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Math Gamification and ICT for University Learning: Systematic Review Article

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Abstract

The integration of math gamification and Information and Communication Technologies (ICT) in learning has been a subject of growing interest. This approach seeks to improve student motivation and performance by transforming mathematics teaching into a more interactive and hands-on experience in university education. In this research the PRISMA method was used, 80,000 academic papers were systematically reviewed on ICT-supported math gamification in education whereof 79,994 academic papers corresponding to other fields were excluded, selecting and using at the end 55 articles to conduct this research. Studies were identified that explored the effectiveness of this combination at different educational levels, with a particular emphasis on higher education. The results highlight a significant increase in student engagement and motivation, as well as improvement in knowledge retention as shown in the figures and tables of this research. Instant ICT feedback and the application of digital educational games contributed to have a more active learning adapted to individual needs. Although the results are encouraging, challenges remain, such as the need for personalization and equity in ICT access. Continued research seeks to perfect these strategies maximizing the benefits of gamification and ICT, highlighting the importance of adapting to the diversity of learning styles in mathematics education.

Keywords: *Math Gamification, Mathematics Teaching, Mathematical Tools, Mathematics and ICT, Mathematics Learning*

INTRODUCTION

Due to the globalized system given by the internet we find a great variety of information that help us to develop a structure in mathematics teaching, being all mediated by ICT within the classrooms of higher education; whether it is distance or virtual learning, this scenarios make education in the teaching of mathematics be influenced by new approaches helping to improve the quality of education in a creative and dynamic way by the different online platforms or programs that make the discipline favorable in its contents giving a visual simulation or mathematical modeling.

The problem found at the international level concerns teachers, whom are in charge of transmitting information to students and conducting classroom classes in a fun way using all possible tools, and for this purpose it is observed in the classrooms that educators continue carrying out teaching practices as when the first educational school was established, with no progress in the pedagogical format at all academic levels.

Gamification mentioned by (Lee et al.,2023), shows the incorporation of game elements in non-game contexts, taking advantage of the intrinsic nature of human beings to seek challenges, rewards and achievements, thus creating a more interactive and engaging learning environment. In today's educational environment, university students are growing up in a digital world, surrounded by technology and games. The integration of gamification makes possible to take all its advantages, turning learning sessions into immersive and engaging experiences (Holguín-Álvarez et al.,2022) and (González et al.,2021).

By using technological resources, such as online platforms, educational applications and interactive simulations, a more dynamic learning environment adapted to the preferences of nowadays students can be provided

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(Dorado Martínez & Chamosa Sandoval, 2019). Gamification promotes friendly competition, collaboration and problem solving, as well as essential skills in life and work (Holguin-Alvarez et al., 2023). By introducing game elements, such as points, levels and virtual rewards, an immediate feedback system is created that motivates students to try harder and overcome academic challenges (Fraga Varela et al.,2021) and (Izzyan et al.,2018).

The objectives of this research are to answer the following questions: What is the relationship between math gamification and ICT for learning? What educational levels are math gamification and ICT being applied to? What are the research approaches with the greatest impact on gamification in mathematics learning and ICT tools?

This not only increases students' participation, but also improves long-term retention of information, as they associate learning with positive and rewarding experiences (Chen et al.,2023). Gamification can also personalize the learning process, adapting itself to individual learner styles and paces. Also, technological resources allow the creation of personalized educational experiences (Fraga Varela et al.,2021), where students can advance as their own pace, explore areas of interest and receive specific feedback. This contributes to a more meaningful and lasting learning, as the diversity of students' abilities and preferences are addressed (Del Olmo-Muñoz et al., 2023) and (Melgar et al., 2021).

This work is justified by the importance that lies in the overwhelming existing information on how to improve the educational quality of teaching, it means, learning with innovation using technology as an ally to the development of learning and professionalization according to academic disciplines.

We can say that math gamification is an educational strategy that integrates elements of games in the process of teaching and learning mathematics. It uses ludic principles, such as challenges, rewards and competitions, to motivate students and make mathematical activities more attractive (Rojas et al.,2023). Through digital platforms like interactive applications and technological resources, educators can create immersive educational experiences developing mathematical skills (Ester et al.,2022). Math gamification seeks to change the traditional perception of mathematics as something abstract and difficult, turning it into a fun and practical experience, contributing to students' improvement (Magat, 2023) and (Piñero Charlo et al.,2022).

We can refer to ICT as the ability to use, understand, and benefit digital technologies effectively in various areas of life. This also includes the ability to use software (Guzmán Rivera et al.,2020), surf the internet, understand principles of digital security, and participate in online environments in an ethical and responsible manner. ICT competences also includes the ability to analyze and evaluate digital information (Mayorga et al.,2023), solve problems using technological tools, and collaborate effectively in virtual environments. And in an increasingly digitized world, employment and participation in today's society (Valencia et al; Olivares & de Sotomayor,2022)

Research show that studies concerning this variable are very fascinating because university teachers begin to experiment new strategies for teaching, using Moodle platforms, Flipped Classroom, Flipped Learning, GeoGebra, Octave, Scila, Youtube, etc, each of these tools use the gamification of mathematics and the existence of other tools that can improve learning (Fedriani et al.,2023; Kunwar et al., 2022), some researchers mention that, nowadays, these tools are not very consistent in their use despite there is connectivity in all nations, cities or countries; the problem is that in some towns and nations people do not have a good economic acquisition, not allowing them to make agreements with internet companies and having digital electronical tools which is something that could enable teacher-student and vice versa be connected to each other (Zabala-Vargas et al.,2021) y (Akperov et al., 2022).

The use of mathematics is important in all academic disciplines and the acquisition of knowledge in this field involves having the mastery of logical and abstract language to take them into the practice of vocational training allowing students to perform or operate real problems and provide solutions; effectively, it is necessary that the teacher seeks to improve the class, being interactive, dynamic and attractive for their development in learning, allowing them to develop study habits and complex challenges to be solved using mathematics and technological tools.

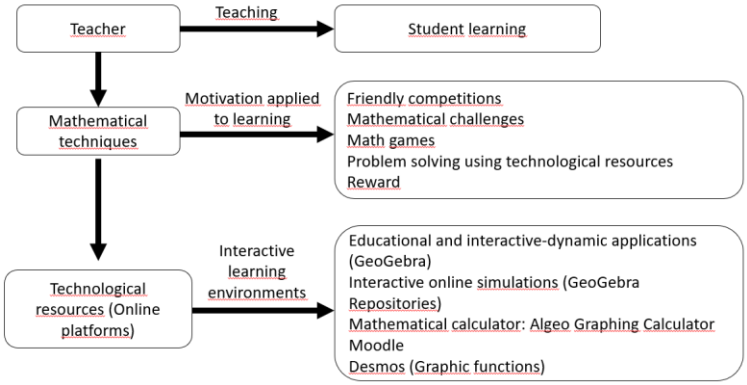


Image 1 *Semiotic practices and gamification processes in teaching and learning*

Note. The table shows the simple way to order and simplify a diversified and dynamic class section for learning and academic growth.

Likewise, digital competences converge in the learning of mathematics, with the inclusion of techniques mediated by these emerging technologies during the process of professional training, it is mentioned the word "emerging" because in a few days, weeks, months and years, technologies will overcome those that started education with these ICT, this makes ICT-based education profitable because it is innovative, and transformative, for this it must be taken into account that in order to make students develop quality learning (Rodríguez et al.,2022), it is necessary that they feel emotionally well to enjoy the new digital tools (Encalada Díaz,2021), this makes students feel motivated to formulate practical solutions through verbal semiotic exchanges, which makes the interaction between students and teachers pleasant, seeking more opportunities for team and collaborative learning within the disciplines of science, engineering, education, medicine, administration, among all other professional careers (Chen et al ;Arias-Flores et al ; Neugebauer et al.,2023) , (Ricce Salazar et al.,2021) ,(Nowostawski et al.,2018)

It is also mentioned that there is a limited use of the tools between teachers and students due to educator's work in universities that continue with the traditional teaching method, where the teacher takes the role-play as an educator who has all the knowledge and does not include the new formats to make a dynamic, practical and versatile education, where the student learns playing with technologies, especially for complex engineering courses if it were the case (Lee et al ; Magat, 2023) ,(Zhao et al ; García et al.,2021), (Simg & Trigueros,2022)

Online teaching is fundamental in semi face-to-face and virtual education, in order to use E-learning tools and virtual platforms, the Flipped Learning or inverted learning, and a pedagogical approach with direct instructions to train the student with autonomous learning are applied; students spend time at the performance moment, so they can carry out the class verification and get a feedback of the learned or previous knowledge in a class section, this requires students to be disciplined with their preparation and professional training to achieve the academic objectives of the course given by the teacher, this approach improves the academic learning processes (Zakaryan & Sosa,2021), that can be used from cell phones, which is the most common tool among students and teachers, and one of its features is that the student can observe, memorize, summarize and thus obtain the knowledge prior to the class section from the teacher (Olivares & de Sotomayor ; Prieto et al.,2022),(Zhao et al ; Rückert et al ; Jácome-Amores et al.,2021),(Tundjungsari ,2020) (Pires et al.,2019).

A dynamic and interactive application for mathematics is GeoGebra, a very powerful software that helps to improve mathematical concepts and allows the student to interact promoting cognitive learning, with fundamental processes of algorithms at user and programmer level, and thanks to the use of this tools the student reaches a high level achieving mathematical simulations and applications to other disciplines of engineering and education (Companioni et al ; Zerpa ; Rengifo et al.,2023), (Rodríguez & Muñoz ; Olivares & de Sotomayor,2022), (Andrés et al ; Aldazabal Melgar et al ; Santonja & San José,2021), (Aguilar & Núñez,2019) ,(Arcavi,2018), (Sosa Guerrero et al.,2016), (D'Amore et al.,2015)

RESEARCH METHODOLOGY

The PRISMA method (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) is a 27-step guide used in scientific research to perform systematic reviews and meta-analyses. Its aim is to improve the transparency and quality of such studies. PRISMA provides detailed guidelines for the planning, execution and presentation of investigations based on evidences, including the search, selection and critical assessment of relevant studies. This methodology helps to reduce bias and ensure objectivity in the synthesis of available evidence, thus promoting more informed clinical and policy decisions (Urrútia & Bonfill, 2010).

The following research was conducted using the PRISMA methodology, which is a very sophisticated method because it makes the research very rigorous and its structure avoids the possible biases of the researchers; it is a method with safe steps in the procedure of obtaining the information to conduct original, and not repetitive researches, or in the case of those that are repeated is because of the investigation results from the findings worked by many researchers in all disciplines or scientific areas, it can be also used to seek contributions on a specific topic as mentioned (Urrútia & Bonfill, 2010).

By using PRISMA, a consistent and transparent methodology is ensured, allowing evidence to be evaluated and synthesized in an objective manner. This is particularly important in research such as math gamification and ICT in learning, where evidence can be diverse and abundant.

PRISMA helps minimizing selection bias, improving review quality, and allowing effective communication of results. By following this method, researchers can identify trends, key findings, and gaps in the literature, which contributes to evidence-based decision making in education and other fields. In summary, PRISMA is fundamental in ensuring the validity and reliability of research based on systematic reviews and meta-analysis.

In the search for academic papers, the first filter was made in Scopus with the keyword "Gamificación AND matemática" giving a result of 3 academic papers that were selected for this research.

A second search of information was made in Scopus with the keyword "mathematical AND gamification" in the English language, giving a result of 197 academic papers, then a first filter was performed with a range from 2014 to 2023 with 10 years of difference to find significant studies, type of documents in articles, in educational computing, mathematical programming, and in the languages of English, Spanish and Portuguese, delivering at the end 4 papers, after that another filter was made in topics like gamification and mathematics education, delivering 41 academic papers that were analyzed one by one and selecting the academic papers that correspond to the research, being 30 academic papers excluded because they belonged to other specialties, leaving 14 articles for the study, likewise a duplicate academic paper was found, which was not part of the study, being excluded a total of 183 academic papers.

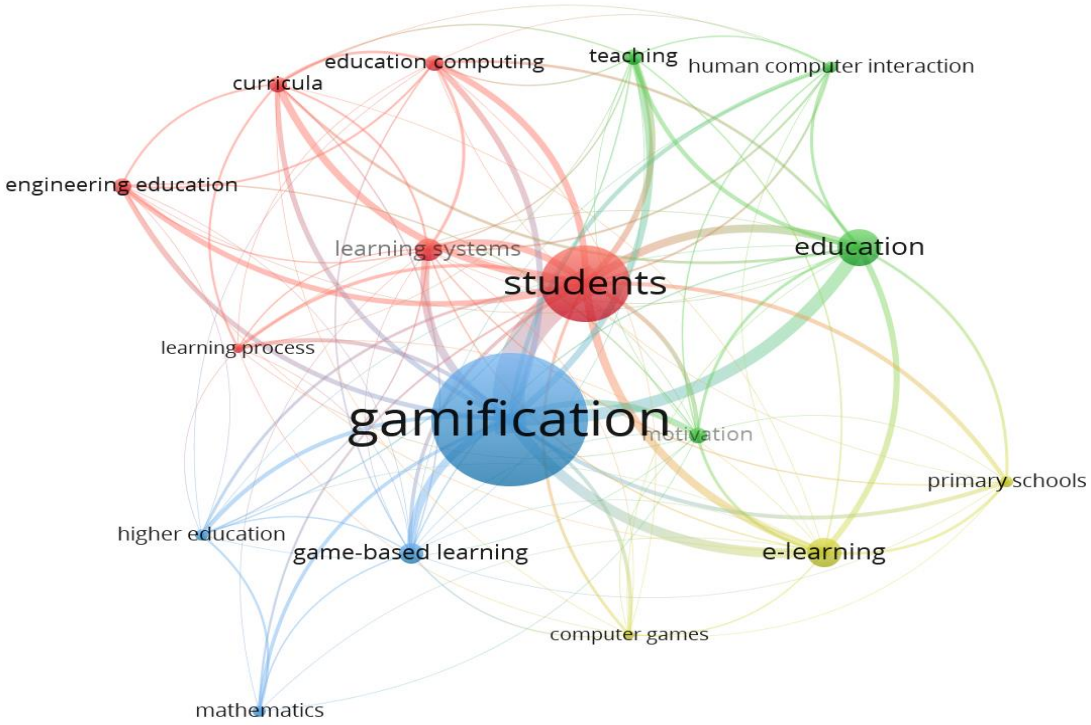


Image 2 Representation of all occurrences of the keyword math gamification, downloaded from the Scopus database

Note. The initial database in Scopus was downloaded with the keyword "Math gamification" being possible to verify according to the database of the total of 197 academic papers thanks to the possible keywords related to the research, it means that if we focused on developing each keyword to verify the contributions in this area of research, the greater the inputs to be achieved and the longer the research time would be.

Likewise, we continued searching for information in Scopus with the keyword in Spanish "gamificación AND y AND aprendizaje AND matemática" giving a result of zero academic papers. Then a research with the same keyword but in English was made.

The information search was initiated in Scopus with the keyword "gamification AND mathematical AND learning", giving a result of 152 academic papers that were filtered by years of publication from 2014 to 2023, being 10 years of interval, helping to review the process of the development of this academic discipline dedicated to education, being filtered by keyword gamification, and educational computing, in the languages of English, Spanish and Portuguese, obtaining 105 academic papers where they were evaluated one by one, leaving 14 academic papers for study, and 91 academic papers excluded.

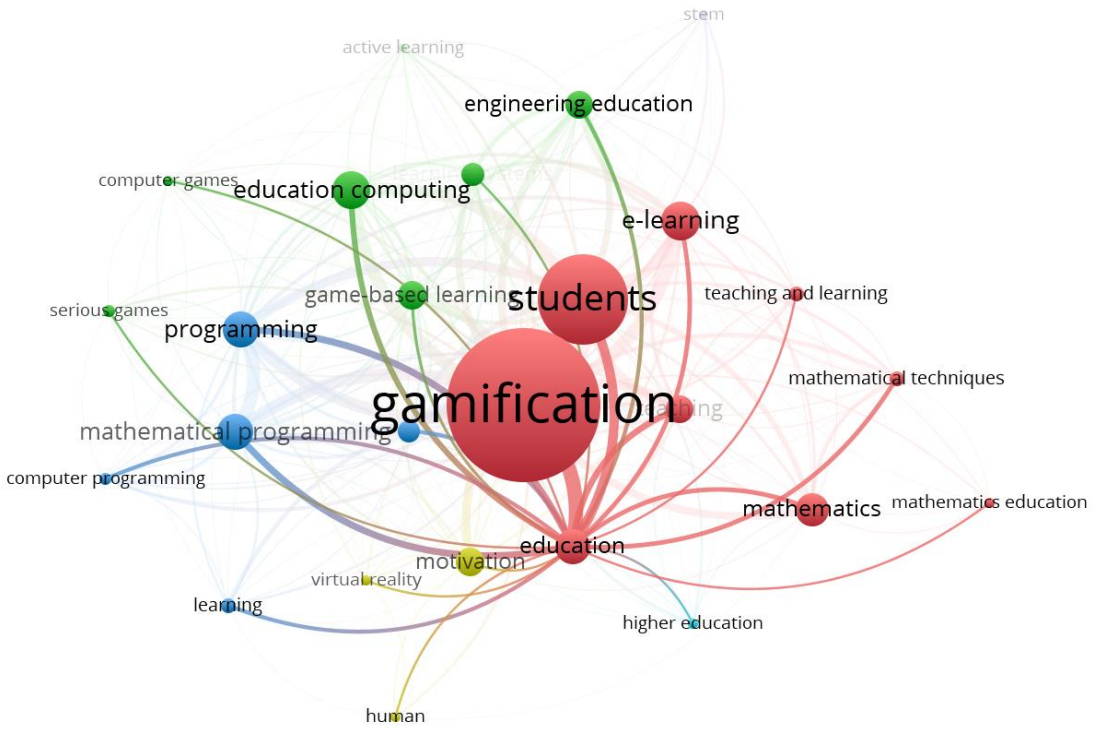


Image 3 Representation of all occurrences of the keyword gamification AND mathematical AND learning, downloaded from the Scopus database x database.

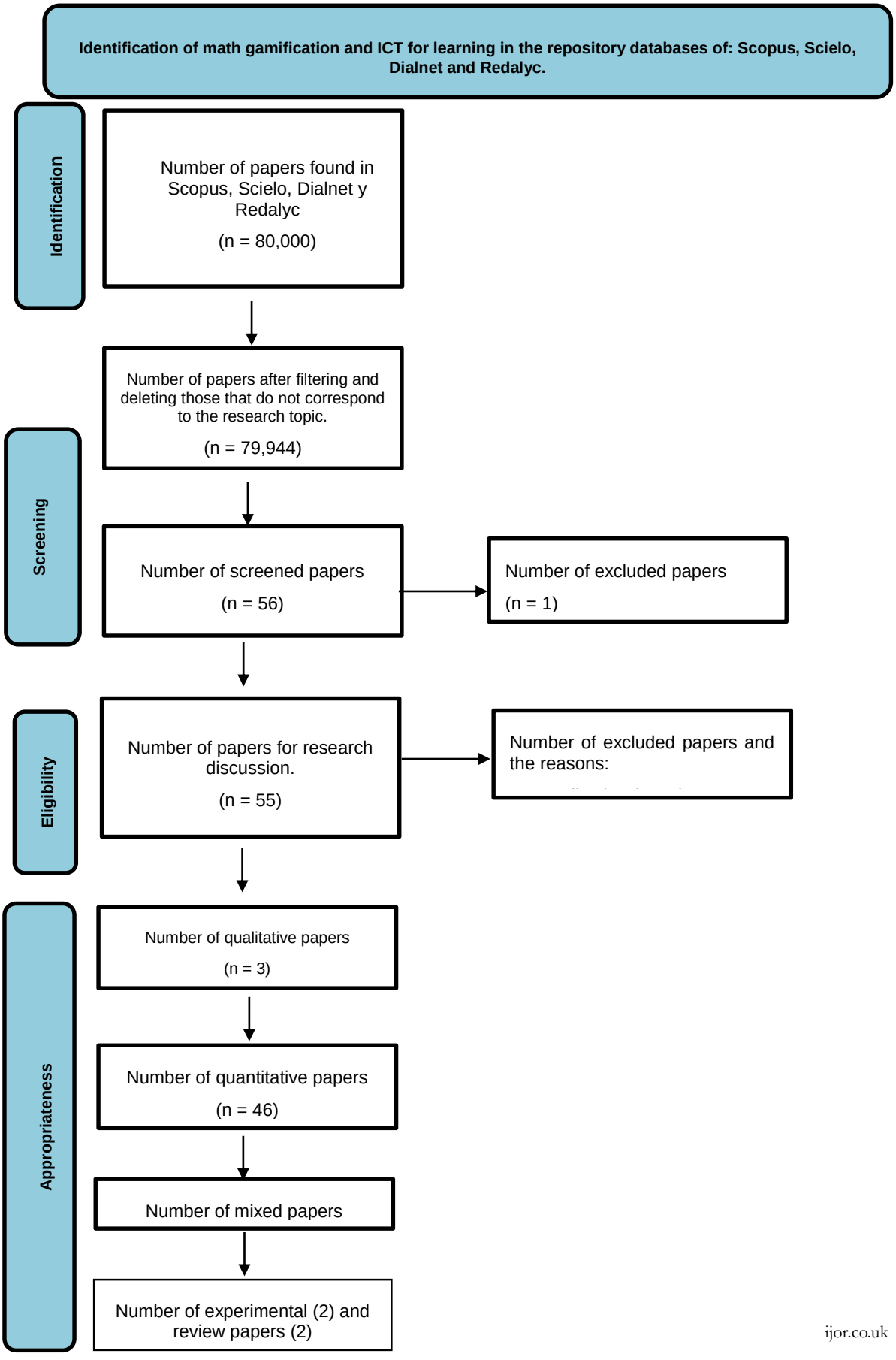
Note. The Scopus database was downloaded for the keyword "gamification AND mathematical AND learning", from the 152 academic papers, the following keywords referring to the research were found through the processed database analysis, which were the most relevant for the research.

Continuing the search for information, the Scielo database was searched with the keyword "gamificación AND matemática" giving a result of 3 academic papers, that were filtered one by one, having a final result of 2 academic papers of study, excluding 1 of them that did not belong to the research.

The search for information continued in the Scielo database with the keyword "Enseñanza matemática" having a result of 838 in the first search, which were filtered by type of research article, from 2014 to 2021 because there were no studies from 2022 to 2023, or in mathematics education specialty, from this filter the number of articles were reduced to 78 academic papers to be evaluated for their study one by one, where 7 academic papers were left for research, being excluded a total of 831 scientific articles.

In the following search for information on academic papers related to the research, the first filter was made in the Dialnet database, with the keyword "Enseñanza matemática superior" giving a result in the first search of 1,291 academic papers, being all them selected using filters to reduce the search for information related to gamification of mathematics in higher education, the filtering was done using the type of work as articles giving a result of 821 papers, and continuing with the filtering one by one, there were selected just 16 academic papers at the end for the research.

RESULTS


Identification of math gamification and ICT for learning in the repository databases of: Scopus, Scielo, Dialnet and Redalyc.
Identification
Number of papers found in Scopus, Scielo, Dialnet y Redalyc
(n = 80,000)
Number of papers after filtering and deleting those that do not correspond to the research topic.
(n = 79,944)
Screening
Number of screened papers
(n = 56)
Number of excluded papers
(n = 1)
Eligibility
Number of papers for research discussion.
(n = 55)
Number of excluded papers and the reasons:
Appropriateness
Number of qualitative papers
(n = 3)
Number of quantitative papers
(n = 46)
Number of mixed papers
Number of experimental (2) and review papers (2)

PRISMA Diagram: Expresses the rigorous search for information in the databases.

Table 1 ***Bibliometric table of research papers on "Math Gamification and ICT for learning"***

Authors	Year of publication	Country	Study approach	Database	Language
(Holguín-Álvarez et al.,2022).	2022	Spain	Quantitative	Scopus	Spanish
(Gonzalez et al.,2021)	2021	Spain	Quantitative	Scopus	Spanish
(Fraga Varela et al.,2021)	2021	Spain	Quantitative	Scopus	Spanish
(Chen et al.,2023)	2023	Taiwan	Mixed	Scopus	English
(Holguin-Alvarez et al., 2023)	2023	Mexico	Quantitative	Scopus	English
(Lee et al.,2023)	2023	Switzerland	Quantitative	Scopus	English
(Del Olmo-Muñoz et al., 2023)	2023	Spain	Quantitative	Scopus	English
(Magat, 2023)	2023	Spain	Quantitative	Scopus	English
(Piñero Charlo et al.,2022)	2023	Spain	Quantitative	Scopus	English
(Ester et al.,2022)	2022	Spain	Quantitative	Scopus	English
(Melgar et al., 2021)	2021	Peru	Quantitative	Scopus	English
(Zabala-Vargas et al.,2021)	2021	Colombia	Quantitative	Scopus	English
(Nowostawski et al.,2018)	2018	Norway	Quantitative	Scopus	English
(Izzyan et al.,2018)	2018	Malaysia	Quantitative	Scopus	English
(Chen et al.,2023)	2023	Taiwan	Quantitative	Scopus	English
(Lee et al.,2023)	2023	Switzerland	Quantitative	Scopus	English
(Magat, 2023)	2023	Philippines	Quantitative	Scopus	English
(Arias-Flores et al, 2023)	2023	Ecuador	Quantitative	Scopus	English
(Neugebauer et al.,2023)	2023	Alemania	Quantitative	Scopus	English
(Yllana-Prieto et al.,2023)	2023	Spain	Quantitative	Scopus	English
(Akperov et al., 2022)	2023	Russia	Quantitative	Scopus	English
(Zabala-Vargas et al.,2022)	2022	Colombia	Quantitative	Scopus	English
(Zhao et al.,2021)	2021	Taiwan	Quantitative	Scopus	English
(Talavera-Mendoza et al.,2021, julio)	2021	Peru	Quantitative	Scopus	English
(Rückert et al.,2021, November)	2021	Germany	Qualitative	Scopus	English
(Jácome-Amores et al.,2021)	2021	Ecuador	Quantitative	Scopus	English
(Pires et al.,2019)	2019	Brazil	Quantitative	Scopus	English
(Tundjungsari ,2020)	2020	Indonesia	Quantitative	Scopus	English
(Ricce Salazar et al.,2021)	2021	Bolivia	Quantitative	SciELO	Spanish
(Encalada Díaz,2021)	2021	Bolivia	Quantitative	SciELO	Spanish
(Simg & Trigueros,2022)	2022	Mexico	Quantitative	SciELO	Spanish
(Prieto et al.,2022)	2023	Mexico	Quantitative	SciELO	Spanish
(Zakaryan & Sosa,2021)	2021	Mexico	Quantitative	SciELO	Spanish
(Andrés et al.,2021)	2022	Mexico	Quantitative	SciELO	Spanish

(Arcavi,2018)	2022	Mexico	Quantitative	SciELO	Spanish
(Sosa Guerrero et al.,2016)	2022	Mexico	Quantitative	SciELO	Spanish
(D'Amore et al.,2015)	2022	Mexico	Qualitative	SciELO	Spanish
(Rojas et al.,2023)	2023	Cuba	Quantitative	Dialnet	Spanish
(Companioni et al.,2023)	2023	Cuba	Quantitative	Dialnet	Spanish
(Zerpa,2023)	2023	Venezuela	Quantitative	Dialnet	Spanish
(Fedriani et al.,2023)	2023	Spain	Literature review article	Dialnet	Spanish
(Mayorga et al.,2023)	2023	Ecuador	Qualitative	Dialnet	Spanish
(Rengifo et al.,2023)	2023	Brazil	Mixed	Dialnet	Spanish
(Olivares & de Sotomayor,2022)	2022	Dominican Republic	Quantitative	Dialnet	Spanish
(Olivares & de Sotomayor,2022)	2022	Guatemala	Quantitative	Dialnet	Spanish
(Olivares & de Sotomayor,2022)	2022	Ecuador	Quantitative	Dialnet	Spanish
(Rodríguez & Muñoz,2022)	2022	Colombia	Quantitative	Dialnet	Spanish
(Valencia et al.,2022)	2022	Spain	Quantitative	Dialnet	Spanish
(Rodríguez et al.,2022)	2022	Cuba	Quantitative	Dialnet	Spanish
(Aldazabal Melgar et al.,2021)	2021	Peru	Quantitative	Dialnet	Spanish
(García et al.,2021)	2021	Spain	Experimental	Dialnet	Spanish
(Santonja & San José,2021)	2021	Spain	Experimental	Dialnet	Spanish
(Aguilar & Núñez,2019)	2019	Ecuador	Quantitative	Dialnet	Spanish
(Guzmán Rivera et al.,2020)	2020	Mexico	Systematic review article	Redalyc	Spanish
(Dorado Martínez & Chamosa Sandoval,2019)	2019	Mexico	Quantitative	Redalyc	Spanish

The research work was carried out over a period of 10 years, but the results of the information search showed that there is a significant research period of 5 years as shown in the following table, because the academic works found are from the last 5 years.

Table 2 Range of publication

Year of publication	
Range	5,00
Minimum	2018,00
Maximum	2023,00

Table 3 Table of frequencies, percentages and number of publications in the English and Spanish languages

Language				
	Frequency	Percentage (%)	Valid percentage (%)	Cumulative percentage (%)
Spanish	30	54,5	54,5	54,5

Valid	English	25	45,5	45,5	100,0
	Total	55	100,0	100,0	

Note. It is observed that the Spanish language represents 54.5% having 30 academic papers, and in the English language represents 45.5% equivalent to 25 academic papers related to mathematics gamification and technological tools.

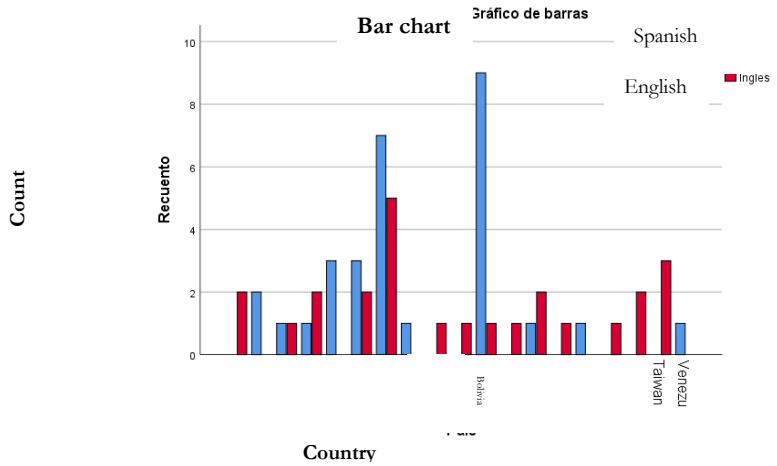


Image 4 Bar chart representing publications in English and Spanish languages

Note. Papers published in Spanish and English languages, showing in databases that the largest publication was made in Spanish.

Table 4 Frequency of evolution of research on the subject under study

Year of publication					
		Frequency	Percentage (%)	Valid percentage (%)	Cumulative percentage (%)
Valid	2018	2	3,6	3,6	3,6
	2019	3	5,5	5,5	9,1
	2020	2	3,6	3,6	12,7
	2021	14	25,5	25,5	38,2
	2022	14	25,5	25,5	63,6
	2023	20	36,4	36,4	100,0
	Total	55	100,0	100,0	

Note. The research shows the process and development of gamification databases and technological tools in university education, also the progress of this research variable is observed.

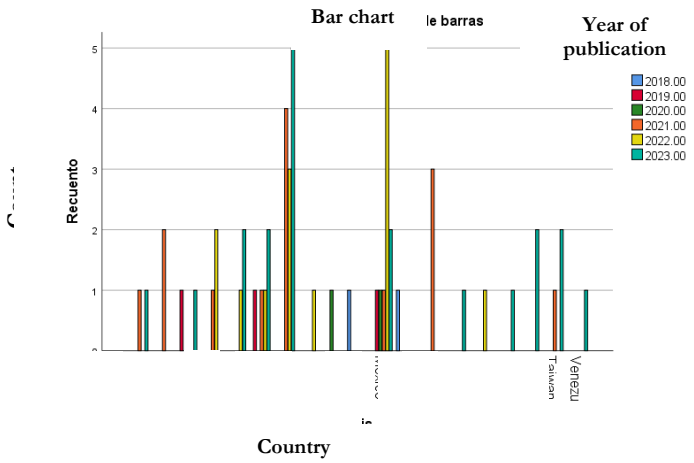


Image 5 Bar chart showing the percentage of academic papers according to the type and year they represent in the databases.

Image 5 shows that the countries with the highest demand for research on math gamification and the development of the use of technological tools are Spain, Mexico, and Peru, which implies that Peru is developing its scientific production.

Table 5 ***Type and focus of study found in the Scopus, Scielo, Dialnet y Redalyc databases.***

Study approach					
		Frequency	Percentage(%)	Valid percentage (%)	Cumulative percentage (%)
Valid	Systematic review article	2	3,6	3,6	3,6
	Qualitative	3	5,5	5,5	9,1
	Quantitative	46	83,6	83,6	92,7
	Experimental	2	3,6	3,6	96,4
	Mixed	2	3,6	3,6	100,0
	Total	55	100,0	100,0	

Note. According to the statistical results it is observed that in the types of research or study approach the most developed is the quantitative investigation with 46 academic papers equivalent to 83.6%, 3 qualitative academic papers represented by 5.5%, 2 experimental academic papers represented by 3.6% and 2 systematic review papers 2 equivalent to 3.6%.

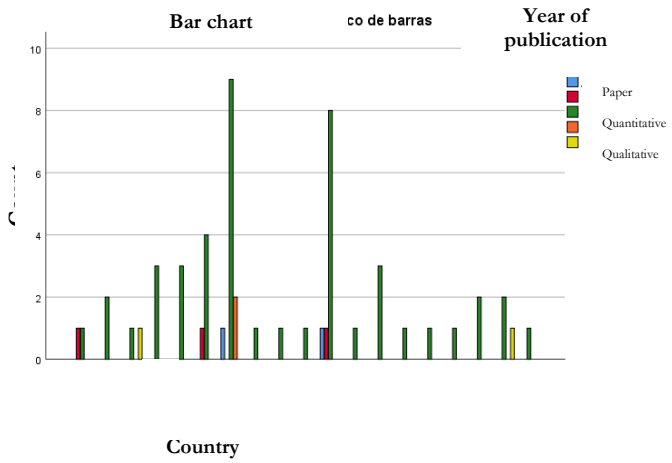


Image 6 Bar chart showing types of research papers by country

Note. It is observed that Spanish the largest producer of quantitative research on the topic of math gamification and ICT.

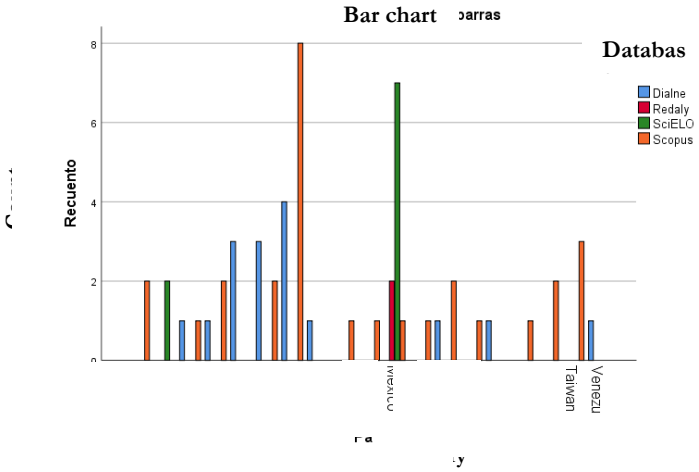


Image 7

Note. It is observed that the greatest demand for research in math gamification is Scopus, being in the first place having Spanish researchers, the second place is for Scielo represented by researchers from Mexico, and in third place is Ecuador; it is also observed from Image 4 that Taiwan takes the fourth place in scientific publications on math gamification and teaching, as well as technological tools in learning.

Table 6 Table of publication frequencies by country in the repositories under study.

Countries					
		Frequency	Percentage (%)	Valid percentage (%)	Cumulative percentage (%)
	Germany	2	3,6	3,6	3,6
	Bolivia	2	3,6	3,6	7,3
	Brazil	2	3,6	3,6	10,9
	Colombia	3	5,5	5,5	16,4
	Cuba	3	5,5	5,5	21,8

Valid	Ecuador	5	9,1	9,1	30,9
	Spain	12	21,8	21,8	52,7
	Guatemala	1	1,8	1,8	54,5
	Indonesia	1	1,8	1,8	56,4
	Malaysia	1	1,8	1,8	58,2
	Mexico	10	18,2	18,2	76,4
	Norway	1	1,8	1,8	78,2
	Peru	3	5,5	5,5	83,6
	Philippines	1	1,8	1,8	85,5
	Dominican Republic	1	1,8	1,8	87,3
	Russia	1	1,8	1,8	89,1
	Switzerland	2	3,6	3,6	92,7
	Taiwan	3	5,5	5,5	98,2
	Venezuela	1	1,8	1,8	100,0
	Total	55	100,0	100,0	

Note. It is observed that Spain represents 21,8% of academic papers, while Mexico 18,2%, Ecuador 9,1%, Cuba, Peru, Taiwan 5,5% respectively.

Table 7 ***Academic papers found by repositories and the representative percentage of each one of them.***

Database					
		Frequency	Percentage (%)	Valid percentage (%)	Cumulative percentage (%)
Valid	Dialnet	16	29,1	29,1	29,1
	Redalyc	2	3,6	3,6	32,7
	SciELO	9	16,4	16,4	49,1
	Scopus	28	50,9	50,9	100,0
	Total	55	100,0	100,0	

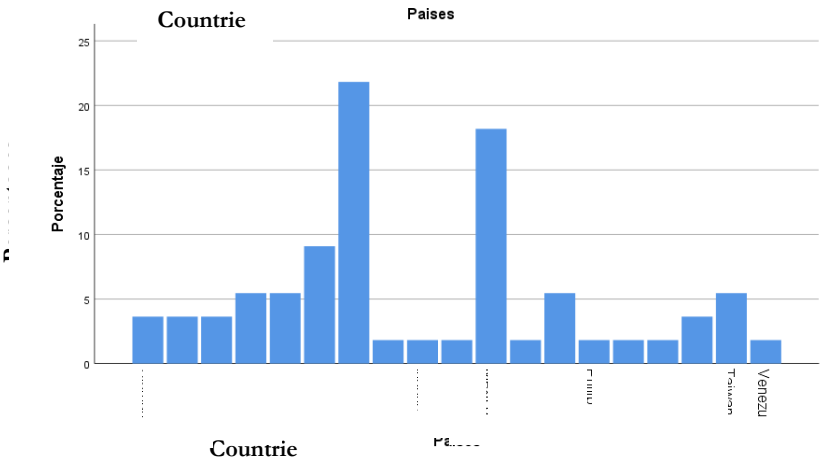


Image 8 The bar graph shows the publication of academic papers related to research as a percentage.

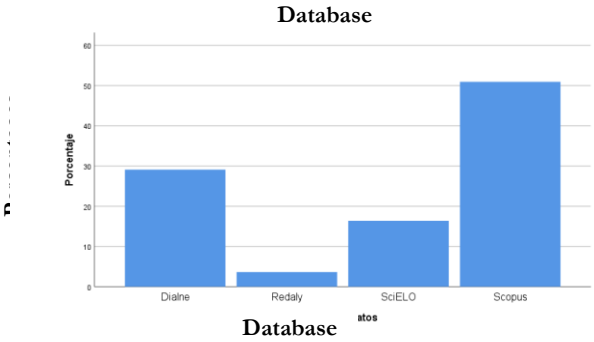


Image 9 Bar chart representing in percentage

Academic papers published in that 5 years' period, remembering that the research is established for a period of 10 years of information search, the results gave this new range.

DISCUSSION

After conducting the research, we can answer the initial question: What is the relationship between math gamification and ICT for learning? We can answer it through the contributions of several authors who developed research. Math gamification (Holguín-Álvarez et al.,2022), which incorporates game elements such as challenges and rewards, is effectively combined with information and Communication Technologies (ICT) to enhance learning (Gonzalez et al.,2021). ICTs offer interactive platforms and applications that make the study of mathematics more engaging, using educational games and simulations. These digital tools provide immediate feedback, encouraging student participation and engagement. In addition, online collaboration and competition, facilitated by ICTs, promote an interactive learning environment. Virtual and augmented reality, integrated through ICT (Magat, 2023), offer immersive experiences that make mathematics concepts more tangible. Progress monitoring through digital platforms allows personalized adaptation of teaching. Overall, ICT-supported math gamification transforms mathematics learning (Melgar et al., 2021), making it more motivating, interactive and tailored to the individual needs of students.

Likewise, the question is answered as a result of the objectives of the other scientific publications: What educational levels are math gamification and ICT being applied to? And for this we have: the application of math gamification and Information and Communication Technologies (ICT) extends to all educational levels, from primary to higher education (Izzyan et al.,2018). In primary education extended to higher education, ICT is employed through interactive games to make mathematics more accessible and fun. At the secondary level, online platforms and digital games are integrated to strengthen mathematical learning. At the university level,

ICT is applied in virtual learning environments and collaborative tools, while gamification is used to maintain interest. The combination of gamification and ICT seeks to improve students' understanding and motivation, adapting to the different educational needs at each stage.

Answering to the research question: What are research approaches with the greatest impact on gamification in mathematics learning and ICT tools?

Research approaches on gamification in mathematics learning and Information and Communication Technologies (ICT) focus on pedagogical effectiveness and impact on student motivation and achievement. It is investigated how gamification influences the acquisition of mathematical skills and how ICT, such as interactive platforms and educational games, optimize the teaching-learning process. In addition, aspects related to the adaptability to different educational levels, the inclusion of students, and the creation of digital environments that favor collaboration and the development of practical skills in mathematics are explored (Zhao et al.,2021).

So far, the application of gamification in mathematics learning supported by Information and Communication Technologies (ICT) in higher education has demonstrated great results as shown in the tables of this research. An increase in student engagement and motivation has been observed, contributing to a more interactive and stimulating learning environment (Zhao et al.,2021). The introduction of educational games and online platforms has facilitated active practice of mathematical concepts, improving knowledge retention. In addition, the instant feedback provided by ICT has enabled faster and more efficient assessment of student progress. However, challenges remain, such as the need to further customize gamification to accommodate diverse learning styles and ensure equity in access to ICT. Ongoing research seeks to refine these strategies to maximize the benefits of gamification and ICT in higher education.

CONCLUSION

The integration of math gamification and ICT in learning has proven to be an effective strategy to increase student motivation. The use of game elements and the interactive of ICT capture students' interest, fostering sustained engagement and participation in the study of mathematics, as shown in the figures and tables in the results.

ICT-supported gamification provides an educational environment that allows students to apply mathematical concepts in a practical way. Digital games and simulations offer immersive experiences that facilitate the understanding of abstract topics, making mathematics learning a more tangible and relevant experience.

ICTs allow instant feedback on student performance, which facilitates the identification and correction of problems areas in a timely manner. In addition, gamification and ICT enable personalized adaptation of learning, attending to the individual needs of each student for a more effective development of mathematical skills.

The integration of ICT tools in mathematical gamification facilitates collaboration among students and fosters healthy competition. Online platforms and cooperative games promote teamwork, while challenges and rewards stimulate individual progress, creating a dynamic and socially enriching educational environment. These combined applications have the potential to significant transform the mathematics learning experience.

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