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Scientific articles

Análisis sistemático del empleo de la gamificación en el desarrollo de software o aplicaciones educativas de matemáticas

Systematic analysis of the gamification use in the development of mathematics educational software or applications

Análise sistemática da utilização da gamificação no desenvolvimento de software ou aplicações educativas no domínio da matemática.

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Resumen

En el nuevo milenio ha habido un crecimiento considerable de estudios que abordan la técnica de gamificación para el desarrollo de software que es útil en la educación. La finalidad de este artículo fue hacer una revisión de la literatura, para indicar al lector qué elementos de la gamificación son los que más se emplean en la construcción de software educativo y aplicaciones móviles educativas, y que apoyan a mejorar tanto la motivación como el rendimiento académico de estudiantes que cursan matemáticas. Para llevar a cabo este análisis, se empleó la metodología PRISMA (preferred reporting ítems for systematic reviews and meta-analyses), ya que permitió realizar una búsqueda de artículos, en 4 distintas bases de datos, a partir de palabras clave relacionadas con la gamificación y el software educativo. En una primera revisión se encontraron 437 artículos, después de aplicar los criterios de exclusión, se redujo a 37 artículos científicos. A partir del análisis realizado se concluyó que el 68% de los estudios revisados permitieron aumentar la motivación de sus estudiantes y 49% logró mejorar el rendimiento académico de los mismos. Estos resultados fueron obtenidos con el empleo de diferentes técnicas estadísticas.

Palabras clave: Adaptabilidad, aplicaciones móviles gamificadas, gamificación, motivación, rendimiento académico, software educativo de matemáticas.

Abstract

In the new millennium there has been a considerable growth of studies that address the gamification technique for the development of software that is useful in education. The purpose of this article is to make a review of the literature, to indicate to the reader which elements of gamification are the most used in the construction of educational software and educational mobile applications.

To carry out this analysis, the PRISMA (preferred reporting items for systematic reviews and meta-analyses) methodology was used, since it allowed a search of articles in 4 different databases, based on keywords related to gamification and educational software. In a first review, 437 articles were found; after applying the exclusion criteria, this was reduced to 37 scientific articles. From the analysis it was concluded that 68% of the reviewed studies allowed to increase the motivation of their students and 49% managed to improve their academic performance. These results were obtained with the use of different statistical techniques.

Keywords: Adaptability, Gamified mobile apps, gamification, motivation, academic performance, mathematics educational software.

Resumo

No novo milénio tem havido um crescimento considerável de estudos que abordam a técnica da gamificação para o desenvolvimento de software útil na educação. O objetivo deste artigo é fazer uma revisão da literatura, para indicar ao leitor quais os elementos de gamificação mais utilizados na construção de software educativo e aplicações móveis educativas. Para realizar esta análise, foi utilizada a metodologia PRISMA (preferred reporting items for systematic reviews and meta-analyses), que permite uma pesquisa de artigos em diferentes bases de dados, com base nas palavras-chave: software educativo e gamificação.

Para efetuar esta análise, foi utilizada a metodologia PRISMA, que permitiu uma pesquisa de artigos em 4 bases de dados diferentes, com base em palavras-chave relacionadas com a gamificação e o software educativo. Numa primeira revisão, foram encontrados 437 artigos; após a aplicação dos critérios de exclusão, estes foram reduzidos a 37 artigos científicos. Da análise concluiu-se que 68% dos estudos revistos aumentaram a motivação dos seus alunos

e 49% melhoraram o seu desempenho académico. Estes resultados foram obtidos através de diferentes técnicas estatísticas.

Palavras-chave: Adaptabilidade, aplicações móveis gamificadas, gamificação, motivação, desempenho académico, software educativo de matemática.

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Introduction

People have been in a constant evolution since the emergence of the species, along with them the tools and technologies have also changed, however, a constant regardless of the period of time in which we find ourselves has been the need to learn, an action that is achieved through observing our world, listening to the teachings of a teacher and many other ways. In today's world we have very useful technological devices such as computers and mobile devices, which allow us to carry out a large number of activities, such as searching for information and finding it in a matter of seconds. Due to their prominence in the lives of most people, since the last two decades and even a little before, they have been used to teach and learn, however, learning is not always easy, sometimes it can become a tedious task regardless of the medium, especially if it involves complex subjects such as mathematics, which is why teachers seek to motivate their students in some way.

Although there are many possible ways to motivate someone, one that has received special attention from teachers and researchers in the field has been gamification (Soledispa *et al.* , 2021), since it is entertaining because it incorporates mechanics, dynamics and components of video games in another discipline, for this reason various applications have been developed for mobile devices, which are also known as educational software, as they are created for desktop computers, that is, computers that are not designed to be easily transportable.

Based on what has been reviewed in the previous paragraphs, the objective pursued in this document is to analyze, through a bibliographic review, which are the elements of gamification that are most used when developing educational software and educational mobile applications, related to mathematics, in order to know what positive and negative effects they have on a student's learning.

The specific objectives are presented below:

i) Identify the most commonly used gamification elements in mathematics educational software or applications.

ii) Identify gamification as a support for student motivation in their mathematics courses.

iii) Identify gamification as a resource that improves students' academic performance in some mathematics subject.

iv) Identify whether the educational application adapts to the students' profiles.

The literature review considered both national and international publications in Spanish and English. Below are some definitions referring to the topics that were worked on.

Gamification

Gamification refers to using game design elements and features in unrelated contexts to obtain a positive outcome in an activity, such as learning (Sánchez *et al* ., 2020).

Some design elements considered by Dicheva *et al*. (2015) are as follows:

- Objectives or goals.
- Challenges and missions.
- Personalization of the experience.
- Progress.

Its associated mechanics are points, progress bars, levels, virtual currency, among others.

Its dynamics include:

- Feedback.
- Competition and teamwork.
- Involves badges, leaderboards, levels and avatars.
- Player status visible.
- Freedom of choice to achieve a greater goal.
- Narrative.
- Time limit.

Similarly, Sailer *et al*. (2017) highlight the importance of the aforementioned elements in order to satisfy three basic psychological needs: autonomy (element of freedom), social interaction (teamwork and narrative) and competence (competition and feedback). If a gamified application has these elements and manages to meet these needs, its users will feel satisfied and willing, or in other words, they will be motivated and interested in the subject of the application.

Gamification is a term that formally emerged in 2010, however, since the early 2000s, the feasibility of implementing games in the learning of students at any educational level has been studied, starting with licensed games created explicitly to teach children a moral, continuing with serious games whose objective is not to entertain, but to learn a particular topic or skill, until evolving into the various techniques that are analyzed and implemented today (Simoes , 2013).

With this outline of what gamification involves in general, it is important to highlight some of the results that have been obtained when using it in learning contexts, in addition to the way in which they have been implemented.

Education and gamification

Simoes (2013) establishes that gamification allows a teacher to create challenges according to the level of the students, give a range of options for the fulfillment of intermediate objectives, set goals, consider failures as part of the learning process in order to reduce the frustration that they may cause and use healthy competition to promote values. On the other hand, Sánchez *et al. (2020) mention that a series of* gamified online questionnaires were applied to a control group and traditional questionnaires to another group, obtaining as a result that those who took the gamified version obtained a better result in a subsequent exam, however, the assumption was that students would automatically solve more questionnaires just because they were gamified , which seems to indicate that the positive effects of said activity were not particularly long-lasting. The above shows that gamification in itself is not enough to motivate, but that the way in which these gamified elements are integrated into learning is of vital importance, a fact reinforced by Aguiar *et al.* (2021), who establishes that the gamification cycle ideally occurs as follows: gamified mechanisms (extrinsic motivation), promoted behavior, internalized extrinsic motivation, and self-regulatory behavior, which no longer depends on gamification itself since now the desired behavior is a habit of its own.

Regarding the benefits offered by gamification, Manzano *et al* . (2022), as well as Godoy (2019) comment that it allows students to increase their creativity, thereby contributing to the selection of different strategies in problem solving, and also to the management of the resources they have and the time they have available.

Reyssier *et al.* (2022), mention that gamification must consider the characteristics and experiences that the student has in relation to gamification, in order to increase motivation for learning the topic that they wish to work on.

Educational software

According to Stanisavljević *et al.* (2015), educational software is a program whose objective is to assist learning by offering a different form of teaching. These programs are implemented on all types of devices, computers, tablets and even cell phones. As with teaching, Traditional, educational software requires capturing students' attention and motivating them, which is why several authors have studied it from a gamified perspective , such as Rosero and Medina (2021), who observed the effect of the classcraft online platform , which is similar to Google classroom , but with the difference that it allows the teacher to implement gamified elements , such as including a story or narrative, each student having their avatar, individual or team competition through the dynamics of the formulation of questions by manipulating an instrument called a time wheel, among other dynamics and elements. At the end of the study they found that said software certainly allowed students to reinforce their knowledge of mathematics compared to conventional tasks, however, they stressed that it would be ideal for the teachers had prior preparation to be able to use the platform properly without major difficulties.

Supporting the above approach, Castronovo *et al.* (2018) designed a virtual simulator and applied it to a group of students, a game called Virtual Construction Simulator 4, which helped students improve their skills, although based on the results it is estimated that, if this gaming aspect is combined with a self-assessment of each student, the advantages of this software could be even greater. Meanwhile, Plass *et al.* (2013) highlight the importance of software not only being for individual use, but for more effective learning, competition and, in a certain way, cooperation between the student and someone else (who may well be another student or a character controlled by the computer) must be promoted.

Educational mobile applications

A mobile application is software or a program that runs on a mobile device such as a cell phone. It should be noted that there is mobile software that also has a desktop and even web version, but by convention only the mobile version is commonly called an application, or more commonly, *an app* . Now, the vast majority of people have access to a cell phone with Internet, so there has been an attempt to bring education to these devices, which can be used anywhere and at any time, thanks to their portability and size, although it should be noted that these have fewer resources than a computer, which is an important factor to take into account when developing mobile applications.

Wei (2023) comments on the use of a mobile application to help teenagers learn vocabulary. When carrying out this study, he found four main factors that can help students in their autonomous mobile learning: direct links to activities, immediate feedback when solving an exercise, communication with the teacher and classmates, and emotional support, that is, promoting positive emotions, which complements very well what has already been mentioned about the gamified approach .

Gamification as a teaching strategy

A teaching strategy is a procedure that supports the teacher in planning his/her activities, and in general in his/her actions, whose purpose is for the student to have a learning according to the predetermined educational goals. As part of the actions that the teacher carries out in his/her planning, there are the techniques, resources and contents that he/she will use in his/her classes, and for this reason gamification, being a technique that is used to involve the student in the tasks to be carried out and, thus, increase his/her motivation and interest in solving them, can be considered as a teaching strategy (Area and González, 2015; Villegas *et al* ., 2017).

Elements of gamification

Gamification is made up of mechanics, dynamics and components.

Mechanics are considered to be all those actions, mechanisms and aspects that generally allow an activity to be carried out as if it were a game, which makes it possible to achieve an environment that is attractive and easy for the student to incorporate. Some of the mechanics are: avatars with the roles they have within the activity, challenges, scales defined for scores and achievements, among others (Acosta *et al* ., 2020).

The dynamics include the rules of the game and, in general, the goals that the activity wants to achieve (Borrás, 2015). It includes those aspects that allow the mechanics to be carried out and that are related to the motivation of the users, who in this case would be the students (Coello, 2019). Some of the dynamics are: narrative or story in which the gamified activity is developed , establishment of rules, progression of actions, etc.

Components refer to those tools that are used to carry out the activities within the game (Reyes, 2018). For example, they would be the prizes given to participants, badges, leaderboards. For (Hernández and Legañoa , 2016) the components represent the rewards for the execution of the dynamics and mechanics of the game.

Materials and methods

This section describes the materials and methods used to develop this research; first, the materials used are discussed, and in the second part, the methods applied are shown.

Materials

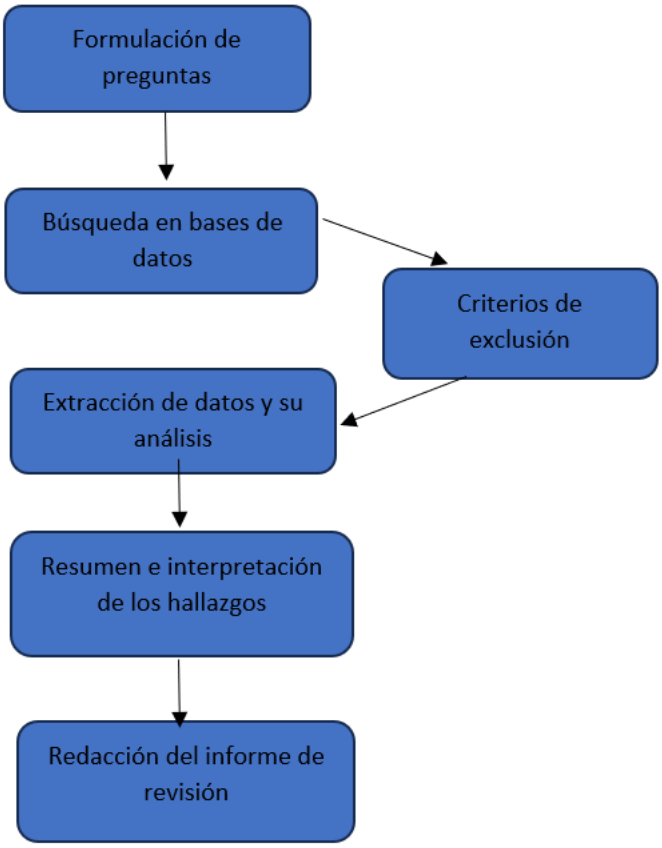
Five of the recognized databases that are consulted by many researchers were considered to make the selection of articles that have to do with the development of gamified software and that is used in Mathematics for higher education. The three databases that were worked with were: IEEE Xplorer , Scopus , Science Direct, Web of Science and Scielo, whose selection was from the period 2019 to 2023, with the purpose of reviewing studies carried out recently and that are current, which can be useful to several teachers who teach Mathematics classes at any educational level and need to know the gamification elements contained in educational software.

With this selection, it was also intended to present the findings found by specialists in the fields of Educational Technology, Education, Educational Mathematics, Educational Computing, use of ICT in education, which shows the diversified scenario of the efforts of researchers and academics.

Methods

The bibliographic review was carried out in accordance with the provisions of the 2020 version of the PRISMA framework (Moher *et al.* , 2009), whose acronym stands for *Preferred Reporting Items for Systematic reviews and Meta- Analyses* , which can be translated as *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* ; which offers a sequential approach to collect, identify, exclude and select those articles that are related to the object of study, that is, it does not focus on content but on how the search was developed, as it is presented. The purpose of this method is to support authors in reporting systematic reviews and meta-analyses. In a very summarized way in accordance with the statement by Page *et al* . (2021), Figure 1 shows the flow established by PRISMA and adapted to the present research.

Figure 1. Diagram of the phases of the PRISMA method



Source: own elaboration

Formulating questions

To carry out the bibliographic review, it is necessary to formulate one or more questions that represent the guiding thread that will guide the research. For this article, 4 questions were raised, which are the following: what are the elements of gamification most used by educational software and educational mobile applications? Does gamified software improve student motivation? Does gamified software improve academic performance in mathematics? Does educational software adapt to student profiles?

Searching in databases

To search for articles, search terms that match the topic and question asked are entered into the respective search engines. In the case of this work, the terms used were:

- Gamified math software
- Elements of gamification in gamified mathematics software.

The following databases were included in the systematic recovery process:

- IEEE Xplore
- Scopus
- Science Direct
- Web of Science
- Sky

The period included in the systematic recovery process was from 2019 to 2023.

Exclusion criteria

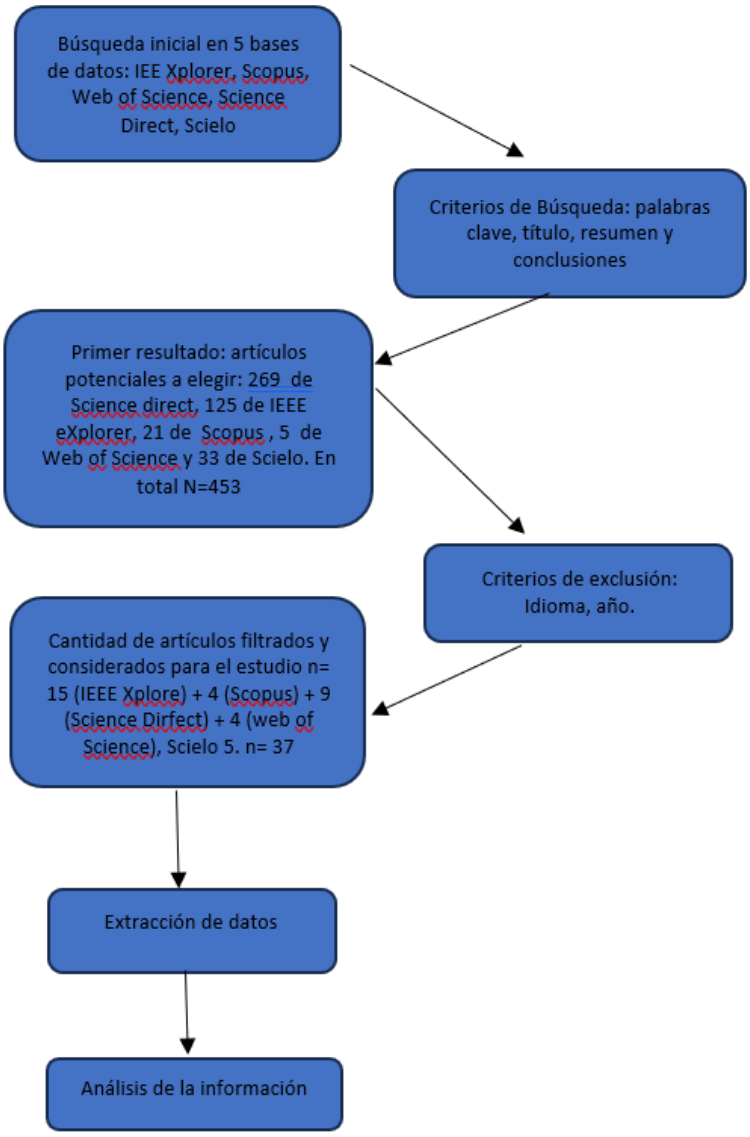
Once the search was carried out in the three selected databases, and the potentially eligible articles were identified, because they contained the previously established terms; the articles were downloaded and each of them was analyzed for its title, abstract and conclusions, based on the exclusion criteria, which allowed several articles to be discarded. The results section presents the articles that were considered in the study, once those that did not meet the required conditions were eliminated. The exclusion criteria were the following:

a) The article is not written in English.
b) The article is not written in Spanish.
c) The educational software or mobile application is not about mathematics
d) The software is not gamified
e) The gamification elements used in the software are not specified.

Data Extraction

In this section, the selected articles are analyzed based on the factors that affect the object of study, which in this case refers to the gamification elements used by educational software for Mathematics, the improvement that may occur in the motivation and/or academic performance of students, as well as whether it adapts to the profiles of the students. Fig. 2 shows the systematic process used.

Figure 2. Flow established by PRISMA and adapted



Source: own elaboration

Results

This section presents the results of the literature review analysis using the methodology described in the previous chapter.

It is necessary to mention that the search repositories consulted were IEEE eXplore , Scopus , Science Direct, Web of Science and Scielo. To start the literature review, the keyword Gamified mathematics software in Spanish and English was introduced Gamified mathematics software, both languages were used to see the number of articles published

during the last 5 years (from 2019 to 2023), on the topic in each repository, checking if any article was simultaneously found in at least two of these.

Scopus database was chosen for its recognized prestige, broad historical coverage, and number of publications, as pointed out by García *et al.* (2020). The search and analysis was carried out during the month of December 2023, to determine the current trend, using data from the last 5 years (2019-2023). A meta-analysis was proposed to increase reliability and specificity, limiting the results to scientific production in the area of social sciences, education, and technology (Gabriel, 2018), since the objective of the study was to analyze which elements of gamification are the most used in the construction of educational software and educational mobile applications in the area of mathematics, as well as to review how gamification has allowed an increase in student motivation in their mathematics courses and whether there has been an improvement in their academic performance.

Table 1 presents the results of these consultations, up to December 2023.

Table 1. Articles published in each search repository consulted

Source consulted	Syntax (English)	Result
IEEE Xplore	Terms: Gamified mathematics software OR Elements of gamification in mathematics software Title, abstract or author-specified keywords: Higher level OR University. Year (s): 2011-2023	125
SCOPUS	Terms: Gamified mathematics software OR Elements of gamification in mathematics software Title, abstract or author-specified keywords:	21
Science Direct	Software Gamified Filters Applied: Journals 2019 – 2023	269
Web of Science	Terms: Gamified mathematics software OR Elements of gamification in mathematics software Title, abstract	5
Scielo	Gamification Elements OR Gamified Math Software	33
Total		453

Source: own elaboration

Exclusion criteria

Thanks to the exclusion criteria, the eligible articles were reduced and Table 2 shows the results after applying these criteria.

Table 2. Articles considered for the study

Source consulted	Number of items
IEEE Xplore	15
SCOPUS	4
Science Direct	9
Web of Science	4
Scielo	5
Total	37

Source: own elaboration

Data Extraction

Based on the information obtained from the consultations, Table 3 shows the top 21 countries from which most contributions come.

Table 3. Countries with the greatest number of contributions to the study of gamified software in recent years.

Country	Amount
India Asia	4
Peru South America	4
Philippines Asia	3
England Europe	3
Germany Europe	2
Türkiye Asia	2
Mexico North America	2
Bulgaria Europe	1
Chile South America	2
Sweden Europe	2
China Asia	1
Denmark	1
Cuba North America	1
Estonia Europe	1
Japan Asia	1
Malaysia Asia	1
South Africa Africa	1
Thailand Asia	1
Brazil South America	1
Spain Europe	1
Canada North America	1
Israel Asia	1
Total	37

Source: own elaboration

From Table 3 it can be observed that 38% of the articles correspond to research carried out in Asian countries, 30% correspond to Spanish-speaking countries, 27% to European research articles, 2.5% correspond to studies carried out by African researchers and 2.5% to North America.

It can also be observed that the Spanish-speaking country that has contributed the most to this research in general has been Peru, while the repository where the most information was found was IEEE Xplorer . Considering these data, it can be noted that the study of gamified software has been gaining more and more interest in the public eye, this in accordance with the exponential growth in the use of technology that has occurred since the beginning of the new millennium.

Data interpretation

In order to carry out the analysis of the topics and aspects addressed in the studies reviewed and, thus, to answer the 4 questions posed, the keywords of the 37 studies were identified. 43 keywords were found in the 37 articles, with a total of 153 mentions, which is shown in Table 5.

It is observed that the ten keywords with the highest number of mentions are “Gamification”, “Mathematics”, “game”, “mobile applications”, “education”, “game-based learning”, “motivation”, “educational software ”, “ game elements” and “early childhood education”. These initial findings suggest a range of factors to be analyzed in greater detail within the course of this research.

Table 4 contains the details of the 153 mentions of the keywords identified in the 37 articles reviewed.

Table 4. Keywords and mentions

	Keyword	Mentions
1	Gamification	16
2	Math	11
3	Game	7
4	Mobile applications	7
5	Education	7
6	Game-based learning	7
7	Motivation	6
8	Educational software	5
9	Game elements	5
10	Early childhood education	5
11	Academic performance	4
12	e-learning	4
13	Mobile learning	4
14	User experience	4
15	Strategies	3
16	Playful experience	3
17	Teaching Mathematics	3
18	Satisfaction	3
19	Interest	3
20	Arithmetic	3
21	Taste	3
22	Enthusiasm	2
23	Technology	2
24	Teaching	2
25	Mobile game	2
26	Learning math	2
27	Augmented reality	2
28	Working memory training	2
29	Game mechanics	2
30	Personalized approach	2
31	Learning	2
32	Cognitive load	2
33	Programming languages	2
34	Adaptive learning	2
35	Task analysis	2
36	Technological innovation	2
37	Unity 3D	1
38	High school students	1
39	Student	1
40	Student evaluation	1
41	Engineering students	1
42	Differential equations	1
43	Learning Management System	1
44	Escape Rooms	1
45	Visual record	1
46	Perception of time	1

	Total	153

Source: own elaboration

Keywords They were grouped into two dimensions, according to similar aspects, with the aim of establishing relationships between them.

The proposed dimensions are as follows:

1) Education and aspects of the teaching-learning process in a Mathematics subject. In this dimension, motivation, feedback and academic performance were considered as aspects, as well as those related to perception, memory and attention, which are cognitive processes that occur in the performance of activities carried out in class. The subjects considered by the researchers were: Arithmetic, which predominates in basic education, Algebra, Geometry, which is included in secondary education, or Differential Equations and Calculus, which are taught at the higher level.
2) Gamification approach, elements, mechanics, games and playful components using technology. This included the term gamification, seen as an approach or methodology used in the reviewed study, as well as the elements, mechanics and dynamics that compose it, according to what was specified by Dicheva. *et al.* (2015), which were integrated into the educational software or application used.

Table 5 shows the total number of mentions according to the two proposed dimensions.

Table 5. Organization of keywords in 6 dimensions

Dimensions	Mentions	
Education and aspects of the teaching-learning process in some Mathematics subject	90	58.8%
Gamification approach, elements, mechanics, games and playful components using technology	63	41.2%
Total	153	100%

Source: own elaboration

Based on the dimensions obtained, it was found that 58.8% of the reviewed studies included more keywords referring to some aspect of the teaching-learning process in a Mathematics course, such as motivation, feedback and academic performance, as well as working memory or some educational component; which allowed us to identify that these studies focused more on reviewing whether there had been any improvement in at least one of the processes mentioned. Consequently, it is perceived that the use of gamified strategies

provide relevant results to promote new scenarios that support learning and encourage student motivation, as well as their commitment and improve their academic performance. In this sense, it is highlighted that 11.1% of the articles that are located in this first dimension include the keywords of motivation and academic performance and explicitly manifest a positive benefit or improvement of motivation. Despite this, there are works that were reviewed and that use other terms that can be considered synonymous with the term motivation, which are: interest, satisfaction, pleasure and enthusiasm. As well as synonyms for academic performance such as: student efficiency and learning obtained. In this sense, the percentage of articles that positively relate gamification with motivation is 68%, that is, 57% with respect to the previous one. And the percentage that deals with the performance obtained by the student constituted 49%. As a part of this percentage also dealt with motivation, it is found that 92% of the articles, which did have the objective of investigating the relationship between gamification and motivation, confirm that gamification promotes both intrinsic motivation, in the absence of other reinforcers, and extrinsic motivation when, in addition, its performance is reinforced externally through different achievement reinforcement systems .

41.2% included gamification elements or some playful component as key words, taking into account technology, in particular some educational program or software. This shows that the interest of these studies was more inclined to identify which mechanics, dynamics or components of gamification had the greatest impact on their students when working on their mathematics course.

In order to gain a deeper understanding of the research carried out, the 37 scientific articles were read, which allowed us to analyse each reported study based on the purpose of this research, which is to answer the 4 questions formulated at the beginning of the PRISMA methodology and which correspond to the 4 specific objectives set out in the introduction of this article.

After having carried out the reading and analysis of the selected scientific articles, the information was organized in a table highlighting the factors identified in relation to the 4 questions formulated. The first column contains the progressive number of the scientific article reviewed, the second column contains the first author of the article and the year of publication, the third column corresponds to the gamification elements, that is, mechanics, dynamics, or components used in the software or educational applications of mathematics addressed in the reported study. The fourth column includes those studies that focused on reviewing whether the application, with the gamification elements included in it, managed to

improve the motivation of the students in the sample with whom they worked. The fifth column shows those studies that reported whether there was an improvement, either in the academic performance of the students, or, an improvement in their learning. The sixth column refers to whether the gamified software used allowed adaptation to the profile of the students, promoting personalized learning. Table 6 shows the organization described.

Table 6. Authors of the articles and factors considered in the questions asked

No.	Authors and year of publication	Gamification elements	Improved motivation	Improved academic performance	Focused on customization	Testing
1	Damaševičius and Sidekersniene (2023).	History, avatars, virtual world			Yeah	
2	Koleva *et al* . (2022).	Dynamic virtual environment			Yeah	
3	Beltrán *et al.* (2020).	Gamification strategies	Yeah	Yeah		Autonomous tasks
4	Robledo- Rella *et al* . (2022).	Badges, awards	Yeah			
5	Elaish *et al* . (2021)	Attractive virtual environment, missions, competition	Yeah			
6	Feng *et al* . (2019)		Yeah			User satisfaction and intention to remain
7	Hastings *et al* . (2022)	Dynamic gamification elements	Yeah		Yeah	Increased participation.
8	Lopez *et al* . (2023)	Points, challenges, rewards, levels	Yeah			
9	Yabut *et al* . (2019)				Yeah	Teachers monitor progress
10	Borotić and Jagušt (2022)	Points rewards, trophies	Yeah	Yeah	Yeah	Pre and post test
11	Flattery *et al.* (2023)			Yeah		Pre and post test, effectiveness, satisfaction
12	Solano-Gonzales *et al* . (2023)			Yeah		High satisfaction in usability
13	Karunasekara (2022)	gamified mobile app	Yeah			Questionnaire
14	Polestic *et al.* (2022)	Leaderboard scores, prizes, rewards	Yeah			Group activities

15	Ramirez *et al* . (2022)	Game-based mobile learning		Yeah		Teacher monitored progress. Grades
16	Mammoth *et al.* (2022)	Challenges	Yeah			Social interaction
17	Boytchev *et al* . (2020)	Aspects of visual aesthetics, musical scores and incentives	Yeah	Yeah	Yeah	Ratings, monitoring
18	Sallik *et al* . (2022)	Game mechanics, characters, missions, points	Yeah			Greater participation
19	Leon -Pazminho (2022)	Gamification		Yeah		
20	Kummanee *et al* . (2020)	Points, rewards, achievements, challenges, levels, leaderboards				Questionnaire
21	Kumar, S. (2021)	Virtual environment, challenges.				Awakens self-learning capabilities
22	Alt, Dorit . (2023).	Avatars, rewards	Yeah			Greater participation
23	Americo *et al* . (2023)			Yeah		Tests . Verbal memory improved and performance
24	Yllana -Prieto *et al* . (2023)	Clues, challenges, rewards	Yeah	Yeah		Pre and post test
25	Koparan *et al* . (2023)	Augmented reality	Yeah			Pre and post test
26	From Mooij *et al* . (2019)	Virtual environment, missions	Yeah			Greater participation in teams.
27	Kakavand *et al* . (2023)	Game elements	Yeah	Yeah		Improved enjoyment and engagement pre and post test
28	Pedersen, M.K. , *et al.*, 2023	Gamified virtual environment , challenges		Yeah		Improved engagement. Pre and post test
29	Aksayli *et al.* (2019)			Yeah		Test to measure working memory capacity

30	Hernandez, C. and Salinas, P. (2019)	Multi-touch table	Yeah	Yeah		Greater participation in the group when manipulating the graphs. Exam
31	Seemann , E. (2014)	Immediate feedback	Yeah			
32	Jimenez-Hernandez *et al* . (2020)	Points, leaderboard	Yeah	Yeah		Reinforce learning, exams
33	Encalada-Diaz, I. A. (2021)	Points, levels, prizes, challenges, leaderboards, avatars	Yeah	Yeah		Competition. Pre and post test questionnaires
34	Espinoza *et al.* (2023)	Stories, missions, awards	Yeah	Yeah		Interacted with the environment. Continuous monitoring
35	Guevara *et al* . (2023)	Stories, avatars , challenges, levels, virtual world	Yeah	Yeah		Monitoring your progress . Quizzes and grades
36	Huamaní, M. del C., and Vega, C.S. (2023).	Badges, points, leaderboards, avatars, rewards, narrative	Yeah	Yeah	Personalization	Pre and post test
37	Cuba, EB, and Mallea, IP (2021).	Points	Yeah			
	Totals		25	18	7	

Source: own elaboration

It can be observed from Table 6 that 68% of the reported investigations focused on reviewing whether gamification made it possible to increase the motivation of the students with whom they worked in their mathematics courses, using educational software or applications, which coincides with the first analysis carried out around the two dimensions established based on the keywords. In their entirety, the studies concluded that motivation had improved or increased in their students thanks to the gamification strategies used. Of the 68% of the aforementioned investigations, 27.2% used the mechanics specified by Acosta, *et al.* (2020) and which refer to either using an attractive virtual environment for the student, or using *avatars* , as well as defining scales for scores and achievements in the educational software used. 16.32% used as dynamics in the software or application, a story or narrative, the formulation of missions or challenges and in general the establishment of rules according

to what was indicated by Coello (2019) . 25.84% used points, prizes, rewards, trophies, badges and leaderboards as gamification components, as expressed by Manzano *et al.* (2022). It should be noted that the sum of the percentages does not equal 68% because in the same study, both mechanics, dynamics and components were used.

It was striking that several of the stories included in the software were related to settings and characters from Japanese literature. In this regard, Godínez *et al.* (2018) comment that Asia is a country that has a great influence on the development of video games, where the era of the samurai predominates, as well as the use of martial arts in combat, also science fiction where dragons and other mythical beings appear, which many software and video game developers use in their stories. It is possible that some of the research carried out on the elements used in gamification are related to aspects of Asian culture due to the large number of films and series that abound on streaming platforms , since currently the market for films and series that include *anime* has a great influence, for example, on the fashion of adolescents and young people.

The use of the different gamified elements improved the student's motivation towards the mathematics content worked on, which was largely due to the way in which the teacher planned his classes to carry them out as pointed out by Espinoza *et al* . (2023), and Guevara *et al* . (2023), when designing a story with the use of avatars and cognitive challenges, which were interesting to their students, in addition to constantly monitoring their performance with the software. This infers that the role of the teacher is fundamental, we cannot leave all the work to the software or the app, due to the fact that its design contains aspects of gamification, rather, it is the work of the teacher and actions carried out in the classroom to involve the student in interesting and competitive work. For example, for Moya (2023) it is essential that the teacher can use the different representation registers when working on Calculus topics such as when it is required to analyze a function or obtain the limit of a function, not only should one work with the algebraic register, but with the iconic, the graphic and the tabular, so that the student can move between them and reach the consolidation of the concept. The student can build the graphs with the software and verify that what he obtained with pencil and paper is the same, also when a context is included that surrounds a problematic situation that the student must solve, it makes it more interesting and attractive to the student, and, more so if there is a story or narrative involved and the student can adopt an avatar. All together it promotes a motivating scenario for the student. This implies that the teacher must be trained in the knowledge and use of playful or gamified tools and can combine aspects of the content of the subject he is teaching, with didactic and metacognitive strategies, to achieve a greater

benefit from the use of educational software.

49% of the reviewed studies focused on analyzing whether gamification had allowed their students to increase their academic performance, finding that this gamification approach, or for some considered as a methodology, managed to improve their performance or their learning. But since academic performance and learning are complex aspects to address because they are multifactorial processes, these reviewed articles focused on how gamification allows the development of the cognitive aspect of the student, their level of involvement through their participation and the strategies used by the teacher. Thus, within the cognitive aspects that intervened when using the software, they considered the cognitive functions used by the student when using the gamified software : memory, attention or comprehension, as well as strategies that allow a positive influence by involving the student with their active participation and metacognitive strategies used by the teacher, such as feedback. To verify that there was an improvement in student performance, 10.6% used the pretest and posttest technique , 22.51 % carried out constant monitoring of the students' work, measuring the progress obtained with questionnaires. 15.9 % applied an exam as part of the course and the professor in charge of the subject made a comparison between the grades obtained before working with the gamified software and after its use.

18.91% of the studies reviewed reported that the educational application they used was characterized by being personalized, thanks to the gamification elements incorporated into it, allowing it to adapt to the different profiles of their students.

It could be observed in the results found by the analyzed studies, that the software or application that allowed the cognitive, social, affective and motor development of the students (Kumar, 2021, Beltrán, *et al* ., 2020 and Americo , *et al* ., 2023) positively influenced the student's participation and their cognitive and socio-affective development, since it presented cognitive challenges, collaborative work and contained positive reinforcements, such as experience points, levels, achievements, trophies, which awakened the student's interest, in addition to presenting a new approach to learning, providing feedback, both in terms of grades, participation and attendance, as well as the students' attitude towards learning. Consequently, it is perceived that a learning environment based on the different forms of the game is an appropriate strategy.

Along the same lines, the authors Hernández and Salinas (2019) found in their study that those introverted students managed to participate in their team to get the points they required, that is, the competition helped to disinhibit the students. According to the results they obtained, it can be said that students get involved in a more easy way in social

circumstances compared to their individual participation, which is the most used form in non-gamified designs .

Discussion

Through the scientific articles reviewed, the theoretical bases of gamification and its relationship with learning were explored, and several studies demonstrated, using statistical techniques, how these principles can be applied effectively in a virtual environment to foster greater student engagement and motivation.

All the studies reviewed used some educational software or application for mathematics, which made use of some mechanics, dynamics or component of gamification, as specified by Dicheva . *et al.* (2015). In 68% of the studies reviewed, the researchers aimed to analyze whether gamification helped increase students' motivation or interest in the mathematics course being taught, and found that it did indeed capture their attention and interest in the topics addressed, which coincides with what was pointed out by Rosero and Medina (2021), who comment on the great educational utility that has been found in gamification. The analysis carried out indicated that the most commonly used aspects of gamification are rewards, trophies, badges, points or prizes , as well as the competition that is generated, which serves as a stimulus for the student to continue with their academic work.

In several reviewed studies, it was found that the participation of the teacher is required both in the planning and in the development of their activities, which include the use of gamification, which is why it is stated that gamification in itself is not enough to motivate the student, but that the way in which gamified elements are incorporated into the teaching-learning process is fundamental, which coincides with what was pointed out by Aguiar *et al.* (2021).

Also, gamification was found to support improving students' academic performance and in 49% of the studies reviewed it was considered as its fundamental purpose. For example, in the study by Beltrán *et al.* (2020) to determine whether the gamified platform used with university students in their mathematics course improved their performance, they evaluated the differences between groups using the t- Student test in the case of having a normal distribution and the non-parametric U-Mann-Whitney test for the case of non-normality. The nine experimental groups that used the gamified methodology were compared through the Kruskal-Wallis test and the k-sample mean . Concluding that academic performance had been improved.

As far as personalized education is concerned, 18.91% of the analyzed researches were interested in working with gamified applications that had a degree of customization, whether the information was presented in a different way, or the problems to be solved, the challenges and the missions had different degrees of complexity, so that it could be adapted to the different levels of knowledge of the students. Having personalized software helps the teacher a lot, because the groups of students are heterogeneous and there is not enough time for the teacher to adapt the topics to the different levels of knowledge of the students or to the different learning styles they have.

Conclusions

After carrying out this study on gamified software , its platforms, and the components it usually includes, it can be concluded that using elements of games in another field, such as education, in order to support the teaching-learning process, is a technique that, depending on the way in which the teacher uses it, as well as the activities that he or she designs and applies in his or her group as part of the gamification, is what allows for increased motivation, as well as an improvement in the student's academic performance.

As a result of the review of scientific articles, it is stated that the gamification of the digital resource used in the different studies kept students interested in the mathematics topics worked on, causing students to commit to achieving their goals, which allowed them, on the one hand , to reinforce their knowledge and, on the other, to improve their academic performance. The gamified digital resource also allowed students to review concepts and apply them in problem solving. The virtual environment of the resources offered an exciting and interactive setting.

Gamification has been considered in the educational field for more than two decades and over time it has been adapted to people in today's society and the technology that surrounds us. This adaptation involves being able to teach young children and young adults using the same basic concepts, which is why elements such as scoring, competition, badges, narrative and feedback are used, since regardless of age, every person feels good about themselves when they see that they obtain positive results and are recognized for it, in addition to the fact that everyone can be immersed in a story.

Future lines of research

The research is planned to be expanded by considering new questions that allow us to discover more benefits of using gamification, not only in mathematics courses, but in other subjects, with the aim of offering the reader different options that can be used to support their classes, whether remotely or in person. It is also considered to build gamified technological tools , validate them with case studies and statistical techniques to be able to show them to teachers who teach the subject of Calculus, whether at the high school or university level.

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