

Gamification as an educational strategy in the learning of arithmetic for elementary school students

La gamificación como estrategia educativa en el aprendizaje de aritmética para estudiantes de Educación General Básica

A gamificação como estratégia educativa na aprendizagem da aritmética para alunos do Ensino Básico Geral

Denis Javier Salazar Morante*
Oscar Daniel Sánchez Rubio*
Christian Francisco Tomalá Vergara*
Segundo Bienvenido Camatón Arízabal*

Abstract

Arithmetic knowledge in the education of students of General Basic Higher Education (EGBS) is fundamental, since it is the basis of mathematics and its branches, such as Algebra, Geometry and Calculus. This research work seeks to contribute to the improvement of arithmetic learning through gamification as a pedagogical tool for eighth grade EGBS students. For this purpose, a quantitative methodology was used to measure learning progress, develop didactic material with educational games as pedagogical tools and evaluate the evolution of arithmetic knowledge, with the objective that students reach the minimum knowledge required according to the educational standards established by the Ministry of Education for the eighth grade of EGBS. In addition, the inductive method was applied, obtaining conclusions from the observation of specific facts by grouping students and having them develop the proposed material. This allowed establishing precise conclusions, showing that 100% of the students satisfactorily surpassed the knowledge required for their level. In conclusion, it was determined that gamification through didactic material with educational games is an adequate methodology in the face of the large amount of distractions faced by young students both in society and in technological social media.

Keywords: Arithmetic teaching, Quantitative methodology, Higher Basic Education, Gamification.

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* Magister en Tecnología en Innovación Educativa
Universidad de Guayaquil
Facultad de Filosofía, Letras y Ciencias de la Educación
denis.salazarm@ug.edu.ec
<https://orcid.org/0000-0001-7674-1065>

* Licenciado en Pedagogía de las Matemáticas y la Física
Universidad de Guayaquil
Facultad de Filosofía, Letras y Ciencias de la Educación
oscar.sanchezru@ug.edu.ec
<https://orcid.org/0009-0005-8230-1871>

* Magister en Riesgos Financieros y Seguros
Universidad de Guayaquil
Facultad de Filosofía, Letras y Ciencias de la Educación
christian.tomalav@ug.edu.ec
<https://orcid.org/0009-0000-3789-1423>

* Magister en Enseñanza de la Matemática
Universidad de Guayaquil
Facultad de Filosofía, Letras y Ciencias de la Educación
segundo.camatona@ug.edu.ec
<https://orcid.org/0000-0001-8327-2869>

Resumen

Los conocimientos aritméticos en la educación de los estudiantes de Educación General Básica Superior (EGBS) son fundamentales, ya que constituyen la base de las matemáticas y sus ramas, como el Álgebra, la Geometría y el Cálculo. Este trabajo de investigación busca contribuir al mejoramiento del aprendizaje de la aritmética mediante la gamificación como herramienta pedagógica para los estudiantes de octavo grado de EGBS. Para ello, se utilizó una metodología cuantitativa que permitió medir el progreso del aprendizaje, desarrollar material didáctico con juegos educativos como herramientas pedagógicas y evaluar la evolución del conocimiento aritmético, con el objetivo de que los estudiantes alcanzaran los conocimientos mínimos requeridos según los estándares educativos establecidos por el Ministerio de Educación para el octavo grado de EGBS. Además, se aplicó el método inductivo, obteniendo conclusiones a partir de la observación de hechos específicos al agrupar a los estudiantes y hacer que desarrollaran el material propuesto. Esto permitió establecer conclusiones precisas, mostrando que el 100% de los estudiantes superaron satisfactoriamente los conocimientos requeridos para su nivel. En conclusión, se determinó que la gamificación a través de material didáctico con juegos educativos es una metodología adecuada frente a la gran cantidad de distracciones que enfrentan los jóvenes estudiantes tanto en la sociedad como en los medios sociales tecnológicos.

Palabras clave: Enseñanza de la aritmética, Metodología cuantitativa, Educación Básica Superior, Gamificación

Resumo

O conhecimento aritmético na formação dos alunos do Ensino Básico Geral Superior (EGBS) é fundamental, pois é a base da matemática e seus ramos, como Álgebra, Geometria e Cálculo. Este trabalho de investigação procura contribuir para a melhoria da aprendizagem da aritmética através da gamificação como ferramenta pedagógica para alunos do oitavo ano do EGBS. Para isso, foi utilizada uma metodologia quantitativa para medir o progresso da aprendizagem, desenvolver material didático com jogos educativos como ferramentas pedagógicas e avaliar a evolução do conhecimento aritmético, com o objetivo de garantir que os alunos atinjam o conhecimento mínimo exigido de acordo com os padrões educacionais estabelecidos pelo Ministério da Educação para o

oitavo ano da EGBS. Além disso, foi aplicado o método indutivo, obtendo conclusões a partir da observação de factos concretos, agrupando os alunos e fazendo-os desenvolver o material proposto. Isto permitiu tirar conclusões precisas, mostrando que 100% dos alunos passaram satisfatoriamente os conhecimentos exigidos para o seu nível. Em conclusão, determinou-se que a gamificação através de material didático com jogos educativos é uma metodologia adequada face à grande quantidade de distrações que os jovens estudantes enfrentam tanto na sociedade como nas redes sociais tecnológicas.

Palavras-chave: Ensino de aritmética, Metodologia quantitativa, Ensino básico superior, Gamificação.

INTRODUCTION

Arithmetic is the oldest and most elementary branch of mathematics, which deals with the study of numbers and the basic operations that can be carried out with them. These operations include addition (addition), subtraction (subtraction), multiplication and division, and arithmetic also explores how these operations relate to the nature of numbers, whether natural, whole or rational. This subject is fundamental and is taught from the earliest years of formal education, especially at the level of Educación General Básica Media, which covers fifth to seventh grade.

The Ecuadorian Ministry of Education, in its Higher Basic General Education (EGBS) curriculum document, highlights the increasing complexity of mathematical content and processes from the intermediate and higher sub-levels of EGB. According to this document, "from the middle and upper sublevels of EBE, mathematical content and processes become systematically more complex, (...) leading to the development of reflective and logical thinking that allows them to solve real-life problems" (Ministry of Education of Ecuador, 2019, p. 344). This means that students at this level acquire essential competences, integrating mathematical skills into their reasoning and problem-solving in everyday life. To achieve this, it is essential to have a broad knowledge and mastery of elementary arithmetic operations and their application to various sets of numbers.

However, a significant problem has arisen in the wake of the COVID-19 pandemic. A large percentage of pupils in the eighth year of General Basic Secondary Education arrived at this level with significant deficiencies in their knowledge of arithmetic. This situation is exacerbated given the curriculum and quality standards

set by the Ministry of Education, which require students to have an adequate command of this basic knowledge in order to facilitate the teaching-learning process, both individually and collectively.

An article entitled "Mathematics Education and COVID-19 in the Americas" (Llinares, 2021, p. 25) mentions that, according to preliminary data from the state of California (USA), in May 2021, significant losses in mathematics learning were observed among students in the early grades, with those from low family incomes being the most affected. The article also highlights the importance of documenting how different contexts have responded to these demands, in order to identify gains and areas for improvement in mathematics education. This demonstrates that the pandemic has had a profound impact on mathematics education and that it is essential to consider adaptations and lessons learned to address deficiencies in students' numeracy.

In this regard, several reasons have been identified behind the gaps in eighth graders' numeracy knowledge. These reasons include demotivation due to fear of the subject, personal problems, pressure from parents and boredom due to negative perceptions or the way the subject has been taught so far. These negative perceptions of mathematics can have a significant impact on students' academic performance.

The psychological aspect plays a crucial role in learning numeracy. Responsibility, self-esteem and willingness are fundamental values that influence students' performance. Without proper management and support, negative perceptions of mathematics can lead to further problems. An article from the University of Costa Rica notes that "according to the students' view of mathematics, in general, the characteristics of difficult, complicated, boring, mechanical, rigid, exact, that cannot be changed, (...) and that generates fear stand out" (Gamboa & Moreira, 2017). These negative perceptions highlight the need to approach numeracy learning in a way that is engaging and accessible to students.

It is in this context that gamification emerges as a viable solution. Gamification, which involves the use of game elements and dynamics in educational contexts, can transform the perception of numeracy and improve student learning. By incorporating educational games and playful activities into the teaching process, learning arithmetic can become more interactive and motivating. This not only helps to reduce fear and demotivation, but also promotes a deeper and more practical understanding of mathematical concepts.

In conclusion, arithmetic is a fundamental basis in mathematics teaching, essential for the development of reasoning and problem-solving skills. However, the COVID-19 pandemic has exacerbated deficiencies in arithmetic knowledge among eighth-grade EGBS students. Psychological factors and negative perceptions of mathematics also contribute to these deficiencies. Gamification presents itself as a promising pedagogical tool to address these challenges, making learning more engaging and effective. Adopting innovative approaches such as gamification can help improve academic performance and better prepare students for future mathematical challenges.

MATERIALS AND METHODS

This study employs a pre-experimental design (Hernández-Sampieri, 2014) with a single group of 23 eighth grade students of Educación General Básica Superior (EGBS). The intervention consists of the use of gamification to improve arithmetic learning. The study will be conducted by applying an entrance test (pretest) before the intervention and an exit test (posttest) after the intervention.

The participants of the study are 23 eighth grade students. These students have been selected due to prior identification of gaps in their arithmetic knowledge, exacerbated by educational difficulties during the COVID-19 pandemic.

Pretest: An arithmetic test will be designed to evaluate students' knowledge of basic operations (addition, subtraction, multiplication and division) and their application to everyday problems. This test will be applied before the intervention to establish a baseline of students' knowledge.

Post-test: After the intervention, a test similar to the pre-test will be administered to evaluate the same arithmetic concepts. This test will allow measuring progress and improvements in students' knowledge as a result of the intervention.

The intervention will consist of the implementation of gamification as a pedagogical tool in arithmetic classes for a period of 8 weeks. Gamification will be integrated into the curriculum through the following activities:

Digital Educational Games: digital platforms offering interactive games focused on arithmetic operations will be used. These games will be designed to adapt to the skill level of each student, providing immediate feedback and opportunities for repeated practice.

Competitions and Challenges: Arithmetic competitions and challenges will be organized in which students can participate individually or in groups. These activities will foster collaboration and team spirit, as well as motivate students to improve their skills.

Rewards and Recognition: A reward system will be implemented in which students will earn points, badges or certificates by completing tasks and reaching certain levels of proficiency in arithmetic games. This system will incentivize active participation and continued effort.

Classroom Integration: Gamification games and activities will be integrated into daily arithmetic lessons. Teachers will use these resources to complement traditional teaching and make learning more engaging and dynamic.

Preparation Phase:

- Selection and adaptation of digital educational games and design of competencies.
- Training of teachers in the use of gamification tools.
- Design and validation of pretest and posttest.

Implementation Phase:

- Application of the pretest to the 23 students to assess their initial knowledge.
- Implementation of the gamification intervention for 8 weeks, integrating game activities into the arithmetic lessons.
- Monitoring and recording of students' participation and progress during the intervention.

Evaluation Phase:

- Application of the posttest at the end of the intervention period.
- Comparative analysis of pretest and posttest results to measure the impact of gamification on arithmetic learning.
- Collection of feedback from students and teachers on the gamification experience.

Data Analysis

Data obtained from the pretests and posttests will be analyzed using descriptive and comparative statistical methods. Means, medians, and standard deviations of test scores will be calculated to assess overall performance. A t-test for dependent samples will be used to determine if there is a significant difference in student scores before and after the intervention.

RESULTS

After the gamification intervention in teaching arithmetic to the 23 eighth grade students, significant improvements in their arithmetic knowledge and skills were observed. The pretest and posttest results were analyzed using a t-test for dependent samples to determine if the difference in scores was statistically significant.

Pretest: The mean pretest scores were 60.3 with a standard deviation of 8.2. This indicates that, prior to the intervention, students' arithmetic knowledge was below the expected level for their grade level.

Posttest: After the intervention, the mean of the posttest scores increased to 85.7 with a standard deviation of 6.5. This significant increase shows a marked improvement in students' arithmetic performance.

Paired t-test

A paired t-test was performed to compare pretest and posttest scores. The results were as follows:

$$- t(22) = -14.82; p < 0.001.$$

These results indicate a significant difference in scores before and after the intervention. The p-value less than 0.001 demonstrates that the observed improvement is not a product of chance, but can be attributed to the effectiveness of gamification in teaching arithmetic.

The significant improvement in the posttest scores suggests that gamification was an effective pedagogical tool for improving students' arithmetic knowledge and skills. The motivation and interest generated by the gamified activities likely contributed to increased engagement and understanding of arithmetic concepts. In addition, the use of rewards and recognition within the gamification system may have incentivized students to try harder and overcome their challenges in learning arithmetic.

The results of this study demonstrate that gamification can be an effective strategy to address gaps in arithmetic knowledge, especially in contexts affected by educational disruptions such as the COVID-19 pandemic.

CONCLUSIONS

This study focused on evaluating the impact of gamification on arithmetic learning among eighth grade students of General Basic Higher Education (EGBS). The results obtained show that gamification can be a highly effective pedagogical tool to improve arithmetic knowledge and skills. Before the intervention, students showed arithmetic knowledge below the expected level, with a mean pretest score of 60.3. However, after eight weeks of gamified activities, the mean posttest score increased significantly to 85.7. The t-test for dependent samples yielded a $t(22)$ value = -14.82, with a p-value < 0.001; indicating a statistically significant improvement in students' scores after the intervention. This result suggests that gamification not only increased academic performance, but also improved students' motivation and engagement in learning arithmetic.

The gamification intervention included digital educational games, competitions and challenges, as well as a reward and recognition system. These strategies not only made learning more engaging and fun, but also fostered an environment of collaboration and healthy competition, which contributed to the development of reflective and logical thinking in students.

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