcid.org/0000-0001-7766-4073

Rossana Teresa Veramendi-Vernazza
Universidad César Vallejo, Perú
rveraver@gmail.com; rveramendi@ucvvirtual.edu.pe
https://orcid.org/0000-0002-2935-6380

Resumen

En el sector educativo, es importante mantenerse actualizado en los avances de las tecnologías de la información y comunicación (TIC). Asimismo, en las matemáticas, es muy necesario adaptarse a los cambios y normalizar el uso de las herramientas digitales, las cuales conllevan al desarrollo de clases interactivas y favorecen la enseñanza-aprendizaje. Sin embargo, hay que reconocer que aún existen barreras que impiden la anhelada normalización del uso de las TIC, como la resistencia de los docentes a innovar. Por tal motivo, el objetivo de este trabajo es presentar una revisión sistemática de la literatura sobre aspectos importantes, las barreras y los efectos que hay que considerar para que la enseñanza-aprendizaje de las matemáticas, por medio de las TIC, entre docentes y alumnado, sea un éxito. La búsqueda se realizó en Scopus, Scielo, DOAJ, Redalyc, EBSCOHost, Academic OneFile y ProQuest, desde el año 2020 hasta diciembre de 2022. Se consideró importante incluir un estudio realizado en 2016. Mediante la búsqueda de palabras clave, se localizaron 1661 artículos y como resultado de la revisión sistemática se analizaron 48 estudios,

identificándose 13 aspectos a tener en cuenta al usar intencionalmente las TIC y 13 efectos positivos que deben conllevar a generar un cambio en el aprendizaje de las matemáticas. También se reconocieron 16 barreras en su uso. Asimismo, se encontró que debido a diversos aspectos en las clases de matemática, las TIC todavía siguen siendo usadas como herramientas tecnológicas auxiliares bajo un enfoque tradicional.

Palabras clave: clases interactivas, enseñanza aprendizaje, herramientas digitales, TIC.

Abstract

In the education sector it is important to keep up to date with advances in information and communication technology (ICT), likewise, in mathematics it is very necessary to adapt to changes and normalize the use of digital tools, which lead to the development of interactive classes and favor teaching learning. But it must be recognized that there are still aspects that prevent the desired normalization of the use of ICT. For this reason, the objective of this work is to present a systematic review of the literature on important aspects that must be considered so that the teaching-learning of mathematics through ICT between teachers and students is successful. The search was carried out in Scopus, Scielo, DOAJ, Redalyc, EBSCOHost, Academic OneFile and ProQuest, from the year 2020 to December 2022, it was considered important to include a study carried out in 2016. Through the keyword search, 1661 articles were located and as a result of the systematic review, 48 studies were analyzed, identifying 13 aspects to take into account when intentionally using ICT and 13 positive effects that should lead to generating a change in the learning of mathematics; also recognizing 16 barriers in its use. Likewise, it was found that, due to various aspects in mathematics classes, ICTs are still being used as auxiliary technological tools under a traditional approach.

Keywords: interactive classes, teaching-learning, digital tools, ICT.

Revista Iberoamericana para la Investigación y el Desarrollo Educativo
ISSN 2007 - 7467

Resumo

No setor da educação, é importante manter-se atualizado com os avanços das tecnologias de informação e comunicação (TIC). Da mesma forma, em matemática, é muito necessário se adaptar às mudanças e normalizar o uso de ferramentas digitais, que levam ao desenvolvimento de aulas interativas e favorecem o ensino-aprendizagem. No entanto, é preciso reconhecer que ainda existem barreiras que impedem a desejada normalização do uso das TIC, como a resistência dos professores em inovar. Por esse motivo, o objetivo deste trabalho é apresentar uma revisão sistemática da literatura sobre aspectos importantes, barreiras e efeitos que devem ser considerados para que o ensino-aprendizagem da matemática, por meio das TIC, entre professores e alunos, seja um sucesso. A busca foi realizada na Scopus, Scielo, DOAJ, Redalyc, EBSCOHost, Academic OneFile e ProQuest, no período de 2020 a dezembro de 2022. Considerou-se importante incluir um estudo realizado em 2016. Por meio da busca por palavra-chave, foram 1661 artigos localizados e como resultado da revisão sistemática, foram analisados 48 estudos, identificando 13 aspectos a serem considerados ao usar as TIC intencionalmente e 13 efeitos positivos que devem levar a gerar uma mudança na aprendizagem da matemática. 16 barreiras também foram reconhecidas em seu uso. Da mesma forma, constatou-se que devido a vários aspectos nas aulas de matemática, as TICs ainda estão sendo utilizadas como ferramentas tecnológicas auxiliares sob uma abordagem tradicional.

Palavras-chave: aulas interativas, ensino-aprendizagem, ferramentas digitais, TIC.

Fecha Recepción: Enero 2023 **Fecha Aceptación:** Junio 2023

Introduction

Today, teachers show a marked weakness in the proper use of ICT during learning. Undoubtedly, we are in a time of change and innovation, and the appropriate tools must be sought to respond to the complexity of the times. The pertinent use of mobile devices in the development of educational activities is notable (Palmero et al., 2021). In this way, students should be motivated to become actively involved in their learning and promote research in teachers to choose the virtual tools and strategies appropriately. These must respond to the prevailing need for the digitization of society and the context of the students.

Currently, students are digital natives and it is vital that they use sophisticated Information and Communication Technologies (ICT) under a pedagogical and technical

expectation (Juanes et al., 2020). It is also necessary to do so from a collaborative, responsible, critical and ethical expectation (Chávez et al., 2020). Therefore, in education, the application of strategies for the design of materials and activities that lead to teaching and learning must be favored, under the demands of modernity.

In 2021, Dávila and Agüero specified that, during virtuality, mobile devices played a key role in learning and were well received as they were relatively within the reach of many families. Although in learning mathematics the opportunity to develop interactive classes was missed (Flores and Dullius, 2022). Moreover, in the midst of virtual teaching, the different technological tools have barely responded to the context of the students. Given this, Amaya-Conforme and Yáñez-Rodríguez (2021) stated that there is a lack of knowledge of its proper use in mathematics, a highly motivating source of the learning process being wasted.

It is evident that there is a high percentage of teachers who have not become familiar with ICT, which is why they have difficulties working in virtual environments (Morales-Zambranog et al., 2021). The reason why the new generation of teachers does not appropriate the ideal technological tools for teaching each educational subject is the low technological and pedagogical training of teacher educators (Arancibia et al., 2020). Hence, the teachings are taught in a traditional way, without responding to the demands of digital modernity.

Likewise, it is added that the scarcity of technological conditions and tools in universities and institutes prevents teachers and students from successfully deploying their digital skills (Varela-Ordorica and Valenzuela-González, 2020). Mathematics teacher educators give up using ICT in their classes due to insufficient training they have in handling specialized software for teaching mathematics, such as Geogebra, Desmos, Geo TIC, MathPapa, Cabri, MATLAB, Cyberchase 3D Builder, Fetch! Lunch Rush, among others (Padilla et al., 2022).

However, Padilla et al. (2022) recognized the need for teachers not only to master the various technological tools, but also to articulate them with methodological models specific to each area of study. For this reason, it is essential that they prepare for the efficient use of ICTs (Flores-Tena et al., 2021). That is, teachers and students need to equip themselves with technology, but always accompanied by adequate training.

In turn, in 2021, Gómez-Artela and Escobar-Mamani argued that in Peru the pandemic highlighted the enormous disparity cracks in the approach to virtual education, the same one that was marked by interruptions in virtual classes, especially in areas

geographically with difficult access and notable poverty. It is essential to use ICT to address certain social, generational, economic, gender and cultural aspects (Goin and Gibeli, 2020; Padilla-Carmona et al., 2022). It is highlighted that ICTs make it possible to enjoy learning and arouse greater motivation to learn, given the freedom to choose the space and moment for the study (Cabanillas et al., 2020; Martínez, 2020G). Hence, when considering the various aspects that optimize the relevant use of ICT, positive effects on learning will be obtained.

On the other hand, Da Silva-Bueno et al. (2021) revealed that the majority of teachers use ICTs only as digital resources to provide facilities in the presentation of content or to apply routine algorithms, without deploying skills with greater cognitive demand. At the same time, some teachers consider that ICTs distract students and lead to superficial learning, despite recognizing that they strengthen autonomy and active participation (Arancibia et al., 2020; Barrios et al., 2022; Casnati et al. al., 2020; Demartini and Lara, 2022; Fernández et al., 2020; Gazzola et al., 2020; Goin and Gibelli, 2020; Juanes et al., 2020; Robles-Francia et al., 2020; Sandoval et al. ., 2020; Umaña et al., 2020). They even recognize that it allows to have a general visualization of the process of building knowledge (Fernández et al., 2020; Guerrero et al., 2020).

Moreover, the incorporation of digital resources and new methodologies in the educational process has grown exponentially (Dávila and Agüero, 2021), making it evident that young teachers are better trained in ICT and use it in a broad sense (Gómez-García et al. al., 2020). Therefore, the need to propose new and varied learning activities to respond to the characteristics and needs of digital native students is shown. Since, with the novel digital resources, attention must be drawn to learning mathematics and break the appreciation that mathematics is difficult and boring.

The relevant use of digital resources motivates the learning of mathematics (Cencia et al., 2021; Varela-Ordorica and Valenzuela-González, 2020). A process that can be effective by allowing students to understand basic concepts (Da Silva-Bueno et al., 2021). Its use has become essential due to the context of virtuality that has occurred as a result of the pandemic. Given this, the question arises: What aspects should be considered so that the use of ICT in mathematical activities in teachers and students is a success?

It should be noted that, as the world and education have acquired the great challenge of using ICT, there is a need to work on mathematics under a modern, different and motivating teaching, without losing focus on what must be learned. Teachers must learn to develop their digital educational resources in line with the needs presented by students.

In short, it is essential to investigate to generate knowledge that supports the teacher in the achievement of students' mathematical skills through the use of ICT. Therefore, this review article compiles theoretical information in a detailed, selected, exhaustive and critical manner on aspects, barriers and effects to consider in the use of ICT in mathematical activities.

Method

When carrying out the respective systematic review of the study, the Kitchenham and Charters (2007) methodology was used as a guide, determined by three phases: Planning, Development and Results of the review.

Review planning: It is the first phase, where the research questions are asked and the inclusion and exclusion criteria are defined.

Development of the review: In this second phase, the search for information begins with the search protocol.

Results of the review: It is the last phase, where the results of the search are presented.

Additionally, a section was developed where the analysis of the results was carried out, where the questions raised in the planning phase were answered.

Review planning

To provide an answer to the general question of the study, the following three questions were formulated:

Q1. What aspects are considered when using ICT in mathematical activities?

Q2. What barriers exist in the use of ICT in mathematical activities?

Q3. What is the effect of the use of ICT in mathematical activities?

Taking into account the taxonomies that were obtained from the questions raised above, the literature scan was carried out exhaustively in seven databases. These are detailed below: Scopus, DOAJ, Scielo, Redalyc, EBSCOHost, Academic OneFile and ProQuest.

Different types of searches were carried out in order to respond to the objective of the study. It is noted that the keywords that were defined in the search were "use of ICT", "students", "teachers", "education", "use of ICT in education", "aspects of using ICT in mathematics" , as well as "use and effects of ICT in mathematics". The exploration chain described in Table 1 was used in the titles, abstracts and keywords.

Table 1. Search string according to database

Database	Search result	Search string
Scopus	1	(KEY (use AND of AND ICTs) AND KEY (students)) AND (LIMIT-TO (PUBYEAR , 2020))
	1	Use of ICT in mathematics (TITLE (I use AND due AND the AND ICT) AND TITLE (mathematical AND and AND ICT)) (TITLE(I use AND of AND the AND ICT) AND TITLE (mathematics AND and AND ICT))
	3	Use of ICT AND teachers (TITLE (use AND of AND ICTs) AND TITLE (teachers)) AND (LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020))
	6	Use of ICT AND education (TITLE (use Y of Y ICT) AND TITLE (education)) AND (LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020)) AND (EXCLUDES (EXACTSRCTITLE , "University Education")))
DOAJ	1	Use of ICT in education
	1	Teacher Perceptions on the Effects of the use of ICT
Scielo	15	Use of ICT in education
	5	ICT and mathematics
Redalyc	1	Use of ICT in education
	4	Effects of ICT in mathematics
EBSCOHost	3	Factors when using ICT AND mathematics (KEY(USE OF ICT) AND KEY(students)) AND (LIMIT-TO (PUBYEAR,2020))
	1	Use of ICT AND mathematics (KEY(USE OF ICT) AND KEY(MATH)) AND (LIMIT-TO (PUBYEAR,2021))
Academic OneFile	1	Use of ICT in mathematics
ProQuest	5	Use of ICT in mathematics

Source: self made

The reviewed studies correspond to articles from journals indexed to different databases, written in Spanish, Portuguese and English, corresponding to the years 2020 and 2022, with the exception of the Academic OneFile database, a study from the year 2016 was considered because it emphasizes aspects essential to consider during the use of ICT in mathematics classes. Table 2 shows the inclusion and exclusion criteria.

Table 2. Inclusion and exclusion criteria of the studies selected by each database

Database	Inclusion criterio	Exclusion criteria
Scopus	Year: 2020 and 2022 Type of documents: Articles	By reading, university education studies that did not respond to the taxonomies under study and therefore to the proposed objective were excluded.
DOAJ	Year: 2020 and 2022 Subject: education Publication type: magazine Name of the journal: Ecomatemática.	Not applied
Scielo	Año 2020 y 2022 Tipo de documentos: Artículos Áreas temáticas de educación.	Not applied
Redalyc	Year 2020 and 2022 Type of documents: Articles Thematic areas of education.	By reading the abstracts, introduction and conclusions, those that did not respond to the taxonomies studied were excluded.
EBSCOHost	Year: 2020-2022 Publication type: magazines Spanish Language Type of magazines: Mathematics	By reading the abstracts and introduction, of the 6 articles that were selected from the years 2021-2022, only 3 were selected because they led to achieving the objective of the study.
Academic OneFile	Year: 2016, a study, for belonging to a Latin American journal on mathematical matters and that detailed one of the taxonomies. Type of documents: articles Type of journals: Latin American research in educational mathematics.	Not applied
ProQuest	Type of documents: scientific journals, articles evaluated by experts. Subject: Mathematics	Not applied

Source: self made

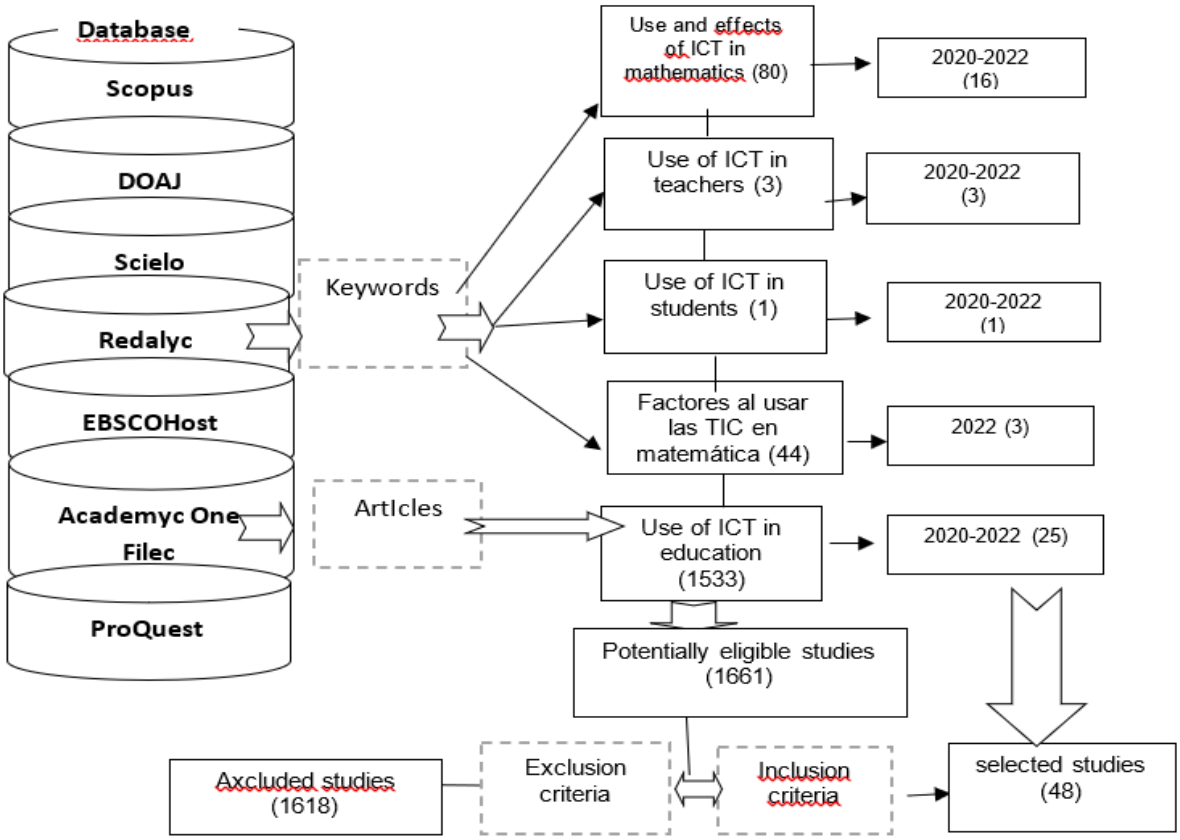
Development

Based on the proposed strategy, the results obtained from the search were subjected to a rigorous selection process, according to the established inclusion and exclusion criteria. The relevance of the literature found was taken into account to define if it responded to the questions raised, to the current times of the rise of virtual classes and to the educational sector. Figure 1 details the process followed and the results obtained. Priority was given to topics related to mathematics, reading the titles of potentially eligible articles and, finally, making a manual selection based on reading the abstracts, introduction and conclusions, according

to the established taxonomy. Those that did not align with the objective of the study and those that were repeated in different databases were excluded, considering them only once.

A total of 1661 potentially eligible articles were identified. 48 were selected that met the search criteria and responded to the objective of the study, as can be seen in Table 3.

Figure 1. Literature exploration process



Source: self made

Table 3. Potentially eligible studies and selected studies

Database	Potentially eligible studies	Selected studies
Scopus	29	11
DOAJ	70	2
Scielo	44	20
Redalyc	1446	5
EBSCOHost	44	4
Academic OneFile	6	1
Pro Quest	21	5
Total	1661	48

Source: self made

Review results

Regarding the results phase of the review, as a result of the process followed and taking into account the inclusion criteria for the selection of research, it was possible to collect 48 studies. Table 4 shows the chronological evolution of the articles reviewed, with the year 2020 showing the highest percentage of publications. This year was decisive due to the prevalence of the use of ICT in education as a consequence of the pandemic and confinement worldwide. Of the 48 selected articles, 48% correspond to the year 2020, with the Scielo database being the one with the largest number of publications.

Table 4. Evolution of the studies required in the selection

Studies by database	2016	2020	2021	2022	Total
Scopus	0	8	3	0	11
DOAJ	0	1	1	0	2
Scielo	0	14	1	5	20
Redalyc	0	2	3	0	5
EBSCOHost	0	0	4	0	4
Academic OneFile	1	0	1	0	1
Pro Quest	0	1	3	1	5
Total	1	26	16	6	48

Source: self made

The previously selected articles were analyzed taking into account the taxonomy, hereinafter referred to as "Classification". This classification consists of three categories: ASPECTS (P1), BARRIERS (P2) and EFFECTS (P3), which are related to each of the research questions initially posed. Table 5 shows the number of articles selected for each category, and Table 6 details the sources according to the database to which they belong.

Table 5. Classification by year of the studies in the systematic review of the literature

Question	Classification	Sources	Amount	Total
P1	Aspects	(Steegman *et al*., 2016)	1	28
		(Díaz, *et al*., 2020; Robles-Francia *et al*., 2020; Dillon *et al*., 2020; Montenegro *et al*., 2020; Umaña, *et al*., 2020; Sandoval *et al*., 2020; Fonseca, 2020; Fernández *et al*., 2020; Goin y Gibelli, 2020; Echeverría y Alanoca, 2020; Ulco y Baldeón, 2020; Varela-Ordorica y Valenzuela-González, 2020; Luzardo *et al*., 2020; Echeverría y Alanoca, 2020; Barahona *et al*., 2020; Castellano, 2020; Díaz-García *et al*., 2020)	17	
		(Cencia *et al*., 2021; Da Silva-Bueno *et al*., 2021; González, 2021; Flores-Tena *et al*., 2021; Cebrián-Cifuentes *et al*., 2021; Torrado, 2021; Halpern *et al*., 2021; Ariza *et al*., 2021; Rigo y Rovere, 2021)	9	
		(Padilla-Carmona *et al*., 2022)	1	
P2	Barriers	(Arancibia *et al*., 2020; Robles-Francia *et al*., 2020; Casnati *et al*., 2020; Díaz-García *et al*., 2020; Fernández *et al*., 2020; Gazzola *et al*., 2020; Goin y Gibelli, 2020; Varela-Ordorica *et al*., 2020; George, 2020)	8	14
		(Cebrián-Cifuentes *et al*., 2021; Ye *et al*., 2021)	2	
		(Flores y Dullius, 2022; Dewa y Ndlovu, 2022; Padilla *et al*., 2022; Ruiz-Aquino *et al*. 2022)	4	
P3	Effects	(Aguilar *et al*., 2020; Arango *et al*., 2020; Cabanillas *et al*., 2020; Gutiérrez *et al*.,2020; Sandoval *et al*., 2020; Umaña, *et al*., 2020; Guerrero *et al*., 2020; Ulco y Baldeón, 2020; Varela-Ordorica y Valenzuela-González, 2020)	9	16
		(Cencia *et al*., 2021; Rigo y Rovere, 2021; González, 2021; Ye *et al*., 2021; Yangali *et al*., 2021; Coutinho *et al*., 2021)	6	
		(Barrios *et al*., 2022)	1	

Source: self made

Table 6. Studies based on the systematic review of the literature on obtaining requirements by classification and databases

Classification	Aspects	Barriers	Effects
Scopus	(Díaz *et al*., 2020; Robles-Francia *et al*., 2020; Dillon *et al*., 2020; Barahona *et al*., 2020; Díaz-García *et al*., 2020; Da Silva-Bueno *et al*., 2021)	(Arancibia *et al*., 2020; Robles-Francia *et al*., 2020; Díaz-García *et al*., 2020; Ruiz-Aquino *et al*., 2022)	(Arango *et al*., 2020; Aguilar *et al*., 2020)
DOAJ	(Montenegro *et al*., 2020; Rigo y Rovere, 2021)		(Rigo y Rovere, 2021)
Scielo	Umaña, *et al*., 2020; Sandoval *et al*., 2020; Fonseca, 2020; Fernández *et al*., 2020; Goin y Gibelli, 2020; Echeverría y Alanoca, 2020; Ulco y Baldeón, 2020; Varela-Ordorica y Valenzuela-González, 2020; Luzardo *et al*., 2020; Echeverría y Alanoca, 2020; Castellano, 2020)	(Casnati *et al*., 2020; Fernández *et al*., 2020; Gazzola *et al*., 2020; Goin y Gibelli, 2020; Varela-Ordorica y Valenzuela-González, 2020; Flores y Dullius, 2022; Dewa y Ndlovu, 2022; Padilla *et al*., 2022)	(Umaña, *et al*., 2020; Guerrero *et al*., 2020; Ulco y Baldeón, 2020; Varela-Ordorica y Valenzuela-González, 2020; Sandoval *et al*., 2020; Barrios *et al*., 2022)
Redalyc	(Cencia *et al*., 2021; González, 2021; Flores-Tena *et al*., 2021)	(George, 2020)	(Gutiérrez *et al*., 2020; Cencia *et al*., 2021; González, 2021).
EBSCOHost	(Cebrián-Cifuentes *et al*., 2021; Torrado, 2021; Halpern *et al*., 2021)	(Cebrián-Cifuentes *et al*., 2021; Ye *et al*., 2021)	(Ye *et al*., 2021)
Academic OneFile	(Steegman *et al*., 2016)		
Pro Quest	(Ariza *et al*., 2021; Demartini y Lara, 2022)		(Cabanillas *et al*., 2020; Yangali *et al*., 2021; Coutinho *et al*., 2021)
Total	28	15	16

Source: self made

Analysis

Next, we proceed to answer the questions that have been raised in the planning phase of the review.

Q1. What aspects should be considered when using ICT in mathematical activities?

Aspects to take into account when using ICT, with a view to strengthening teacher-student interaction and the student-knowledge link, which allow technology to accompany

the teaching-learning process, where teachers and students have an optimal approach to use. of ICT in various mathematical activities. Table 7 presents 13 aspects:

Table 7. Aspects that should be considered when using ICT in mathematical activities

Id	Aspects	Description	Sources
A1	Social relationships	The way teachers and students live their lives plays a substantial role when using ICT in learning.	(Goin y Gibelli, 2020; Dillon *et al*., 2020; Luzardo *et al*., 2020; Echeverría y Alanoca, 2020; Cebrián-Cifuentes *et al*., 2021)
A2	Generational	Predominantly young university students do not use technology to promote interaction spaces that lead them to learn for their professional development.	(Goin y Gibelli, 2020)
A3	Economic	The lack of economy prevents institutions from being equipped with the appropriate technology to respond to changes in education.	(Goin y Gibelli, 2020; Montenegro *et al*., 2020; Castellano, 2020; Torrado, 2021)
A4	Of genre	Women are the ones who demonstrate the best performance in the use of ICT while learning mathematics.	(Goin y Gibelli, 2020; Luzardo *et al*., 2020; Sandoval *et al*., 2020; Aguilar *et al*., 2020; Barahona *et al*., 2020; Padilla-Carmona *et al*., 2022)
A5	Cultural	Cultural elements influence whether or not the teacher incorporates ICT in teaching. Which have to change so that more teachers understand that their proper use allows them to achieve outstanding learning achievements.	(Goin y Gibelli, 2020; Varela-Ordorica y Valenzuela-González, 2020; Castellano, 2020; Torrado, 2021; Padilla-Carmona *et al*., 2022)
A6	Personal	The use of ICTs differs minimally with respect to gender. Likewise, by increasing their use at school and at home, it allows you to gain confidence to use them in learning.	(Díaz-García *et al*., 2020; Cifuentes *et al*., 2021; Cebrián-Cifuentes *et al*., 2021)
A7	Contextual	They are decisive when the teacher makes the decision to incorporate ICT in teaching.	(Varela-Ordorica y Valenzuela-González, 2020; Umaña, *et al*., 2020; Fonseca, 2020; Luzardo *et al*., 2020; Cebrián-Cifuentes *et al*., 2021; Ariza *et al*., 2021; Halpern *et al*., 2021; Cifuentes *et al*., 2021; Rigo y Rovere, 2021)
A8	The beliefs	They determine that future	(Varela-Ordorica y Valenzuela-

		teachers provide the various uses of ICT in the classroom.	González, 2020)
A9	The actitudes	If university teachers have a positive attitude towards the use of ICT, they will use virtual environments during the development of classes.	(Varela-Ordorica y Valenzuela-González, 2020; Sandoval *et al*., 2020; Luzardo *et al*., 2020; Aguilar *et al*., 2020; Ariza *et al*., 2021; Ruiz-Aquino *et al*., 2022; Padilla-Carmona *et al*., 2022)
A10	Teacher knowledge and skill levels	As for the mastery of ICT, the teacher can be located between the levels: basic, intermediate or expert.	(Varela-Ordorica y Valenzuela-González, 2020; Fonseca, 2020; Ulco y Baldeón, 2020; Da Silva-Bueno *et al*., 2021)
A11	Time	It constitutes a limitation to collegially include the use of technological tools in learning activities.	(Fernández *et al*., 2020; Echeverría y Alanoca, 2020; Da Silva-Bueno *et al*., 2021)
A12	Student characteristics	Within them, motivation, interest, age and willingness to organize and learn through the use of ICT predominate.	(Montenegro *et al*., 2020; Umaña *et al*., 2020; Halpern *et al*., 2021)
A13	Age	It is not an obstacle to integrate ICT during learning. You must choose the relevant digital tools and the way of employment.	(Luzardo *et al*., 2020; Sandoval *et al*., 2020; Echeverría y Alanoca, 2020; Aguilar *et al*., 2020; Torrado, 2021)

Source: self made

A simple but significant example that compares the use of geogebra and youtube in university students was presented by Goin and Gibelli (2020), showing that university students did not know the use of academic software, but did have a high degree of knowledge of the technological entertainment tools, despite the fact that Geogebra is a great tool in learning mathematics. Noting that ICTs are rarely used in educational activities.

Based on the systematic review of the literature of the studies that have been rigorously selected, it has been determined that if all these aspects are taken into account when planning mathematical activities with the support of ICT, it will be possible to strengthen the interactions that favor the performance of the students.

P2. What barriers exist in the use of ICT in mathematical activities?

For this research, barriers are those obstacles that limit the use of ICT in learning activities for both teachers and students. Table 8 shows the 16 barriers studied by different researchers.

Table 8. Barriers in the use of ICT in mathematical activities

Id	Barreras	Descriptión	Fuentes
B1	Barriers	The conceptions that the teacher has about teaching are decisive for the use of ICT.	(Arancibia *et al*., 2020)
B2	Persistence in outdated methodologies	Teachers continue to use traditional methodologies, without prioritizing the use of ICT.	(Arancibia *et al*., 2020; Varela-Ordorica y Valenzuela-González, 2020; Flores y Dullius, 2022)
B3	Low technological and pedagogical training	Teachers who are not trained in the management of technological tools and less in their adequacy in the teaching of mathematics, cannot successfully face the challenges of modernity.	(Arancibia *et al*., 2020; Robles-Francia *et al*., 2020; Varela-Ordorica y Valenzuela-González, 2020; Díaz-García *et al*., 2020; Ruiz-Aquino *et al*., 2022)
B4	Resistance to change	Teachers have difficulty adopting modern teaching technologies and choose to continue applying traditional methodologies or use ICT as auxiliary tools.	(Arancibia *et al*., 2020; Padilla *et al*., 2022)
B5	Negative attitudes towards pedagogical innovations	Teachers, not being properly trained to use ICT, consider them irrelevant to be applied during the development of classes.	(Arancibia *et al*., 2020)
B6	Lack of perception of the importance of innovating	The dominant traditional culture attributes little significance to the use of technological tools during teaching.	(Arancibia *et al*., 2020; Flores y Dullius, 2022)
B7	Lack of use and appropriation of ICT	The bulk of teachers is not sufficiently prepared to use ICT, starting from the immediate context to generate significant learning.	(Casnati *et al*., 2020; Dewa y Ndlovu, 2022)
B8	Logistics	University teachers, seeing themselves in the need to use ICT, found themselves with a multiplicity of logistical obstacles that have not optimized the use of different technological resources.	(Ruiz-Aquino *et al*. 2022)
B9	Technological	Equipping schools with technology without defining usage strategies does not improve learning outcomes.	(Robles-Francia *et al*., 2020; Díaz-García *et al*., 2020)
B10	Economic	Most educational institutions do not have financing to equip themselves with technologies. In addition to the fact that the students did not have a Wi-Fi network at home or did not have mobile phones, which forced them on many occasions to borrow from their relatives to carry out activities.	(Robles-Francia *et al*., 2020; Cebrián-Cifuentes *et al*., 2021)

B11	Institutional	Managers who do not bet on the use of technology in classes and hinder its use.	(Gazzola *et al*., 2020; Varela-Ordorica y Valenzuela-González, 2020)
B12	Technological infrastructure	The lack of implementation with infrastructure prevents teachers and students from increasing their digital skills.	(Gazzola *et al*., 2020; Varela-Ordorica y Valenzuela-González, 2020)
B13	Access, use and generation gap	Students use mobile devices for entertainment and very little as a tool for learning, a situation that is slowly improving.	(Goin y Gibelli, 2020; Flores y Dullius, 2022)
B14	Epistemological	The presence of mistaken mathematical ideas hinder the empowerment of a modern knowledge with the use of ICT.	(George, 2020)
B15	Cognitive	The mathematical ideas conceived at a certain moment allow the successful development of certain problems, the same ones that are inadequate when facing other situations, using ICT.	(George, 2020)
B16	Didactic	Due to the inadequate didactic management of technological tools, students feel bored and reject mathematics.	(George, 2020)

Source: self made

Q3. What is the effect of the use of ICT in mathematical activities?

In the study, effect is understood as those positive consequences of the appropriate use of ICT in mathematical activities. Table 9 shows 13 impacts found, studied by different researchers.

Table 9. Effects on the use of ICT in mathematical activities

Id	Effects	Description	Fuentes
E1	Multimodal learning	ICTs allow teaching to be carried out in different ways, responding to different learning styles.	(Cencia *et al*., 2021)
E2	Academic management at the service of the student	By becoming a process that enriches autonomous learning.	(Cencia *et al*., 2021)
E3	Collaborative online learning	Promotes interaction and commitment within the team, building knowledge in reciprocity.	(Aguilar *et al*., 2020; Cencia *et al*., 2021)
E4	Development of cognitive and metacognitive skills	With the tutorial intervention of the teacher, it is possible to understand and authentically filter the information to later use it in daily life.	(Cencia *et al*., 2021)
E5	A procedural and permanent evaluation system	Being continuous and systematic allows making timely decisions to improve results.	(Cencia *et al*., 2021)
E6	More interactive and participatory learning	Being dynamic, it motivates the student to stay active and deepen their learning	(Varela-Ordorica y Valenzuela-González, 2020; Cencia *et al*., 2021; Demartini y Lara, 2022; Barrios *et al*., 2022)
E7	Development of student autonomy	ICT with its range of innovative tools have favored independence to learn, especially in young students.	(Cencia *et al*., 2021)
E8	Asynchronous feedback to make better use of time	It does not require the student to be online and is done at any time through different forms such as written messages, voice, videos, etc., which can be accompanied by other resources, allowing the teacher and student to have their time according to your needs.	(Cencia *et al*., 2021)
E9	Interaction from the ubiquity	That favors collaborative work because from any place and time students can connect to develop various activities.	(Rigo y Rovere, 2021; Cencia *et al*., 2021; Padilla-Carmona *et al*., 2022)
E10	Implementation of methodological strategies based on the flipped classroom.	With the support of ICT and the teacher, students can access to review study at home Main actor in their learning.	(Cencia *et al*., 2021)
E11	expanded education	The towering social technologies have become the educational potential and provide opportunities to learn inside and outside the classroom.	(Rigo y Rovere, 2021)

E12	Strengthening relevance, warmth and educational quality.	It makes it possible to achieve constant improvement in education.	(Guerrero *et al*., 2020)
E13	Breaking barriers of space, time, physical and cultural distances	ICT allows to be connected online from anywhere and at any time, favoring the organization of learning according to the needs of each student.	(González, 2021)

Source: self made

Discussion

Considering the importance of the study of the use of ICT to make improvements in the learning of mathematics, the need to investigate more on the subject is highlighted due to the limited existing research, specifically in Latin America. It is essential that, from basic training, students use and manage ICT to acquire didactic strategies that facilitate their active participation during learning (Goin and Gibelli, 2020). In this way, the friendly link between teacher, student and knowledge is fostered.

In this sense, it is evident that there are aspects such as social, generational, economic, gender, cultural, personal, contextual relations, beliefs, attitudes, levels of knowledge and teacher skills, time, student characteristics and the age to which attention must be paid to strengthen teacher-student interaction (Díaz-García et al., 2020; Fernández et al., 2020; Goin and Gibelli, 2020; Luzardo et al., 2020; Montenegro et al. , 2020; Varela-Ordorica and Valenzuela-González, 2020).

It should be recognized that, currently, it is a strength that mobile devices used in daily life are used as a fundamental tool for students' virtual learning (Dávila and Agüero, 2021). From a constructivist perspective (Flores and Dullius, 2022; Zárate et al., 2020), it is considered that the inclusion of ICT in the learning of mathematics is significantly outstanding if it is used properly, under a general and complex vision, prioritizing that the student builds his own learning in light of a diversified curriculum.

For their part, Arancibia et al. (2020) studied in detail the barriers that arise when using ICT in mathematical activities, pointing out that these are: the teacher's beliefs, persistence in obsolete methodologies, low technological and pedagogical training, resistance to change, attitudes negative towards pedagogical innovations and the lack of perception towards innovation. In addition, Dewa and Ndlovu (2022) consider the lack of appropriation of ICTs. Ruiz-Aquino et al. (2022) identify the access gaps and, finally, George (2020) points out the

epistemological, cognitive and didactic barriers, which must be addressed to respond to the new ways of learning of digital native students.

Thus, the contribution of Arancibia et al. (2020), because they specified that there is an urgent need to minimize the barriers to the use of ICT in pedagogical practice. It is not just about providing schools with technological resources and training teachers, but it is essential to banish teachers' beliefs, fears and resistance to change.

Likewise, Gómez-García et al. (2020) specified that teachers present a weak use of ICT when using them in the classroom. In fact, Amaya-Conforme and Yánez-Rodríguez (2021) concluded that the number of students who are able to apply digital tools to solve mathematical problems is minimal. Therefore, the challenge of intelligently innovating the way of teaching and learning mathematics must be faced in such a way that it can be adapted. There is also a lack of attention in terms of technology and training for students and teachers (Dewa and Ndlovu, 2022), which has caused a notable lack of motivation on the part of teachers.

Finally, Cencia et al. (2021), González (2021), Guerrero et al. (2020) and Rigo and Rovere (2021) considered as effects of the use of ICT: multimodal learning, academic management at the service of the student, collaborative online learning, optimal development of cognitive and metacognitive skills, an evaluation system processual and permanent, more interactive and participatory learning, the development of student autonomy, asynchronous feedback to make better use of time, interaction from ubiquity, the implementation of methodological strategies based on the flipped classroom, expanded education, the strengthening of relevance, warmth and educational quality; as well as the breaking of barriers of space, time, physical and cultural distances.

Conclusions

When teaching mathematics, it is necessary that the use of ICTs promote collaborative, significant and innovative learning, which leads to stimulate the creation of a new teaching role to train research and autonomous students who respond efficiently and effectively to the changes brought by the modernity. In mathematics, there is the Geogebra tool, which allows studying geometry through augmented reality, making it more interesting, active, pleasant and dynamic, because it associates the theoretical with the practical. Therefore, it is necessary to enrich the teaching practice with the use of ICT to mediate the learning of mathematics, in such a way that they are not used improvisedly.

For this reason, attention must be paid not only to equipping schools with technologies and training teachers in their use, but there are aspects that cannot be seen with the naked eye but are important to consider, to give value and meaning to the use. of ICT. In such a way that barriers and resistance to its use in pedagogical practice are minimized. It is important to support teachers in their beliefs, fears and resistance, since they must be adapted to the changes that exist and will be in the future.

On the other hand, no evidence has been discovered of the measurement of the impact that the use of ICT has produced in the learning of mathematics, nor that the teacher himself has developed tools and digital educational material according to the contextualized activities and the needs. of each group of students. Therefore, digital culture must be integrated into the learning of mathematics with active methodologies, without neglecting the context of its students, in order to reinvent the teaching practice and, therefore, achieve a new pedagogical reality in favor of the students. who better understand abstract knowledge in a creative, attractive, didactic and practical way.

Contributions to future lines of research

The review of the literature has made it possible to identify the aspects to consider so that teachers take advantage of all that ICTs offer in the teaching of mathematics for the benefit of students. This information will serve as a baseline for future research to address this problem and propose a proposal that enriches the learning of mathematics with the use of ICT, providing the opportunity to select the technological tools that facilitate the production of digital and interactive material. in line with the focus of the area, the context, the economic reality of the families and the needs and interests of the students.

Finding abundant scientific evidence that supports the existence of material on the management of ICT in the teaching of mathematics at various levels, the study systematizes said research in such a way that future researchers have at hand the references that address the subject. At the same time, it provides insights to investigate in detail about the interactive digital tools that maximize the level of abstraction of mathematics, as well as those that affect the promotion of autonomy and are easy to monitor, mediate and provide feedback on learning.

References

Aguilar, A., Howlet, L., Diez, M. y Beltrán, J. (2020). La Educación superior durante la contingencia sanitaria COVID-19: Uso de las TIC como herramientas de aprendizaje. Caso de estudio: alumnos de la Facultad de Contaduría y Administración. *Revista Latina de Comunicación Social, 78*, 309-328. https://doi.org/10.4185/RLCS-2020-1479

Amaya-Conforme, D. R. y Yánez-Rodríguez, M. A. (2021). Las TIC en el aprendizaje de la matemática en bachillerato. *Polo del Conocimiento*, *6*(2), 583-594. https://doi.org/10.23857/pc.v6i2.2290

Arancibia, M., Cabero, J. y Marín, V. (2020). Creencias sobre la enseñanza y uso de las tecnologías de la información y la comunicación (TIC) en docentes de educación superior. *Formación universitaria*, *13*(3), 89-100. https://doi.org/10.4067/S0718-50062020000300089

Arango, D., Fernández, J., Rojas, Ó., Gutiérrez, C., Villa, C. y Grisales, M. (2020). Estilos de aprendizaje en docentes universitarios: Evaluación de la relación entre percepción y uso de TIC en entornos educativos. *Revista Ibérica De Sistemas e Tecnologias De Informação, E29*, 406-420.https://www.proquest.com/scholarly-journals/estilos-de-aprendizaje-en-docentes-universitarios/docview/2394537883/se-2

Ariza, J., Saldarriaga, J., Reinoso, K. y Tafur, C. (2021). Tecnologías de la información y la comunicación y desempeño académico en la educación media en colombia. *Lecturas De Economía*, *94*, 47-86. https://doi.org/10.17533/udea.le.n94a33869

Barahona, J., García, J. y Pañego, M. (2020). El conocimiento y la intencionalidad didáctica en el uso de TIC del profesorado de educación física. *Retos: nuevas tendencias en educación física, deporte y recreación, 38*, 497-504. https://doi.org/10.47197/retos.v38i38.74370

Barrios Soto, L. M., Maradey Coronell, J. A. y Delgado González, M. J. (2022). Realidad aumentada para el desarrollo del pensamiento geométrico variacional. *Revista Científica UISRAEL*, *9*(3), 11-28. https://doi.org/10.35290/rcui.v9n3.2022.599

Cabanillas, J., Veríssimo, S. y Luengo, R. (2020). Contraste en la percepción sobre el uso de una plataforma virtual para la mejora de la enseñanza y aprendizaje de las matemáticas. *Revista Ibérica de Sistemas e Tecnologias de Informação*, *38*, 33-47. https://doi.org/10.17013/risti.38.33-47

Casnati, A., Porta, M., Solana, V. y Marrero, C. (2020). Noreste Online: experiencia del CENUR Noreste en contingencia COVID-19. *Inter Cambios. Dilemas y transiciones de la Educación Superior*, *7*(2), 132-149. https://doi.org/10.2916/inter.7.2.13

Castellano, J. (2020). Equipamiento, uso y consumo de TIC en estudiantes de educación en la universidad nacional de Costa Rica. *Conrado*, *16*(72), 334-341. http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S1990-86442020000100334

Cebrián-Cifuentes, S., Almerich, G., Suárez-Rodríguez, J. y Pedró, F. (2021). Incidencia de factores personales y contextuales sobre el uso de los recursos tecnológicos por el alumnado en América Latina. *Archivos Analíticos de Políticas Educativas, 29*(6). https://doi.org/10.14507/epaa.29.5127

Cencia, O., Carreño, M., Querevalú, P., Barrantes, G. y Cárdenas, G. (2021). Estrategias docentes de profesores universitarios en tiempos de Covid-19. *Horizonte de la Ciencia*, *11*(21), 347-360. https://doi.org/10.26490/uncp.horizonteciencia.2021.21.916

Chávez, I., Flores, C., Ordóñez, A. y Sánchez, L. (2020). Nativos digitales: internet y su relación con la lectura en estudiantes universitarios. *Apertura (Guadalajara, Jal.)*, *12*(2), 94-107. https://doi.org/10.32870/Ap.v12n2.1876

Coutinho, W., de Almeida, V. y Jatobá, A. (2021). Aplicativos móveis: Uso e possibilidades para o ensino da matemática na EJA. *Educação Temática Digital, 23*(1), 20-43. https://doi.org/10.20396/etd.v23i1.8656231

Da Silva-Bueno, R., Ballejo, C. y Gea, M. (2021). Profesores que forman profesores y sus percepciones frente al uso de las TIC en las clases de matemáticas. *Revista Iberoamericana de Educación Superior, 12* (35), 169-183. https://doi.org/10.22201/iisue.20072872e.2021.35.1088

Dávila, R. y Agüero, E. (2021). Aprendizaje a distancia e integración tecnológica por la pandemia del Covid-19 en Perú. *Eduweb*, *15*(1), 98–111. https://doi.org/10.46502/issn.1856-7576/2021.15.01.9

Demartini, S. S. and Lara, I. C. M. D. (2022). Teaching mathematics in the pandemic reality: technological tools used in the final years of elementary school. In *SciELO Preprints*. https://doi.org/10.1590/SciELOPreprints.3633

Dewa, A. and Ndlovu, N. S. (2022). Use of information and communication technologies in mathematics education lecturers: Implications for preservice teachers. *Journal for Transdisciplinary Research in Southern Africa*, *18*(1), 1-8. https://doi.org/10.4102/td.v18i1.1165

Díaz-García, I., Almerich, G., Suárez-Rodríguez, J. y Orellana, N. (2020). La relación entre las competencias TIC, el uso de las TIC y los enfoques de aprendizaje en alumnado universitario de educación. *Revista de Investigación Educativa, 38*(2), 549-566. https://doi.org/10.6018/rie.409371

Díaz, V., Vagena, E. y García, S. (2020). Visiones del uso de las TIC para la educación inclusiva desde la perspectiva docente: el caso de Grecia. *Texto Livre: Linguagem e Tecnologia, 13*(3), 181-199. https://doi.org/10.35699/1983-3652.2020.25117

Dillon, F., Freire, I., Rojas, D. y Espinosa, D. (2020). Educación y TIC: El uso de la teoría de redes en el análisis de relaciones sociales y académicas en contextos educativos. *Revista Ibérica De Sistemas e Tecnologias De Informação*, E32, 88-97. https://www.proquest.com/scholarly-journals/educación-y-TIC-el-uso-de-la-teoría-redes-en/docview/2452331638/se-2

Echeverría, S., Alanoca, M. (2020). ICT Mediations: The Family, Money and Gender Inequality. Stories of university students of migrant families. *Educación Superior*, *7*(1), 63-78. http://www.scielo.org.bo/scielo.php?script=sci_arttext&pid=s2518-82832020000100008&lng=es&tlng=es.

Fernández, C., Fuentes, K. y Salcedo, P. (2020). Implementación de Modelo pedagógico para integrar TIC en el tercer nivel de Educación Parvularia. *Revista Iberoamericana de Tecnología en Educación y Educación en Tecnología*, (25), 39-49. https://doi.org/ 10.24215/18509959.25.e04

Flores, S. and Dullius, M. (2022). Mentoring in the professional development of teachers related to the planning of their classes, integrating technologies. In *SciELO Preprints*. https://doi.org/10.1590/SciELOPreprints.3942

Flores-Tena, M. y Ortega-Navas, M. D. C. y Sousa-Reis, C. (2021). El uso de las TIC digitales por parte del docente personal y su adecuación a los modelos vigentes. *Revista Electrónica Educare, 25* (1), 1-21. https://doi.org/10.15359/ree.25-1.16

Fonseca, G. (2020). As TIC na formação inicial de professores – Representações de práticas de formação de formadores. *Da Investigação às Práticas, 10*(2), 4 – 25. https://doi.org/10.25757/invep.v10i2.199

Gazzola, M., Otero, M. y Llanos, V. (2020). Uso de TIC en el contexto de una enseñanza basada en la investigación. *Revista Iberoamericana de Tecnología en Educación y Educación en Tecnología*, *25*, 31-38. https://doi.org/10.24215/18509959.25.e03

George, C. (2020). Reducción de obstáculos de aprendizaje en matemáticas con el uso de las TIC IE. *Revista de Investigación Educativa de la REDIECH*, *11*, 1-16. https://doi.org/10.33010/ie_rie_rediech.v11i0.697

Goin, M. y Gibelli, T. (2020). La relación de los ingresantes de ciencias aplicadas con el saber tecnológico. *Revista Iberoamericana de Tecnología en Educación y Educación en Tecnología*, *25*, 50-56. https://doi.org/10.24215/18509959.25.e05

Gómez-Artela, I. y Escobar-Mamani, F. (2021). Educación virtual en tiempos de pandemia: Incremento de la desigualdad social en el Perú. *Revista Chakiñan de Ciencias Sociales y Humanidades, 15*, 152-165. https://doi.org/10.37135/chk.002.15.10

Gómez-García, M., Hossein- Mohand, H., Trujillo- Torres, JM and Hossein-Mohand, H. (2020). The Training and Use of ICT in Teaching Perceptions of Melilla's (Spain) Mathematics Teachers. *Mathematics*, *8* (10), 1641. https://doi.org/10.3390/math8101641

González, I. (2021). Influencia de las TIC en el rendimiento escolar de estudiantes vulnerables. *RIED. Revista Iberoamericana de Educación a Distancia*, *24*(1), 351-365. https://doi.org/10.5944/ried.24.1.27960

Guerrero, J., Vite, H. y Feijoo, J. (2020). Uso de la tecnología de información y comunicación y las tecnologías de aprendizaje y conocimiento en tiempos de Covid-19 en la Educación Superior. *Conrado*, *16*(77), 338-345. http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S1990-86442020000600338

Gutiérrez, H., Aristizabal, Jorge. y Rincón, J. (2020). Procesos de visualización en la resolución de problemas de matemáticas en básica primaria apoyados en ambientes de aprendizaje mediados por las TIC. *Sophia, 16* (1), 120-132. https://doi.org/10.18634/sophiaj.16v.1i.975

Halpern, D., Piña, M. y Ortega-Gunckel, C. (2021). Mediación parental y escolar: uso de tecnologías para potenciar el rendimiento escolar. *Educación XX1, 24*(2), 257-282. https://doi.org/10.5944/ educXX1.28716

Juanes, B., Munévar, O. y Cándelo, H. (2020). La virtualidad en la educación. Aspectos claves para la continuidad de la enseñanza en tiempos de pandemia. *Revista Conrado*, *16*(76), 448-452. http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S1990-86442020000500448

Kitchenham, B. y Charters, S. (2007). Guidelines for performing Systematic Literature Reviews in Software Engineering, Technical Report EBSE 2007-001, Keele University and Durham University Joint Report.

Luzardo, M., Sandia, B. y Aguilar, A. (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), 1-21. http://scielo.sld.cu/scielo.php?pid=S0257-43142020000100003&script=sci_arttext&tlng=pt

Martínez, D. (2020). ¡Bendita Pandemia! Oportunidad de crecimiento y aprendizaje. *Educación Química*, *31*(5), 121-125. https://doi.org/10.22201/fq.18708404e.2020.5.77269

Montenegro, S., Raya, E. y Navaridas, F. (2020). Percepciones Docentes sobre los Efectos de la Brecha Digital en la Educación Básica durante el Covid -19. *Revista Internacional De Educación Para La Justicia Social*, *9*(3), 317–333. https://doi.org/10.15366/riejs2020.9.3.017

Morales-Zambranog, F. F., Pazmiño-Campuzano, M. F. y San Andrés-Laz, E. M. (2021). Competencias digitales de los docentes en la educación media del Ecuador. *Polo del conocimiento*, *6*(2), 185-203. https://doi.org/10.23857/pc.v6i2.2246

Padilla-Carmona, T., Gil Flores, J. and Rísquez, A. (2022). Self-efficacy in the use of ICT amongst mature students. Educación XX1, *25*(1), 19-40. https://doi.org/10.5944/educXX1.30254

Padilla Escorcia., I.A. Conde Carmona., R.J. y Tovar Ortega., T. (2022). Recursos tecnológicos utilizados por profesores universitarios de carreras de ingeniería, en tiempos de virtualidad en Barranquilla (Colombia). *Tecnura*, *26*(72), 147-166. https://doi.org/10.14483/22487638.18277

Palmero, J., Magaña, E., Rivas, E. y Valenzuela, T. (2021). Estudio del uso y consumo de dispositivos móviles en universitarios. *Digital Education Review*, *39*, 89-104. https://dialnet.unirioja.es/servlet/articulo?codigo=8090175

Rigo, D. y Rovere, R. (2021). El compromiso académico estudiantil presente en una educación expandida por el uso de las TIC. *Revista Andina De Educación*, *4*(2), 46-55. https://doi.org/10.32719/26312816.2021.4.2.6

Robles- Francia, V., Cruz-Caballero, A. y Terrones, A. (2020). El uso de las TIC y la lectura en la educación pública superior mexicana. *Investigación bibliotecológica*, *34*(83), 55-69. https://doi.org/10.22201/iibi.24488321xe.2020.83.58139

Ruiz- Aquino, M., Borneo-Cantalicio, E., Alania-Contreras, R., Garcia-Ponce, E. y Zevallos Acosta, U. (2022). Actitudes hacia las TIC y uso de los entornos virtuales en docentes universitarios en tiempos de pandemia de la COVID-19. *Publicaciones*, *52*(3), 111-137. https://doi.org/10.30827/publicaciones.v52i3.22270

Sandoval, F., Yévenes, J. y Badilla, M. (2020). ACT-ED: instrumento unifactorial para medir la actitud hacia el uso educativo de TIC en docentes chilenos de educación secundaria. *Revista de estudios y experiencias en educación*, *19*(41), 225-237. https://doi.org/10.21703/rexe.20201941sandoval12

Steegman, C., Perez-Bonilla, A., Prat, M. and Juan, A. (2016). Math-elearning@cat: key factors in the use of information technologies in secondary mathematical education/math-elearning@cat. *Revista Latinoamericana de Investigación en Matemática Educativa*, *19*(3), 287- 310. https://doi.org/ 10.12802/relime.13.1932

Torrado, M. (2021). TIC/TAC y Covid-19: uso y necesidades del profesorado de secundaria en Galicia. (Spanish). *Digital Education Review*, *39*, 356–373. https://doi.org/10.1344/der.2021.39.356-373

Ulco, L. y Baldeón, P. (2020). Las Tecnologías de la Información y Comunicación y su influencia en la lectoescritura. *Revista Conrado*, *16*(73), 426-433. http://scielo.sld.cu/scielo.php?pid=S1990-86442020000200426&script=sci_arttext&tlng=pt

Umaña, M., Miranda, E. y Osorio, F. (2020). Uso educativo de TIC en un salón Montessori: diálogo entre la tecnología digital y los ritos de interacción social en el aula. *Revista de estudios y experiencias en educación*, *19*(41), 29-42. https://doi.org/10.21703/rexe.20201941umana2

Varela- Ordorica, S. y Valenzuela-González, J. (2020). Uso de las tecnologías de la información y la comunicación como competencia transversal en la formación inicial de docentes. *Revista Electrónica Educare*, *24*(1), 172-191. https://doi.org/10.15359/ree.24-1.10

Yangali, S., Arboleda, J. y Arispe, C. (2021). Plataforma virtual para el aprendizaje de las matemáticas en Dosquebradas, Colombia. *Revista Ibérica de Sistemas e Tecnologias de Informação*, *E39*, 156-169. https://www.proquest.com/scholarly-journals/plataforma-

virtual-para-el-aprendizaje-de-las/docview/2483109352/se-2

Ye, L., Xia, X., Jiang, P., Jiang, T. y Liu, Y. (2021). Los efectos del uso de Internet por niños: Un estudio longitudinal en China. *Comunicar: Revista científica iberoamericana de comunicación y educación*, *68*, 97-105. https://doi.org/10.3916/C68-2021-08

Zárate, A., Gurieva, N. y Jiménez, V. (2020). La práctica holística de las competencias digitales docentes: Diagnóstico y prospectiva. *Pensamiento educativo*, *57*(1), 1-16. https://doi.org/10.7764/pel.57.1.2020.10

Contribution role	Author(s)
Conceptualization	Jenny Isabel Calero-Cerna
Methodology	Jenny Isabel Calero-Cerna
Software	NO APLICA
Validation	Jenny Isabel Calero-Cerna (principal) Rossana Teresa Veramendi-Vernazza (apoya)
Formal Analysis	Jenny Isabel Calero-Cerna (principal) Rossana Teresa Veramendi-Vernazza (apoya)
Investigation	Jenny Isabel Calero-Cerna
Resources	Jenny Isabel Calero-Cerna (principal) Rossana Teresa Veramendi-Vernazza (apoya)
Data curation	Jenny Isabel Calero-Cerna (principal) Rossana Teresa Veramendi-Vernazza (apoya)
Writing - Original Draft Preparation	Jenny Isabel Calero-Cerna
Writing - Proofreading and Editing	Jenny Isabel Calero-Cerna (principal) Rossana Teresa Veramendi-Vernazza (apoya)
Display	Jenny Isabel Calero-Cerna (principal) Rossana Teresa Veramendi-Vernazza (apoya)
Supervision	Jenny Isabel Calero-Cerna (principal) Rossana Teresa Veramendi-Vernazza (apoya)
Project management	Jenny Isabel Calero-Cerna
Fundraising	Jenny Isabel Calero-Cerna