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Digital tools for the development of basic competencies in mathematics learning

Herramientas digitales para el desarrollo de competencias básicas en el aprendizaje de la matemática

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Johnny Félix Farfán Pimentel [1]
Universidad César Vallejo, Perú
felix13200@hotmail.com
https://orcid.org/0000-0001-6109-4416

Raúl Delgado Arenas [2]
Universidad César Vallejo, Perú
rdelgadoa@ucv.edu.pe
https://orcid.org/0000-0003-4941-4717

Diana Eulogia Farfán Pimentel [3]
Universidad César Vallejo, Perú
diana75_farfan@hotmail.com
https://orcid.org/0000-0002-1555-1919

Rosa Irene, Chero Castillo [4]
Universidad César Vallejo, Perú
rosachero@gmail.com
https://orcid.org/0000-0002-3567-4123

Abstract

In these times of continuous change, the advancement of technology is increasingly accelerated in all fields of human knowledge and is impacting the various areas of social, economic, educational, political and other development; in this sense, the use of digital tools in the process of developing mathematical competencies of high school students helps to improve the learning levels of students in an active, participatory, collaborative, motivating and creative way that generates in students the impulse to strengthen mathematical knowledge in a didactic way. The objective was to analyze the use of digital tools in the development of basic competencies for learning mathematics. The methodology was of non-experimental design, basic type, quantitative approach and the study population consisted of 82 high school students. The results show that there is a significant relationship between the study variables with rho=0.436 and p=0.000<0.05. It was concluded that the use of digital tools helps significantly in the development of mathematical competences in students and to deepen the knowledge of numbers, their properties and applications in the socio-educational context.

Keywords: Digital tools, Digital learning, Mathematical learning, Mathematical competence, Problem solving

Resumen

En estos tiempos de cambios continuos el avance de la tecnología es cada vez más acelerada en todos los campos del conocimiento humano y va impactando en los diversos ámbitos del desarrollo social, económico, educativo, político entre otros; en tal sentido el empleo de las herramientas digitales en el proceso de desarrollo de las competencias matemáticas de los estudiantes de secundaria ayuda a mejorar los niveles de aprendizaje de los educandos de un modo activo, participativo, colaborativo, motivador y creativo que genera en los educandos el impulso para afianzar en los conocimientos matemáticos de una forma didáctica. El objetivo fue analizar el empleo de herramientas digitales en el desarrollo de competencias básicas para el aprendizaje de la matemática. La metodología fue de diseño no experimental, de tipo básica, de enfoque cuantitativo y la población de estudio estuvo constituida por 82 estudiantes de secundaria. Los resultados evidencian que existe una relación significativa entre las variables de estudio con un rho=0.436 y p=0.000<0.05. Se concluyó que, el uso de las herramientas digitales ayuda de manera significativa en el desarrollo de las competencias matemáticas en los estudiantes y a profundizar en el conocimiento de los números, sus propiedades y aplicaciones en el contexto socioeducativo.

Palabras clave: Herramientas digitales, Aprendizaje digital, Aprendizaje de la matemática, Competencia matemática, Resolución de problemas

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Introduction

In these times of constant and incessant change, education must adapt auspiciously to these processes of digital transformation in order to implement digital learning and the use of digital tools for the development of mathematical skills in educational institutions. In this regard, schools must adopt significant improvements in teaching strategies that include modern educational resources and materials in learning processes that respond to the significant demands of the educational community to enhance capabilities, skills, and abilities in problem-solving in the area of mathematics.

From this perspective, Bendezú (2023) points out that one of the major concerns in the educational sector is related to the learning of mathematics, taking into consideration that the acquisition of this knowledge is decisive and necessary for the lives of people in a society that constantly experiences changes.

Likewise, Mollo et al. (2023) point out that the use of digital tools for learning has beneficial effects on the learning process of students; since it contributes to the development of capacities, abilities and skills; likewise, an improvement is evident in the application of didactic strategies, strengthening the training of students in a comprehensive manner, with the pedagogical use of digital technologies, educational software, learning platforms, digital tools and internet access being very necessary for the development of basic competencies in students.

Along these lines, Arriaga et al. (2021) point out the need to implement innovative means such as virtual tools in students' learning processes; Teachers must also be trained in the use of information and communication technologies to effectively optimize teaching work, achieving greater improvement in the application of learning and motivation strategies for students.

Consequently, Area et al. (2020) point out that digital transformation processes are a highly complex process that requires a set of factors of diverse nature such as technological resources, organizational resources, digital infrastructure, employee training, management commitment, digital skills, among other essential factors for achieving organizational purposes in the educational development of the population.

1.1. Digital tools

In the educational field, digital learning tools are a determining factor, as they enable access to new knowledge, facilitate the creation of content, and significantly aid the work of teachers in educational institutions (Cámara & Hernández, 2022). Digital tools are valuable in the teaching and learning process as they provide interactive resources and facilitate the development of basic skills, requiring a higher level of teacher preparation (Brescó & Verdú, 2014). In this sense, these technologies involve a set of virtual media and computer applications that help develop basic learning skills effectively in students (Yépez et al., 2020).

Similarly, the use of educational resources in mathematics teaching has a positive effect because it effectively contributes to teaching and significantly enhances students' learning processes. The incorporation of virtual resources in mathematics teaching and learning also demonstrates substantial improvements in mathematical content and concepts, as well as in the development of mathematical skills (Murillo et al., 2016). In this sense, the efficient and productive use of educational resources has a decisive impact on students' teaching and learning processes (Vargas, 2017). Below are some digital tools that contribute to the development of mathematical competence in secondary school students:

1.1.1. Geogebra

In mathematics learning, it should be noted that Geogebra is one of the teaching tools widely used by students due to its variety of components that motivate problem solving in an enjoyable way, among which the applications in the field of dynamic geometry stand out (Sánchez, 2022). Therefore, the incorporation of technology enables the development of mathematical skills in students and helps to better conceive the problematic situation to be solved (Surichaqui et al., 2022). In this sense, Geogebra is a powerful tool for teaching and learning geometric objects in their two-dimensional and three-dimensional forms. Combined with a set of functions, it allows students to have a broader perspective, facilitating problem solving (Cedeño & Valdez, 2022). Consequently, the use of digital tools enhances students' abilities in the way they think and solve mathematical problems (Campos et al., 2021).

1.1.2. Wolfram Alpha

Wolfram Alpha is a mathematical tool that allows a large number of operations to be performed dynamically, presenting information in numerical, graphical, and symbolic form in a relatively short time with a high level of efficiency (Campuzano & Gonzabay, 2022). Likewise, Wolfram Alpha is a computational search engine that helps solve highly complex equations and problems in real time, being an important support for students in the mathematical area (Solorzano et al., 2023). Consequently, the use of Wolfram Alpha enhances mathematical capabilities to face complex situations and its application generates optimal results in the achievement of mathematical competencies in students (Vergel et al., 2015).

1.1.3. Khan Academy

The Khan Academy platform offers virtual resources that enable access to a range of mathematical situations, taking into account students' learning needs (Pacuruco et al., 2020). Thus, the implementation of this pedagogical resource optimizes mathematical learning by positively contributing effectively to students' mathematical learning processes (Santillán, 2021). Therefore, the Khan Academy learning platform contains environments and tools for online teaching, such as textual material, images, sounds, animations, and educational videos to support educational work (Ramírez & Barajas, 2017). Consequently, the essential purpose of the Khan Academy platform is to facilitate learning in an active, motivating, participatory, challenging, and creative way to

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consolidate learning and achieve mathematical competencies, encouraging teachers to use Khan Academy as an online learning strategy (Pérez, 2018).

1.1.4. Mathway

In the field of teaching and learning, the Mathway application allows students to solve a variety of mathematical problems of varying degrees of complexity, addressing fields of knowledge such as algebra, trigonometry, statistics, and other scientific areas (Castro et al., 2020). Likewise, the use of technological resources generates motivation in students and promotes the development of skills, abilities, and attitudes to face problematic situations in the field of mathematics by applying innovative and creative strategies (Pozo & Vega, 2022).

1.1.5. Dièdrom

Dièdrom is an educational software that aims to graphically develop polyhedral geometric figures through perspective views and in which the construction of solids can be carried out creatively through the virtual environment. It has a wide range of tools and editing options; it also has the ability to generate geometric animations and simulations in real time, being of great support to students (García et al., 2023).

1.1.6. Blutick

Blutick is an educational resource that explains mathematical content and provides contextual feedback automatically, using a platform for machine learning. This platform is designed to complement good classroom teaching and maximize students' confidence and mathematical progress (Quiroz, 2023). Likewise, the use of educational resources facilitates the teaching and learning process effectively, sparking students' interest in exploring mathematical content in more depth (Morales, 2012).

1.1.7. Scilab

Scilab is a free mathematical software with multiple applications, it has a high-level programming language including a variety of mathematical functions to perform numerical calculations with vectors and matrices, rational functions, two- and three-dimensional graphing, solving differential equations, simulation of dynamic systems, statistics and computational programming (Pérez et al., 2021).

1.1.8. Octave

Octave is a free software that provides a satisfactory experience in teaching mathematics by providing a list of applications such as solving linear equations, geometry problems and programming with proven effectiveness (Erausquin, 2017).

1.1.9. Maple

This software is a mathematical calculation system: symbolic, numerical, and graphical. It allows for programming routines and mathematical operations, the organization of texts, the processing of images, and the development of customized executable applications (Pernía et al., 2014). Furthermore, the use of Maple provides an enriching experience for students, serving as a valuable teaching resource that enhances problem-solving skills due to its effectiveness and positive experience in addressing problematic situations (Méndez, 2004).

1.2. Aprendizaje de la matemática

Learning mathematics is fundamental for students, providing them with the capacities, abilities, and skills to cope with the multiple situations in the socio-educational context, providing the essential elements to address complex mathematical situations through numerical strategies and methods that will aid in the process of interpretation and production of resulting information (Intriago & Naranjo, 2023). In this sense, learning mathematics requires means and resources that enable the understanding of the mathematical discipline and that generate motivation in the student in their formative and comprehensive process (Palma & Rodríguez, 2022).

1.2.1. Competencia matemática

In the educational field, the development of mathematical skills in students is crucial. These skills integrate mathematical knowledge and scientific disciplines to resolve everyday situations with varying degrees of complexity and the mobilization of cognitive resources (Arreguín et al., 2012). In this sense, mathematical competencies are evidenced through the skills and abilities associated with identifying and interpreting problematic situations in a variety of socio-educational contexts (Goñi, 2008).

1.2.2. Aprendizaje digital

In these times of great changes in all spheres of knowledge, digital learning is one of the ways to access new knowledge constructs and is positively impacting human development (Rollin, 2001). Consequently, digital learning is closely related to the digital transformation, in which it is considered a flexible learning that prioritizes the needs and interests of students at their own pace and analyzes specific content for their educational development (Flores & Meléndez, 2024).

Methodology

The methodology is basic, because it contributes to the knowledge of technological tools in learning mathematics. Its approach is quantitative since it establishes a numerical relationship between the study variables in order to perform a statistical measurement (Huamán et al., 2022). The study population consisted of secondary school students from an educational institution and the study sample consisted of 82 students in the third year of secondary education (Arias et al.,

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2016). The inclusion criteria considered were that their age ranged between 13 and 16 years, they were officially enrolled, their attendance was regular at the educational institution, they expressed informed consent and resided in the city of Lima (Corona and Fonseca, 2023). The research instruments were validated by the criterion of expert judgment in research instruments and the reliability by Cronbach's alpha coefficient; For the variable Digital Tools (Alpha=0.891) and for the variable Mathematics Learning (Alpha=0.840) it is considered good (Oviedo & Campo, 2005).

Results

Among the results obtained, it can be seen in Table 1 that a good level predominates in the Digital Tools variable in students with 63.4%, for the Digital Educational Resources dimension it is at a good level with 56.1%, for the Digital Technology for Learning dimension it is at a good level with 59.8% and for the Digital Autonomy in the Student dimension it is at a good level with 52.4%, highlighting the need to improve learning processes for the development of digital competences in students. In this sense, the implementation of Digital Tools represents an essential support for the development of capacities, skills and abilities related to virtual environments, online teaching resources, virtual applications, online tutorials, self-learning laboratories that will decisively complement the formative process and academic performance of students.

Table 1.

Level of the variable Digital tools and their dimensions

Level	V1: Digital tools		Dimension 1: Digital educational resources		Dimension 2: Digital technology for learning		Dimension 3: Digital autonomy in learning	
	f	%	f	%	F	%	f	%
Low	1	1.2	1	1.2	1	1.2	1	1.2
Regular	29	35.4	35	42.7	32	39.0	38	46.4
Good	52	63.4	46	56.1	49	59.8	43	52.4
Total	82	100.0	82	100.0	82	100.0	82	100.0

Note: Database

Among the results obtained, it can be seen in Table 2 that a regular level predominates in the variable Mathematics Learning in students with 53.7%, for the Teaching Methodology dimension it is at a regular level with 87.8%, for the Problem Solving dimension it is at a regular level with 64.6%, for the Use of Strategies dimension it is at a regular level with 73.2% and for the Development of Competencies dimension it is at a regular level with 59.8%; Based on the evidence, it is essential to implement actions aimed at improving the processes that affect Mathematics Learning in secondary school students, this being a central axis of educational policy and curricular implementation of current contents; as well as strengthening the continuous training process of teachers of the mathematics specialty in accordance with current approaches, use of teaching resources, teamwork, participatory motivation and greater commitment to pedagogical processes.

Table 2.

Level of the variable Mathematics learning and its dimensions

Level	V1: Learning mathematics		Dimension 1: Teaching Methodology		Dimension 2: Problem Solving		Dimension 3: Use of strategies		Dimension 4: Competence development	
	f	%	f	%	f	%	f	%	f	%
Low	1	1.2	8	9.8	1	1.2	1	1.2	1	1.2
Regular	44	53.7	72	87.8	53	64.6	60	73.2	49	59.8
Good	37	45.1	2	2.4	28	34.2	21	25.6	32	39.0
Total	82	100.0	82	100.0	82	100.0	82	100.0	82	100.0

Note: Database

Table 3 shows the analysis of data normality. Significance values were less than 0.05, meaning they did not show normality. Spearman's rho coefficient was applied, as it best fits the statistical data processing process.

Table 3.

Normality test

	Kolmogorov-Smirnov[a]		
	Statistical	gl	Sig.
Digital tools	,404	82	,000
Digital educational resources	,366	82	,000
Digital technology for learning	,390	82	,000
Digital autonomy in the student	,352	82	,000
Learning mathematics	,365	82	,000
Teaching methodology	,487	82	,000
Troubleshooting	,404	82	,000
Use of strategies	,446	82	,000
Skills development	,396	82	,000

Note: Database

Table 4 shows a relationship between the variables of Digital Tools and Mathematics Learning with a rho=0.436 and p=0.000<0.05, which means a moderate relationship between these constructs. In relation to the dimensions of Digital Tools and Mathematics Learning, a rho=0.410 and p=0.000<0.05 were obtained for the Digital Educational Resources dimension, a rho=0.394 and p=0.000<0.05 for the Digital Technology for Learning dimension, and a rho=0.373 and p=0.001<0.05 for the Digital Autonomy in the Student dimension. The results suggest the need to implement digital tools in educational institutions. These days, it is vital for students to develop digital skills to address a variety of socio-educational situations, while actively and collaboratively impacting the

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mathematics learning process, employing strategies and resources that optimize their capabilities in problem-solving and decision-making.

Table 4.

Correlation of variables and dimensions

	Learning Mathematics	
	ρ	Sig.
Digital tools	0.436	0.000
Digital educational resources	0.410	0.000
Digital technology for learning	0.394	0.000
Digital autonomy in the student	0.373	0.001

Note: Research database.

The objective was to analyze the use of digital tools in developing basic competencies for learning mathematics. The results showed a significant relationship between these variables, with a rho of 0.436 and p of 0.000 < 0.05. Likewise, the dimensions of the digital tools variable were significantly related to learning mathematics.

The research agrees with the scientific contributions of Márquez (2022) in his research work, he pointed out the importance of the application of digital tools since it affects the improvement in the learning of mathematics in students of an educational institution. The results show that there is a direct and significant relationship between digital tools and mathematics learning (rho = 0.333 and p = 0.002 < 0.05). Additionally, digital tools promote the development of creativity and meaningful learning (Padilla et al., 2022)

The agreement with Pérez's research (2022) is evident. His research work indicated the need to implement virtual tools in the achievement of mathematics learning in sixth-grade students; these media help to understand problem-solving situations in an active and creative way in a didactic way. The results show a significant relationship between digital tools and mathematics learning achievement (rho = 0.712 and p = 0.000 < 0.05). Likewise, the incorporation of virtual tools significantly impacts student learning in an effective and productive way (Blanco et al., 2022).

There is also correspondence with the research by Torres (2023), who indicated that the use of digital tools and innovative teaching strategies directly impact the learning process of students in a positive way, helping to improve their mathematical skills and abilities in problem solving. The results were that there is a relationship between digital tools and teaching strategies in the area of mathematics (rho = 0.495 and p = 0.000 <0.05). In this sense, digital tools combine dynamic functional elements that enhance students' learning in an efficient and motivational way (Tipismana, 2023).

In this line, it is agreed with the results of Criollo (2023), who indicated that the use of mathematics is decisive in the learning process and is essential for the development of life skills. It contributes decisively to the cognitive processes of reasoning and solving mathematical problems related

to daily life and the socio-educational environment. The results confirm the influence of the use of digital tools in the learning of mathematics, highlighting autonomous learning with 67.5%, collaborative work with 52.5% and skills assessment with 75%.

Likewise, it coincides with the assessments of Aliaga (2022), who pointed out that the use of virtual environments influences the development of mathematical skills in students, being of vital importance in the achievement of learning since access to information and educational resources reinforces the acquired knowledge and skills for problem solving, being incorporated as part of the teaching strategies in the school. The results show a significant relationship between virtual environments and achievement in mathematical skills (rho = 0.862 and p = 0.000 <0.05). Furthermore, teaching action is aimed at improving the learning process of students in an active and motivating way (Abad, 2021).

Therefore, the assessments of researchers Orellana & Erazo (2022) are reaffirmed, indicating that the management of technological tools is essential in the formative process of students to deepen and expand their cognitive capacities; these technologies for learning contribute substantially to the improvement of digital skills and the promotion of an innovative culture in the application of active strategies with greater agility and motivational dynamism. Likewise, Tarazona (2021) points out that the use of digital tools has a significant effect, providing a better understanding of the content to be studied in an enjoyable and active way.

Conclusion

It is concluded that the use of digital tools significantly contributes to the development of mathematical skills in students, helping them deepen their knowledge of numbers, their properties, and applications. This is in a context where technology significantly supports the achievement of essential learning in solving mathematical problems and in finding alternative solutions to the many situations in the socio-educational context. It also generates higher levels of motivation, performance, organization, and creativity, strengthening their mathematical abilities, creating collaborative learning strategies, and increasing their academic potential. Finally, this study will allow for further exploration as a contribution to future research.

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