International Journal of **Human Sciences Research**

GAMIFICATION PROPOSAL AS A DIDACTIC STRATEGY FOR THE TEACHING OF MULTIPLICATION

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Abstract: Multiplication is often a stepping stone to understanding more complex mathematical concepts, such as fractions, algebra, statistics and probability, which are essential parts of a child's school education. Unfortunately, multiplication is a mathematical operation taught, by most teachers, in a traditional or rote way, limiting a child's logical thinking and applying rote learning in students, who learn in a mechanical way without achieving meaningful learning. The objective of this research project is to improve the teaching of multiplication in the fifth grade group of Agustin Melgar Elementary School located in the city of Aguascalientes, Mexico, through the implementation of gamification as an innovative teaching strategy together with Information and Communication Technologies (ICT) to achieve a significant impact on learning and encourage active and motivating participation of these students. This proposal was applied in two stages and with a sample of 20 students that make up the primary group of Quinto "B". In the first stage, a survey was applied to the students of the whole group together with their parents to determine their preference for the use of ICT in their teaching and learning process. In the second stage, the group of students was divided into two subgroups, each of 10 students. To one subgroup of 10 students, the active learning methodology based on gamification and supported by the use of ICT was applied. The other half of the students were taught using the traditional mathematics teaching methodology. The results obtained within this second stage show that students who have had a teaching-learning process based on the active learning methodology and ICT, have been more satisfactory in relation to those students who have had the traditional teaching process. From the above, it is concluded that, with the systematic application of the active learning methodology based on gamification and ICT, it will cause a significant improvement in the mathematical skills of students at the primary level.

Keywords: Active learning, mathematics, gamification, serious games, ICT.

INTRODUCTION

The use of gamification in the teaching of basic mathematics has proven to be an innovative and effective pedagogical strategy in recent years because it contributes to the development of fundamental cognitive skills in education. Several studies have documented its positive impact on the learning and motivation of elementary school students. For example, Martinez and Lopez (2020) found that the incorporation of digital games and educational applications in the classroom resulted in a significant increase in students' motivation and academic performance when learning basic multiplication. Likewise, Hernandez and Ramirez (2019) conducted a study in elementary schools in Mexico, where it was observed that students who participated in gamified activities showed improvements in the retention of mathematical concepts and increased class participation.

Another relevant work in the same vein is that of Pérez and Gómez (2021), who evaluated various gamified applications for teaching mathematics, highlighting how these tools promote active and collaborative learning, significantly improving students' mathematical skills. In a comparative study, Fernández and Torres (2022) demonstrated that students who used gamified techniques obtained better results in basic multiplication tests compared to those who used traditional methods, showing that gamification not only increases comprehension but also interest in mathematics.

Finally, Ruiz and Vega (2018) examined the impact of gamification on the development of mathematical competencies in primary education, highlighting the benefits of using di-

gital games in the educational environment to strengthen the learning of multiplication. This background consolidates gamification as a valuable and effective tool for teaching basic mathematics, offering a motivating and participatory approach that benefits student learning.

Thus, it is observed that teaching becomes more student-centered, encouraging autonomy and creativity, preparing students for face challenges in an increasingly digital and changing world. With the implementation of innovative teaching strategies, such as ICT-based gamification, students can develop skills and abilities that could allow them to take an active role in their learning and academic training beyond the classroom context.

The objective of this research project is to demonstrate the improvement of the teaching of multiplication in the fifth grade group "B" of the Agustin Melgar Elementary School located in the city of Aguascalientes, Mexico, through the implementation of gamification as an innovative teaching strategy together with Information and Communication Technologies (ICT) to achieve a significant impact on learning and encourage the active and motivating participation of the students in question.

THEORETICAL FOUNDATIONS

This section mentions the topics that provided a solid basis for the analysis of gamification as a didactic tool supported by ICT in the mathematics classroom.

First, the topic of learning theories was addressed. Constructivism, by Piaget and Vygotsky, holds that learning occurs through active interaction with the environment and the personal construction of knowledge. Gamification and the use of ICT in the teaching of mathematics allow students to interact with content in a playful way, encouraging experimentation and self-exploration, fundamental aspects for the understanding of mathematical concepts

in elementary school. According to Vygotsky, learning is more effective in a social and collaborative environment, which can be achieved through interactive and collaborative games on digital platforms (Vygotsky, 1978).

The second topic studied was gamification as a teaching strategy. Gamification refers to the use of game design elements in non-game contexts, such as education, to increase student motivation and engagement. In mathematics education, the use of points, levels, and rewards encourages active participation and creates a learning environment engaging and motivating. This helps students approach abstract concepts, such as basic operations, in a more entertaining and accessible way (Deterding, 2011).

Then, as a third topic, ICT in Education is briefly explained. The use of ICT in primary education provides access to interactive tools that facilitate the teaching of mathematics through gamified activities. Applications and platforms such as Kahoot and Classcraft allow students to solve mathematical problems in a dynamic and visual way, improving both understanding and retention of content (Cabero & Llorente, 2015). The integration of ICT in the classroom also offers teachers more efficient didactic resources to adapt lessons to students' needs.

Regarding the mathematics curriculum in fifth grade in Mexico, it focuses on the development of skills such as solving more complex problems, handling fractions, decimals and advanced multiplication and division operations. As mathematical concepts become more abstract, *one of the biggest challenges is to keep students motivated and engaged in learning*. Gamification, using ICT platforms, offers an innovative approach by providing interactive and fun activities that make these complex concepts more accessible, allowing students to practice in an engaging way without losing interest (SEP, 2017).

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As a next topic it is important to mention the impact of gamification on motivation and academic performance. Several studies have shown that gamification can significantly improve motivation and academic performance in mathematics. The combination of rewards, instant feedback and graded challenges stimulates healthy competition among students, promoting a positive attitude towards learning. A study by Hamari et al. (2014) shows that students who participate in gamified activities tend to be more persistent problem solvers and more engaged with the content.

Finally, and as a last topic, the pedagogical approach in the use of gamification for the teaching of mathematics is mentioned. The pedagogical approach behind gamification is based on active learning, where students are the main agents of their own learning. By using gamification in mathematics education, it promotes an environment in which students solve problems autonomously and collaboratively, acquiring knowledge in a natural way. In addition, gamification allows the personalization of difficulty levels, which facilitates learning differentiation and ensures that all students, regardless of their abilities, benefit from the process (Zichermann & Cunningham, 2011).

MATERIALS AND METHODS

The primary school group of Quinto "B", of the elementary school Agustín Melgar, located in Lázaro Cárdenas Street s/n, in the community of San Antonio de Peñuelas, Aguascalientes, Mexico, has been chosen for the realization of this research project due to the low academic performance in the area of mathematics and, in particular, in the use of multiplication. Also due to the lack of motivation and interest in the classes, since they are usually taught through traditionalist teaching.

This project begins with the application of a survey to both students and parents using a Google form. The above, with the intention of knowing the main problem about the correct use of multiplication in different areas.

Figure 1. Agustín Melgar elementary school facilities.

Subsequently, it was necessary to take into account that the implementation of the didactic strategy based on gamification and ICT would be complicated due to the lack of a technological infrastructure in the elementary school, which is why an analysis was made of a wide range of technological tools that had the ability to manage, without having an Internet connection, different types of digital resources such as text, images, videos, simulations, among others.

After the analysis of the previous situation, it was determined to use a Learning Object as a didactic resource for the implementation and encapsulation of interactive content facilitating the teaching of multiplication through gamification.

A significant number of technological tools have been analyzed for the development of Learning Objects such as eXeLearning, GLO

Maker, H5P, Articulate Storyline, Adobe Captivate, Genially, Camtasia, among others. From the previous exploration, it was determined to use the eXeLearning technological tool because it is open source, exportable to several international formats, multiplatform and constantly updated. Figure 2 indicates the most important reasons for using eXeLearning in the creation of materials. In addition to all of the above, the most important contribution that this platform offers to the research project is the presentation of the Learning Object in the classroom without Internet connectivity.

Reasons for using eXeLearning in the creation of educational resources (Source: www. exelearning.net).

Another advantage offered by the eXeLearning platform is the set of components (iDevices) focused on the creation of activities that contribute to game-based learning. Some of the games offered by this platform are Padlock, Challenge, Identify, Word Search, among others. Figure 3 shows the game-like elements that eXeLearning offers. In order to achieve active learning and knowledge assessment, the following games have been selected: Guess, Match, Flash Cards and Math Problems.

The versatility of eXeLearning has made it possible to embed different types of digital resources in this research proposal, from videos to dynamic presentations, simulations and interactive elements, thus adding great value to the training, allowing students to test, practice and apply the knowledge acquired about multiplication.

The didactic sequence of the Learning Object has been designed based on the official syllabus of the mathematics course and consists of an Introduction to Multiplication, Commutative Property and Evaluation as shown in Figure 4.
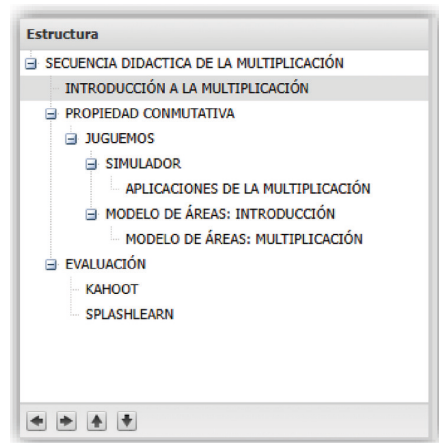

Figure 4. Design of the OA Teaching Sequence.

The *Introduction* section briefly mentions the importance of students' knowledge and understanding of multiplication for use in everyday life. Subsequently, the *Commutative Property* section will allow understanding that, regardless of the order of the factors, the result will be the same. Within this section, interactive games and simulators are presented, facilitating the teaching of Multiplication and making the class interesting, attractive, but, above all, motivating them to want to learn in a simple and fun way. In addition, students not only managed to understand multiplication, but also learned to apply it in solving various mathematical problems, such as calculating the areas of various surfaces.

Finally, in the *Evaluation* section, the technological tools Kahoot and SplashLearn have been embedded to keep track of their achievements and progress in this topic. Based on the Learning Object developed, students and parents were informed of the strategy for using each of the above applications.
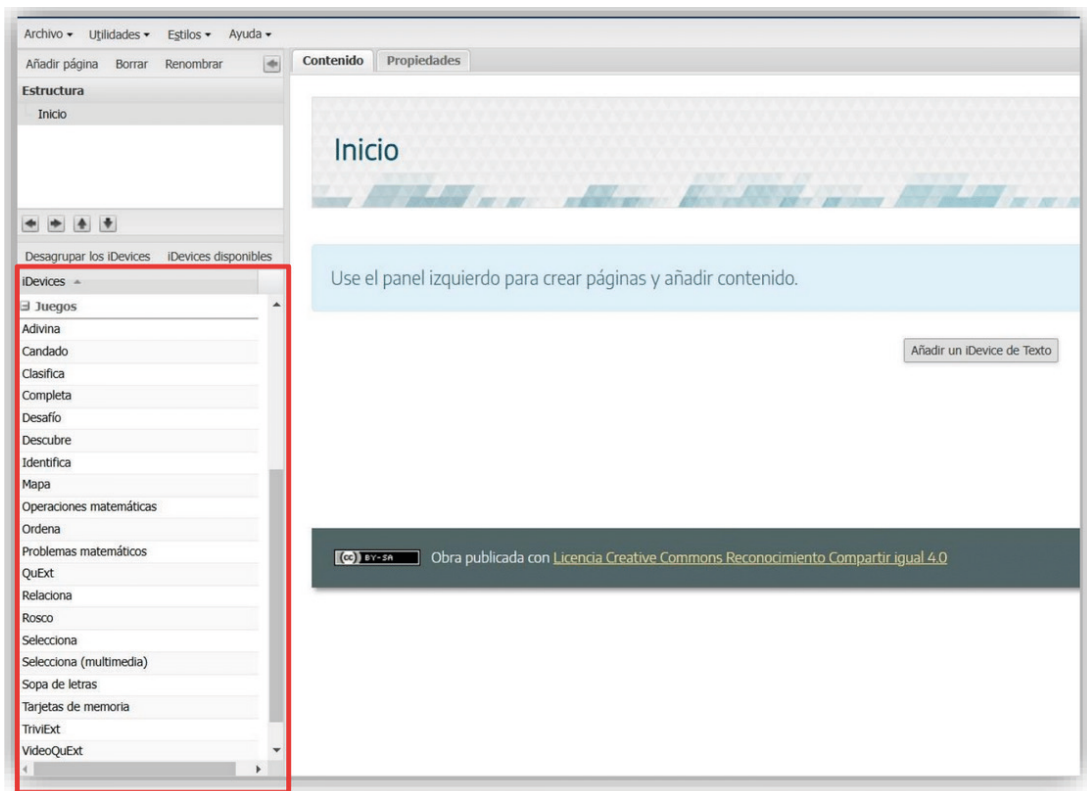
Figure 3. eXeLearning Game-like elements (iDevices).

RESULTS AND DISCUSSION

The results obtained in this research show that gamification offers endless possibilities to provide interesting and motivating teaching, which has allowed fifth grade students to learn significantly about the correct use of multiplication, thus improving their grades and academic performance.

The starting point of this research proposal was the application of the survey to students and parents via a Google form and using the Likert scale to find out the cause of the low results obtained by students in mathematics evaluations, specifically in the subject of multiplication. Figure 5 shows that 43% of the students do not know how to multiply, which is reflected in their low academic performance in some tests involving multiplication.
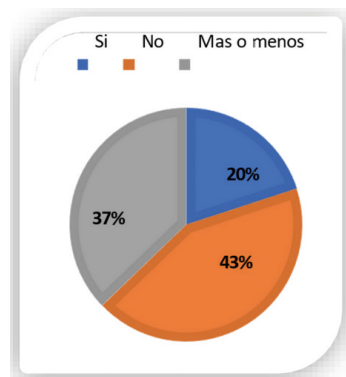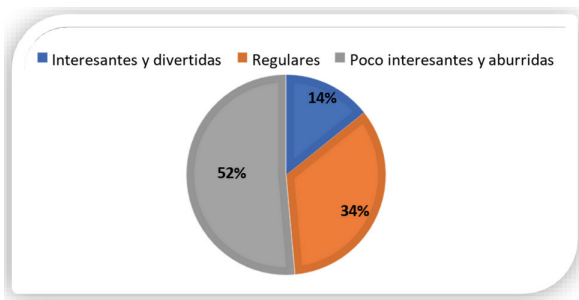

Figure 5. Students' responses on their perception of the correct application of multiplication.

Figure 6 shows that 52% of the students state that they receive classes that are boring. On the other hand, Figure 7 shows that 100% of students would like classes to be more fun and through the use of ICTs; an innate characteristic of digital natives.

Figure 6. Students' perceptions of multiplication teaching.

After identifying the causes of the lack of learning about the use of multiplication, the fifth grade group was divided into two subgroups, each with a sample size of 10 students.

Figure 7. Students' perception of the use of ICTs in the teaching of multiplication.

In Figures 8 to 10, you can see some sections of the OA implemented integrating the topic of Multiplication and under the "kids" style in order to visually captivate primary school students.

Figure 8. Main screens of the developed OA.

Figure 9. Games section of the developed OA.

After having carried out the teaching of multiplication through gamification in the OA, where students participated in various games and competitions, showing motivation and interest in completing the established challenges, we worked with platforms such as Kahoot and SplashLearn to evaluate their learning.

Figure 10. View of the Phet simulator embedding in the developed OA.

Figures 11 and 12 show the results obtained after the application of the assessment through the OA and the Kahoot and SplashLearn technological tools, which clearly show an extraordinary school performance of 100%.

On the other hand, the other subgroup of 10 students who have worked on multiplication with traditionalist teaching was evaluated through a written exam, obtaining a 40% pass rate and a 60% fail rate.

Thus, it is concluded that gamification positively affects the teaching-learning processes since it allows stimulating motivation in students, particularly due to the positive interaction between the teacher and the students.
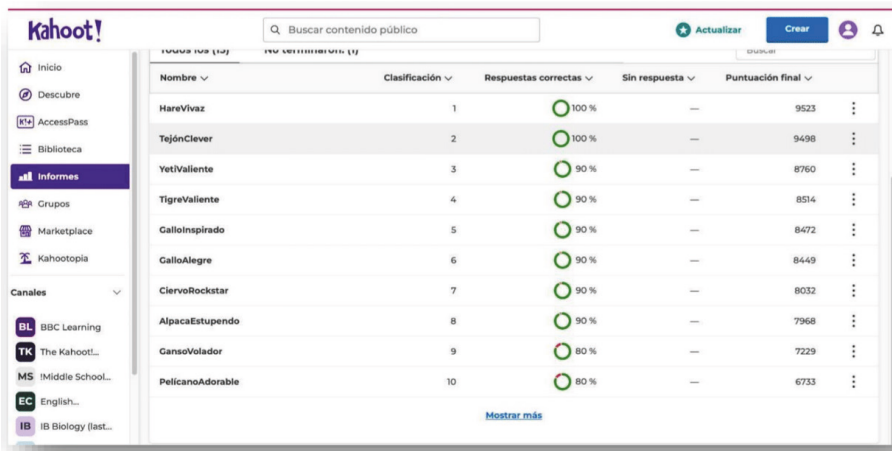
Figure 11. Evaluation report of fifth grade students, Group "B" using Kahoot.
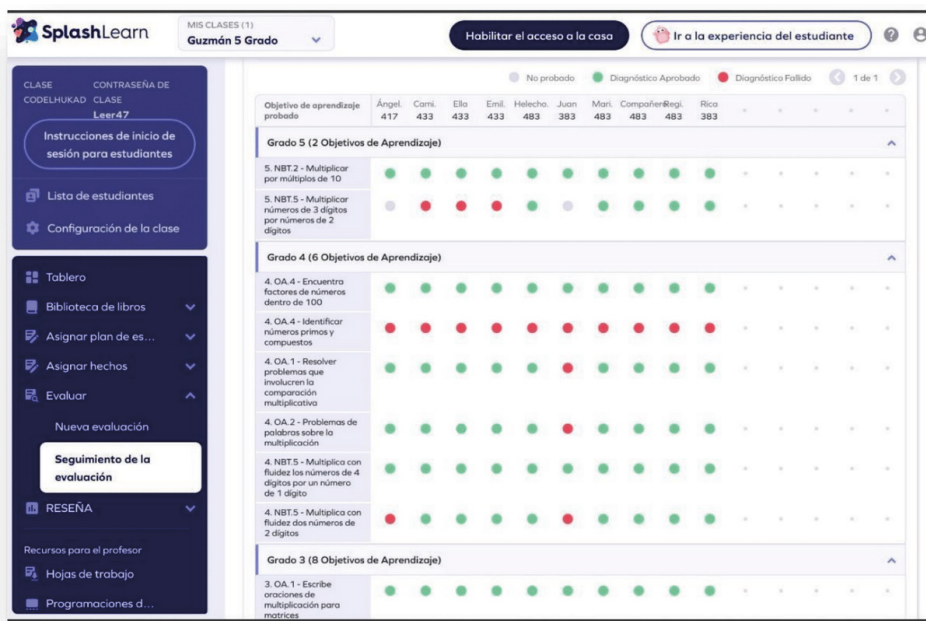

Figure 12. Evaluation report of Fifth grade students, Group "B" using SplashLearn.

CONCLUSIONS

The development of this research work allows us to conclude that gamification, together with ICT, can be used at all educational levels with the purpose of motivating students in their own learning. Also, they are necessary to motivate teachers in the planning and execution of innovative, fun and strategic activities that are oriented to awaken the student's interest to achieve improvements in academic performance.

The results obtained from the implementation of an OA and various digital games are very favorable, showing the great difference in comparison with the data obtained in those students who had a traditionalist teaching-learning process. In addition, it can be demonstrated that gamification works as a motivating didactic strategy in the teaching-learning process to promote specific behaviors in the student within an environment that is more attractive and challenging, that generates a commitment to the proposed activity in which he participates and motivates him to achieve positive experiences to achieve meaningful learning.

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