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La gamificación, una estrategia didáctica para fortalecer la elaboración de algoritmos

Gamification, a didactic strategy to strengthen the development of algorithms

Gamificação, uma estratégia didática para fortalecer o desenvolvimento de algoritmos

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Resumen

El objetivo de este trabajo fue evaluar la relación entre la gamificación y el aprovechamiento escolar en la elaboración de algoritmos en la asignatura de Fundamentos de programación, Correspondiente al primer semestre de ingeniería en sistemas computacionales del Tecnológico Nacional, campus Campeche. La investigación se llevó a cabo en 2023 en el campus mencionado, con la participación de 59 estudiantes de la carrera de Ingeniería en Sistemas Computacionales, específicamente en la asignatura de Fundamentos de Programación. Se empleó un diseño *Pretest-Postes* durante el semestre, con el desarrollo de actividades didácticas y evaluativas.

La hipótesis es la siguiente: los alumnos que utilizan la gamificación como estrategia didáctica, elevan su aprovechamiento escolar comparado con los alumnos que no la usan. Este estudio conlleva un estudio cuantitativo y con un diseño cuasiexperimental *Pretest-Postest*, con un grupo de control y uno experimental.

Los resultados obtenidos indican que la gamificación contribuye efectivamente al incremento del aprovechamiento escolar, Además, fomenta la competitividad en la resolución de problemas algorítmicos y despierta la curiosidad del alumnado respecto a la disponibilidad de nuevo material gamificado, lo cual se traduce en un creciente interés por esta estrategia didáctica.

Palabras clave: Gamificación, educación superior, didáctica, videojuegos.

Abstract

The objective of this study was to evaluate the relationship between gamification and academic achievement in the development of algorithms in the Programming Fundamentals course during the first semester of the Computer Systems Engineering program at the Tecnológico Nacional de México, Campeche campus. The research was conducted in 2023 at the aforementioned campus, with the participation of 59 students from the Computer Systems Engineering program, specifically in the Programming Fundamentals course. A *Pretest-Post* design was used throughout the semester, with the development of didactic and assessment activities.

The hypothesis is as follows: students who use gamification as a teaching strategy improve their academic achievement compared to students who do not. This study involves a

quantitative study with a quasi-experimental pretest-posttest design, with a control group and an experimental group.

The results obtained indicate that gamification effectively contributes to increasing academic achievement. Furthermore, it encourages competitiveness in solving algorithmic problems and arouses students' curiosity regarding the availability of new gamified material, which translates into a growing interest in this teaching strategy.

Keywords: Gamification, higher education, pedagogy, educational videogames.

Resumo

O objetivo deste trabalho foi avaliar a relação entre gamificação e desempenho acadêmico no desenvolvimento de algoritmos na disciplina de fundamentos de programação no primeiro semestre de engenharia de sistemas de computação do Tecnológico Nacional, campus Campeche. A pesquisa foi realizada no Tecnológico Nacional de México, campus Campeche, em 2023, onde participaram 59 alunos da área de engenharia de sistemas de computação, na aula de fundamentos de programação. Foi utilizado um processo de Pré-teste e Pós-teste durante o semestre, desenvolvendo atividades didáticas e avaliativas.

A hipótese é a seguinte: alunos que utilizam a gamificação como estratégia de ensino aumentam seu rendimento acadêmico em comparação aos alunos que não a utilizam. Este estudo envolve um estudo quantitativo e um desenho quase experimental de Pré-teste-Pós-teste, com um grupo controle e um grupo experimental.

Os resultados obtidos indicam que a gamificação contribui efetivamente para aumentar o rendimento escolar, desenvolver a competitividade na resolução de problemas algorítmicos, a curiosidade em saber quando estará disponível mais material de gamificação, o que conclui no interesse pela estratégia.

Palavras-chave: Gamificação, ensino superior, didática, jogos eletrônicos.

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Introduction

The convergence of technology and cognitive psychology has given rise to an emerging field that seeks to transform people's interactions with complex systems. According to Marín, V. (2015), gamification, understood as the application of game design principles and mechanics in non-game contexts, has demonstrated remarkable potential to motivate, foster engagement, and improve performance in various fields. At the same time, algorithms, as sets of instructions that guide decision-making and solve problems, have experienced notable advances, driven by increasing computational power and innovation in artificial intelligence.

In the current digital age, where interaction with computer systems and participation in online activities have become ubiquitous, gamification has emerged as an attractive strategy for addressing challenges in areas as diverse as education, healthcare, marketing, and civic engagement (Rivoir and Morales, 2019). The principles underlying gamification, such as reward, goal achievement, and immediate feedback, can influence human behavior in ways that go beyond traditional methods (Kenny and McDaniel, 2011), with positive effects on the teaching-learning process (Denny, 2013). Banfield and Wilkerson (2014) argue that gamification is a methodology linked to Experiential Learning Theory (ELT), and point out that one of the main current pedagogical challenges is transforming extrinsic motivation into intrinsic motivation.

Playing is one of the most important and enjoyable activities known as a form of recreation, fun or universal activity, used by people, it is a common activity that encompasses the uses and customs of our societies (Dupuy and Gómez, 2022), which have evolved alongside science and technology, today children are found playing with a cell phone or a tablet.

In the early 1980s, the video game industry experienced tremendous growth, driven by the popularity of arcades and the first video game consoles that emerged in the 1970s. A technological revolution followed, with the emergence of 8-bit and 16-bit consoles.

As technology advanced, the way we play changed, with consoles moving into homes and entertainment centers moving away. In 2010, with the convergence of all technology in video games, gamification emerged. Gamification consists of the use of game mechanics, elements, and design techniques in non-game contexts to engage users and solve problems (Zichermann & Cunningham, 2011; Werbach & Hunter, 2012).

Gamification is based on structures specific to video game design, and its integration into educational contexts, such as the classroom, has demonstrated high student acceptance. This strategy fosters motivation by transforming the teaching-learning process into a more engaging experience compared to traditional methods. It also promotes key pedagogical benefits such as immediate feedback, the development of autonomy, and personalized learning.

The synergy between gamification and algorithms presents fertile ground for research and innovation. As technologies advance and pedagogical approaches evolve, an opportunity arises to combine the power of gamification with the efficiency of algorithms to address complex challenges, especially in areas where the impact on learning is significant, such as personalized education. Other fields such as behavioral health and business process optimization also benefit from this convergence.

The purpose of this article is to explore in depth the intersection between gamification and academic achievement. Throughout this article, key issues will be addressed, such as the selection of appropriate algorithms for different gamified contexts, ethical challenges related to the collection and use of user data, and potential limitations and areas for improvement in the integration of gamification and algorithms. Deterding, S. (2011), defines gamification as the use of video game design elements in non-game contexts to make a product, service, or application more fun, engaging, and motivating. For their part, Landers and Callan, (2011) propose the addition of elements commonly associated with games.

The problem centers on the teaching of programming fundamentals, where a high rate of poor academic achievement has been identified. In the Computer Systems Engineering program, 60% of students fail this subject, which significantly contributes to a 20% dropout rate during the first semesters. Among the factors observed are low levels of academic motivation and the limited implementation of innovative pedagogical strategies, which could influence the development of skills necessary for the active construction of knowledge. Similarly, experts agree that the traditional training process based on the knowledge transfer model has fallen short of current society needs (Boude and Sarmiento, 2017).

Teaching, according to Hattie (2012), The teaching process should be based on the student's prior knowledge and oriented toward the course objectives. To consolidate learning, it is key to encourage its practical application through challenges appropriate to the group's skill level, which are stimulating but achievable.

It is essential to provide clear examples as a reference and guide the development of tasks, jobs or expected products (Reigeluth, 2016).

Ultimately, this research seeks to contribute to a deeper understanding of how the synergy between gamification and algorithms can transform the way we interact with educational technologies and systems, providing new insights into how to optimize motivation and learning in the modern world.

Methodology

This project adopts a quantitative research approach, with a quasi-experimental design, whose objective is to analyze the relationship between the use of gamification as a teaching strategy and academic achievement (Hernández and Mendoza, 2018).

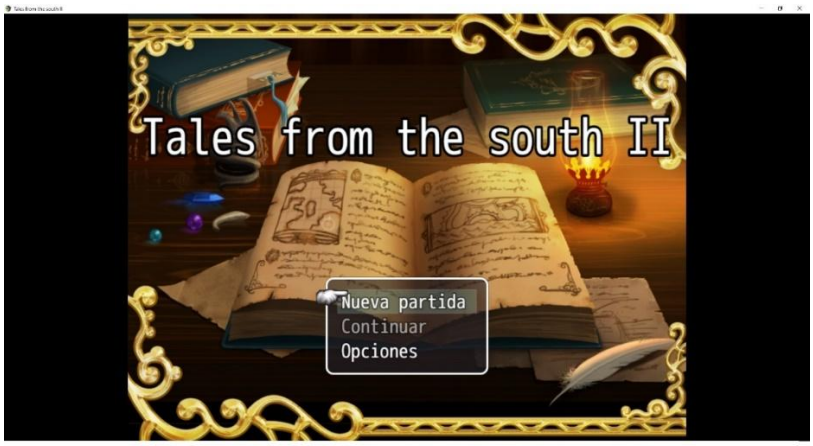
The aim is to determine how various facts, phenomena, concepts, variables or characteristics are related or linked to each other, Hernández and Mendoza, (2018, p.116).

The study was conducted in 2023 at the National Technological Institute of Mexico, Campeche campus, with a sample of 59 first-semester Computer Systems Engineering students. Of these, 29 formed the experimental group and 30 the control group. The control group followed a traditional teaching methodology. In parallel, an educational video game was designed that integrated the content of the "Programming Fundamentals" course. This video game was given to the experimental group, who used it to gamify the learning process. Assessment exercises were then applied to the content.

Analysis of the results

A role-playing game called Tales from the South II was developed, incorporating topics from the first unit of the Programming Fundamentals course (code AED-1285). This game allowed students to reinforce theoretical concepts and analyze programming elements in a narrative environment specifically designed for the project.

Figure 1. Main screen of Tales from the South II



Source: Prepared by the authors.

An initial questionnaire was administered to gather information on the content of the programming fundamentals course in the control and experimental groups, serving as a pretest. The experimental group then began the treatment phase, which included an information session on the rules, mechanics, and objectives of the game, as well as their relationship to the course. The average game duration, from start to finish, ranged between three and four hours. The gamified environment was designed and developed using the RPG Maker MV platform, integrating educational content and adapting video game production tools to a gamification approach.

The first stage of the gamification process was implemented, in which the game's opening act was presented. This phase introduces the narrative development centered on the rise of the protagonist, who must complete various activities, such as identifying adversaries and uncovering a conspiracy within the kingdom, in which the prince is involved. Throughout this journey, the player interacts with secondary characters who provide key information through prompts containing concepts and questions related to the topics of the Programming Fundamentals course.

Figure 2. Event, promotion to captain.

Source: Prepared by the authors

Figure 3 : Dynamic combats

Source: Prepared by the authors

At the end of the first chapter of the game "Gamifying in the Cave," a series of multiple-choice questions are presented to reinforce the content covered. Correct answers grant rewards that facilitate progression within the game, such as a set of items stored in the player's inventory, which reduce the difficulty when facing enemies. It is also important for students to show the teacher the contents of their inventory, as the rewards obtained have pedagogical value that must be evaluated as part of the learning process monitoring process.

Figure 4. Gamification

Source: Prepared by the authors

In order to identify differences in initial academic performance between the experimental and control groups, a Student t-test for independent samples was applied, considering the grades obtained in the pretest of the Programming Fundamentals subject.

The experimental group (n = 29) had a mean of 7.5 with a standard deviation of 0.856, while the control group (n = 30) had a mean of 7.9 and a standard deviation of 0.8985. The t-test yielded a t-statistic of -1.77, with 57.98 degrees of freedom and a p-value of 0.083.

Since the p-value is above the commonly accepted threshold of 0.05, no statistically significant differences were found between the two groups in the pretest. This suggests that levels of prior knowledge of the subject matter were comparable at the start of the study, which allows for the assumption of equivalent conditions for the subsequent analysis of the impact of the experimental treatment.

Following the implementation of the gamified treatment, a comparative analysis was performed between the experimental and control groups using a Student t-test for independent samples, in order to evaluate the impact of the intervention on academic performance.

The experimental group (n = 29) obtained a mean of 8.6 with a standard deviation of 0.6245, while the control group (n = 30) achieved a mean of 7.9 with a standard deviation of 0.8877. The difference in means between the two groups was 0.66 points in favor of the experimental group. Furthermore, a smaller dispersion was observed in the experimental group's grades, indicating a more uniform performance among its members compared to the control group.

The t-test yielded a t-statistic of 3.55, with 53.96 degrees of freedom and a p-value of 0.0008. Since this value is significantly lower than the threshold of 0.05, it is concluded that there are statistically significant differences between the two groups in the post-test. These results suggest that the gamification-based treatment had a positive and significant impact on the students' academic performance.

Discussions

Based on the analysis of the results, it is concluded that gamification is a tool that enhances the teaching process among students of the Computer Systems Engineering program at the National Institute of Technology of Mexico, Campeche campus. The video game used encouraged greater student participation in solving exercises related to flowcharts and programming. Furthermore, teachers actively participated in the design, programming, and validation of the curriculum incorporated into the various chapters of Tales from the South II.

The implementation of video games as a teaching strategy was well received by students, who expressed a high level of acceptance. Furthermore, this resource sparked interest in video game programming, fostering curiosity and the desire to develop their own educational and recreational applications.

During the implementation process, we received various suggestions from students, including new challenges, alternative storylines, and even interactive scenarios such as a "battle arena." These observations led to the identification of opportunities to modify the narrative, incorporate additional content, and expand the learning units within the gamified environment.

The results show that gamification-based educational resources can have a significant impact on learning, facilitating skill development and promoting meaningful learning in students.

Acosta, Aguayo, Ancajima and Delgado (2022) argue that educational resources based on gamification elements can generate motivation in the learning process at all educational levels, contributing to the development of skills and abilities in students.

Martínez and Ríos (2019) argue that gamification is an effective means of promoting innovation processes in higher education by combining technology, active pedagogy, and institutional frameworks. They also propose lines of research aimed at providing the academic community with more dynamic and adaptive learning environments.

Gil-Quintana and Prieto Jurado (2020) point out that the results derived from the application of gamified practices in the classroom have been significant and satisfactory. Teachers observed that learning becomes a more natural and spontaneous process, as students perceive the experience as a game and not as an academic obligation. This perception favors the understanding of content, especially when it is organically integrated into gamified environments.

Conclusions

Gamification incorporates four fundamental structural features: rewards, status, achievements, and competition. During the implementation of this strategy, students demonstrated a remarkable level of interaction and motivation. At the end of each level of the game, participants frequently exchanged information about their progress, compared answers, and consulted with the teacher to determine who had performed best within the group. Gamification as a learning strategy fostered socialization, intrinsic motivation, and active student participation. This dynamic encouraged voluntary repetition of the game with the goal of completing levels, enhancing their performance, and testing both their cognitive skills and technical knowledge.

In summary, the results obtained indicate that the objectives set were met. Educational video games proved effective not only in knowledge acquisition and skill development, but also in creating playful learning environments that foster student participation and engagement. Furthermore, this approach significantly contributes to mitigating educational gaps.

Consequently, gamification is a strategy of growing interest to the academic community, especially in the field of engineering education, given its potential to improve teaching and foster meaningful learning.

Future lines of research

The results obtained suggest a positive influence of gamification in the classroom, especially regarding student motivation. However, more in-depth studies are needed to analyze how video games impact different contexts, such as motivation in the workplace. In this context, new lines of research are also emerging, such as exploring mechanisms that could motivate students to develop their own video games.

The video game's favorable reception by students also raised concerns about its development, opening up a potential line of research focused on teaching programming applied to video game design. Among the possible future lines is teaching the C# programming language through video game development, using platforms like Godot Engine. This proposal would allow for linking the acquisition of technical skills with creative processes in the classroom.

Limitations of the study

Although gamification has proven to be an effective strategy for improving academic achievement, the results obtained do not offer conclusive evidence of its impact on reducing school dropout rates.

From another perspective, while gamification has proven effective in the classroom setting, it is still unknown to what extent this strategy can remain effective outside of that environment, especially considering the constant presence of external distractions.

To strengthen the validity of the findings, it is recommended that the study be replicated in other undergraduate programs or in core subjects such as mathematics and physics, where failure rates have historically been higher.

Gratitude

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