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Estrategia de aprendizaje desde la gamificación para estudiantes con Trastorno por Déficit de Atención e Hiperactividad

Learning strategy from gamification for students with Attention Deficit Hyperactivity Disorder

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RESUMEN: El rendimiento académico en bachillerato es fundamental para promover políticas inclusivas que mejoren la calidad educativa. Este estudio diseñó una estrategia pedagógica para optimizar el rendimiento de estudiantes con TDAH en Programación. Se aplicó una metodología de investigación mixta (cuantitativa y cualitativa) para diagnosticar la situación inicial y justificar la solución propuesta. La estrategia, con enfoque multimodal y multisensorial, incorpora recursos auditivos, visuales y kinestésicos, apoyados en la gamificación. Se desarrolla en tres fases y cinco etapas escalonadas. Validada en una Unidad Educativa, mostró resultados satisfactorios y es potencialmente generalizable al bachillerato actual.

Palabras clave: Estrategia de aprendizaje; Gamificación; Trastorno por déficit de atención e hiperactividad (TDAH); Programación; Multimodalidad; Multisensorial

ABSTRACT: Academic performance in high school is essential to promote inclusive policies that improve educational quality. This study designed a pedagogical strategy to optimize the performance of students with ADHD in Programming. A mixed research methodology (quantitative and qualitative) was applied to diagnose the initial situation and justify the proposed solution. The strategy, with a multimodal and multisensory approach, incorporates auditory, visual and kinesthetic resources, supported by gamification. It is developed in three phases and five staggered stages. Validated in an Educational Unit, it showed satisfactory results and is potentially generalizable to the current high school.

Keywords: Learning strategy; Gamification; Attention deficit hyperactivity disorder (ADHD); Programming; Multimodality; Multisensory

Introduction

The academic performance of students is currently being affected by multiple factors, some of them linked to the teaching-learning process, as it acquires complexities, depending on the activity to be developed, especially in technical areas such as computer programming.

Thus, pedagogical sciences rethink actions to improve students' academic performance from pedagogical alternatives with different approaches; authors such as Cordero and León (2021) emphasize pedagogical attention and teacher preparation. Also, Ethington (1990) examined the validity of the Academic Choice Model (AEM) of Eccles et al. (1984), concluding that previous academic performance affects students' future performance by acting on their self-concept, their perception of study difficulties, their goals, values and expectations of success.

According to Willcutt *et al.* (2005) and Vázquez and Chaves (2020), academic implications in students with Attention Deficit Hyperactivity Disorder (ADHD) are related to deficits in executive functions, such as working memory and inhibitory control. Hence (Barkley, 2002, p. 6), defines it as "a disorder of the executive brain that causes the student's inability to inhibit or delay their responses, to organize and control their attention, behavior or emotions, and to cope with the demands placed on them".

According to Salgado and Núñez (2017), this type of disorder interferes with students' ability to concentrate on tasks that demand prolonged attention and require a high degree of analysis, planning and problem solving, affecting the understanding of complex topics in computer programming.

It is crucial to provide studies and perspectives that facilitate the teaching and learning process of programming with systemic and communicative nature, considering interdependent teaching and learning, as well as the elements, personal (student, teacher, group) and non-personal (objectives, contents, methods, means, evaluation), that make it up Ibáñez *et al.* (2014).

As an important factor for learning in students with ADHD, gamification stands out, the application of game design principles to motivate and engage people in playful activities by integrating game elements in the educational environment, and allowing students to interact with the contents in a more attractive and motivating way (Zichermann & Cunningham, 2011, p. 20) describe gamification as "the use of mechanics, elements and techniques of game design in non-game contexts to engage users and solve problems".

On the other hand, several researches (Abril, 2020) and Duarte (2022), agree that gamification improves intrinsic motivation, constitutes an effective tool to improve attention and interest in learning, encourages active participation, provides a flexible environment and, above all, achieves

the expected impact by ensuring that students correct to a large extent the nature of the difficulty they present in the learning process,

The factual diagnosis was carried out on a population made up of students with ADHD taking the subject of Programming at the "María Auxiliadora" High School Educational Unit. Due to the nature of the population (4 students), enrolled in the subject Programming, within the mesh of the professional figure of Computer Science, we will work with the totality of students identified with ADHD, without the need to apply a sampling, it has been observed that:

- Students with ADHD often disrupt the programming class, indicating that they are confused by the instructions or have difficulty keeping up with the topic.
- During team activities, they are frequently rejected by their peers, as they tend to be distracted and do not consistently collaborate with assigned tasks.
- They have difficulty remaining seated for prolonged periods of time, which leads them to continually stand up or lose focus.
- When performing individual activities, they show a tendency to procrastinate or not finish tasks due to lack of organization and impulse control.

Therefore, the research problem is conceived as: How to improve academic performance in students with ADHD who take the subject programming in the professional figure of computer science? In this sense, the objective is to develop a learning strategy based on gamification, to improve academic performance in students with ADHD who take the subject Programming, in the professional figure of Computer Science in the Educational Unit of the High School "María Auxiliadora".

The approach of this study is mixed and the type of research is applied, since it offers an integral and participative vision of the methodological approaches required for the improvement of the academic performance of students with ADHD. And within the research methods, synthesis analysis, induction deduction, documentary analysis, semi-structured interviews, frequency analysis, qualitative analysis are referred to.

The population and sample will be constituted by the students with ADHD who take the subject of Programming in the Educational Unit. Due to the nature of the population (4 students), we will work with all of them identified with ADHD, without the need to apply sampling.

Several methods will be used to ensure an exhaustive analysis:

Documentary analysis: review of reports of the grades obtained by the students at the end of the first quarter of the present academic year 2024-2025, in the subject Programming of the professional figure Computer Science, to diagnose the current status of the academic performance of students with ADHD.

Semi-structured interviews: Directed to teachers and students to obtain a deeper insight into the possible causes that explain the current state of academic performance of students with ADHD enrolled in the subject Programming in the professional figure of Computer Science.

The key variables in this research are: the dependent variable, academic performance defined as the final grade obtained by the students in the subject of Programming in the professional figure of Computer Science and the independent variable, learning supported by gamification, the multimodal and multisensory approach was used as a methodological strategy in order to improve academic performance.

The data analysis methods used were: frequency analysis: to represent in percentage the tendencies of the current state of the student's academic performance, of the professional figure of computer science and the possible causes that explain it; qualitative analysis: to categorize the recurrent themes reported by the interviewees and identify possible causes.

Development

According to the Meanings Encyclopedia team (2024) computer programming is the action of programming that involves ordering, structuring or composing a series of chronological actions to accomplish an objective. Programming can be applied to social events, to the media and to the computer world. Hence, the proposed learning strategy is based on gamification to improve the academic performance of students with ADHD who are taking the subject Programming in the professional course of Computer Science.

The intervention was based on the implementation of a learning strategy from the gamification of their actions with multimodal and multisensory approach:

Multimodal approach: will have learning formats with readings, interactive videos and collaborative practices to adapt to different learning styles, this methodology integrates resources such as texts, videos, audios, practical activities and group discussions Vera (2023). This allows

educators to tailor their teaching to fit the individual needs of students and foster a deeper understanding of concepts.

Multisensory approach: Activities will be designed to engage a variety of senses in order to capture and hold the attention of students with ADHD. Visual (infographics, videos), auditory (narrated explanations and challenges) and kinesthetic (interactive activities involving the use of physical digital and tools) elements will be used.

According to Łuszczykiewicz (2024) "multisensory learning is an educational approach that integrates multiple senses, such as sight, hearing, touch, taste, and smell, to enhance understanding and retention of information." The idea is that by engaging multiple senses, students can better connect with the material and develop a deeper understanding.

From the above, characterizing elements of the learning strategy are conceived:

The first element characterizing the strategy is gamification with the use of points, rewards, levels and progressive challenges, to motivate students to complete the programming activities. The use of multisensory resources for which tools such as interactive digital boards, programmed challenges with auditory feedback and simulation games to practice programming logic will be used.

Also the learning modalities, with proposed activities designed to cover different ways of learning, combining visual, auditory and kinesthetic exercises. For example, students will be able to watch interactive tutorials, carry out collaborative projects and participate in simulations. Finally, the temporality for the intervention will be developed over a period of 3 months, divided into 3 phases with weekly sessions of 90 minutes in which the gamified elements will be applied. The activities will be adjusted to an adequate pace for the students, allowing short breaks and variation in the tasks.

As shown in Table 1, the diagnosis prior to the implementation of the strategy yielded the following results:

- **Diagnostic results**

Table 1.

Table of student grades

Students	Areas	Subject	Parcial 1	Parcial 2	Average	% Pro (80%)	Exam	%Ex (20%)	Quimestre
Students 1	**Technical Services**	**MF. Programming and Database**	6,50	6.80	6.65	4.65	8.00	1.60	6.25
Students 2	**Technical Services**	**MF. Programming and Database**	5.00	5,50	5.25	3.25	5.00	1.00	4.25
Students 3	**Technical Services**	**MF. Programming and Database**	7,50	8.30	7,90	5.90	9.00	1,80	7.7
Students 4	**Technical Services**	**MF. Programming and Database**	6.00	6,50	6.25	4.25	8,50	1,70	5.95

Source: Authors' elaboration.

The grades of the first semester in the subject “Programming and Database” show that three of four students did not reach the minimum passing grade (7/10), which reflects a low general academic performance in this group. Student 1 and Student 4 obtained partial averages of 6.65 and 6.25, respectively, achieving better results in the final exam (8.0 and 8.5); however, their final grades were insufficient (6.25 and 5.95). Student 2 performed remarkably poorly on all assessments, achieving a final average of 4.25. In contrast, Student 3 was the only one to pass with an overall average of 7.7.

These results suggest a lack of understanding and retention of concepts throughout the quarter, possibly due to traditional teaching methods that do not adequately address the learning needs of students with ADHD, who present difficulties in sustained attention and require multisensory approaches (Barkley, 2021).

As stated by Barclay (2021), individuals with ADHD often need methodologies that include sensory variety and participatory dynamics to engage their interest and promote long-term learning. Before issuing a definitive diagnosis, it will be necessary to complement the analysis with other data collection methods that provide a more complete view of the performance and academic needs of these students.

Among the results of the diagnosis carried out at the María Auxiliadora Educational Unit, students in the subject “Programming” have shown low academic performance during the first semester, a situation that raises the need to identify the causes and develop appropriate interventions to improve their learning and performance.

The low performance in “Programming” in the computer science professional figure can be attributed to two main factors: lack of Progressive Comprehension and Retention: Students show difficulties in understanding and retaining key programming topics that require logical and structured thinking. This lack of progressive understanding affects their performance in partial

evaluations and in the final average; demotivation and the need for adaptive teaching methods. The traditional methodology used is insufficient for students with ADHD, who present difficulties in sustained attention and need methodologies that include sensory variety and participatory dynamics to capture their interest and favor long-term learning.

Recommendations for intervention are offered based on this diagnosis in that the implementation of a learning strategy based on gamification, with a multimodal and multisensory approach, will offer students a more engaging learning experience suited to their needs. This approach will allow presenting programming concepts in an interactive and progressive manner, facilitating comprehension and retention through stimuli that maintain the interest and motivation of students with ADHD. In addition, gamification can provide a safe and playful environment where students are motivated to experiment, make mistakes, and learn through rewards that reinforce their effort and achievement.

This approach seeks not only to improve academic performance in the second term, but also to foster a positive attitude towards the subject, supporting students in the development of logical and technical skills essential to their computer science education.

Methodological learning proposal based on gamification.

The overall objective of the learning strategy is to develop and implement a learning strategy based on gamification, with a multimodal and multisensory approach, to promote the academic performance of students with ADHD in computer programming.

This strategy facilitates the understanding and application of fundamental concepts, such as: data, algorithms, pseudocodes, flowcharts, control structures, operators, functions and the modular structure of programs, through adapted strategies that enhance the motivation, retention and attention of students.

It is structured in phases and stages: Phase 1: Theoretical learning of programming; Phase 2: Practice of theoretical concepts and Phase 3: Gamified evaluation of knowledge. The stages of each phase are the same: Planning, Dissemination, Socialization, Implementation and Evaluation.

Phase 1: Theoretical Programming Learning. The objective of this phase is to familiarize students with the basic concepts of programming in a theoretical way, taking advantage of interactive videos and gamified activities that introduce the fundamentals of each concept.

The Planning stage aims to develop the design of the first phase of theoretical learning in computer programming through gamification with a multimodal approach. The actions are directed to elaborate the planning to implement a gamified methodology in the learning of theoretical concepts (data, algorithms, pseudocodes, flowcharts, control structures, operators, functions, modular structure) another action and to design and adapt interactive materials and educational videos to present each concept in an accessible and visually attractive way.

For the development of these actions will be developed in 6 hours using pencil, paper, computer, interactive video editing software, gamified learning platform. The responsible is the researcher. It should be noted here the planning of interactive materials prioritizing tools that encourage the participation and attention of students with ADHD, selecting audiovisual resources that simplify each concept and allow a continuous evaluation of the learning process.

The **Dissemination** stage aims to present and socialize the theoretical proposal of Phase 1 with authorities and teachers to align objectives and necessary resources. The actions are aimed at communicating the Phase 1 plan to the directors of the educational institution and making a presentation to the teachers to explain the objectives, justification, formulation of the problem and methodology. With the same theoretical structure of Phase 1 detailed in the proposal, it will be developed in 2 hours as an objective. It is important to present the specific benefits of multimodal gamification to capture the interest and support of the educational community in the implementation of the methodology.

The Socialization stage begins with the training of the teaching staff in the use of the multimodal and gamified teaching tools to be used in Phase 1. Explain in detail to teachers the use of interactive videos, gamified activities and their application in the classroom to cover the topics of Phase 1. Among the materials to be used: projector, computer, internet, gamified learning platform, interactive activity sheets for concepts such as: - Data - Algorithms - Pseudocodes - Flowcharts - Control structures - Operators - Functions - Modular structure. In 3 hours the responsible is the researcher, teacher. It is important that teachers understand both the content of the concepts and the gamification strategies and reward mechanisms to guide students in the learning platform.

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The **Implementation** stage aims to initiate the theoretical instruction of programming concepts to students, using interactive materials and rewards to maintain their motivation. The actions are aimed at implementing the theoretical learning of each concept with activities in interactive videos. And to perform dynamic questions at the end of each topic to evaluate understanding and give rewards for learning achievements. The necessary means are the computer, learning platform, interactive videos for each topic (visual examples of data, algorithms, pseudocode, etc.), reward system (badges, points, etc.) for motivation to be developed in 10 hours. As students progress through the topics, rewards and difficulty levels should be adjusted to maintain motivation and measure the effectiveness of gamification on theoretical retention.

The **Evaluation** stage aims to measure students' progress in theoretical understanding of programming topics, adapting strategies according to observed performance. Monitor and evaluate progress in each theoretical topic through short questionnaires on the platform. Analyze results to make adjustments to rewards or video content if necessary. Gamified evaluation platform, online quizzes, tracking sheets, score or achievement evaluation system, computer. 3 hours. Researcher, teacher. Assessment data should be reviewed periodically to ensure that students understand the theoretical concepts. If difficulties are observed in a specific topic, materials or activities should be adjusted accordingly.

Phase 2: Practice of theoretical concepts. The objective of this phase is to consolidate learning through active practice of each of the concepts, using a multisensory environment involving visual, auditory and kinesthetic stimuli.

The planning stage aims to develop a plan for the multisensory practice of the programming concepts, facilitating retention through visual, auditory and kinesthetic stimuli. The actions are

directed to develop practical activities involving direct manipulation and varied stimuli for each topic (data, algorithms, pseudocodes, flowcharts, control structures, operators, functions, modules) and to design auditory and visual feedback mechanisms for each exercise with means such as the computer, visual programming software, interactive resources (building blocks, visual interfaces), audio devices for auditory feedback, digital whiteboards, manipulable physical materials for kinesthetic practices in 6 hours and with the researcher as the responsible.

The inclusion of activities adapted to each learning style (visual, auditory, kinesthetic) and structuring the practice environment to capture the sustained attention of students with ADHD should be observed in this phase. It is essential to select resources that allow real-time feedback.

The Dissemination stage aims to introduce Phase 2 to teachers to explain the multisensory approach and ensure that they understand the dynamic and feedback practices. Among the predetermined actions is to explain the objectives and benefits of the multisensory practice in a presentation for the teachers of the institution and to clarify doubts about the exercises and the application of each type of stimulation. Projector, computer, visual content of Phase 2 with detailed explanations of each concept to be developed in 2 hours; the researcher and the teacher are responsible. It is key that teachers understand how each stimulus (visual, auditory, kinesthetic) improves concept retention. They must be familiar with the specific resources and their objectives in order to guide students effectively.

The **Socialization** stage aims to train the teaching staff in the application of multisensory techniques to guide the practice of programming concepts in a gamified way, instrumented in actions aimed at explaining in detail how to use sensory tools and guide the students' practice with constant feedback, indicating the specific benefits of each type of stimulus.

The media to be used here are projector, computer, multisensory learning platform, interactive materials including: - Visual data simulators - Building blocks for pseudocode and algorithms - Flowchart interfaces - Control structures with sound feedback - Kinesthetic material. To be developed in 3 hours by the researcher, teacher. At this stage, the training should include practical sessions where teachers experience the sensory exercises and receive feedback on their application. All doubts about how to guide and evaluate students in each dynamic should be clarified.

The **Implementation** stage aims to initiate the multisensory practice of the theoretical concepts so that students can apply the programming with stimuli that encourage their attention and retention.

The actions include guiding students in practical activities for each concept, where they interact with visual blocks, sound effects and kinesthetic materials.

Also offer immediate feedback and rewards. Supported by media such as computer, interactive learning platform, programming simulators with visual and auditory blocks, manipulative materials for kinesthetic practices (whiteboards, physical blocks), gamified rewards (badges, points, achievements). To be completed in 10 hours by the researcher, teachers and students. As students complete activities, adjust difficulty and customize stimuli to individual sensory preferences. Rewards should be incentivized to maintain motivation for each exercise.

The **Evaluation** stage aims to measure the effectiveness of the multisensory practice in the understanding and application of programming concepts. Actions are aimed at monitoring the performance in each exercise through a practical evaluation and adjusting the sensory feedback techniques according to the results. This requires an evaluation platform, progress tracking sheets, gamified evaluation system (specific scores and achievements for each concept: data, algorithms, pseudocode, etc.), computer in 3 hours.

The evaluation should include detailed observations on the use of sensory stimuli, identifying which type of stimulus worked best for each concept. The observations will serve to adapt future exercises and strengthen the effectiveness of the multisensory methodology in students with ADHD.

Phase 3: Gamified assessment of knowledge. The objective of this phase is to evaluate the students' understanding of each concept through an interactive and gamified evaluation.

The Planning stage aims to design a gamified assessment system to measure students' knowledge in programming, integrating methods that maintain motivation and reduce evaluative stress. The actions are aimed at elaborating a plan for the evaluation of each learned concept (data, algorithms, pseudocodes, flowcharts, control structures, operators, functions and modules) and designing gamified evaluation activities that include immediate feedback and rewards.

This requires a computer, interactive quiz creation software, gamified assessment platform, achievement and progress tracking sheets, reward system (badges, points, proficiency levels) within 6 hours and with the researcher in charge. The inclusion of quizzes and programming challenges that are progressive in difficulty should be observed. It is important that the activities are structured in a way that measures performance and also reinforces learning through immediate

feedback, rewarding individual achievements to encourage self-confidence in students with ADHD.

The dissemination stage aims to present Phase 3 to teachers and educational leaders to ensure their understanding of the gamified assessment process. The actions are aimed at explaining the objectives and benefits of a gamified assessment to the institution's managers and teachers and to present the reward system and assessment criteria so that they understand how to measure the progress and motivation of the students.

A projector, computer, visual explanatory contents of Phase 3, examples of gamified assessments (with feedback and achievement system) for each key programming concept are needed. In 2 hours, and with the researcher and teacher as responsible. As observations it is important that teachers become familiar with the reward system and evaluation criteria to interpret the results appropriately. They should understand how gamification in evaluation helps to reduce students' anxiety and favors a better demonstration of their knowledge.

The **Socialization** stage aims to train teachers in the administration of the gamified assessment and in the interpretation of the results, ensuring a fair and motivating assessment. The actions are aimed at training teachers in the use of the gamified assessment platform, explaining the reward mechanics and carrying out simulations of the assessment so that teachers can practice and resolve doubts about its use.

As means, a projector, computer, gamified evaluation platform, support materials for the interpretation of results and achievement management, evaluation guides for each programming concept are required. In 3 hours with the researcher and the teacher as researcher. It should be noted that teachers should be comfortable using the platform and know each type of feedback and reward that students receive, to support them in their evaluation process and understand their strengths and areas for improvement. Training should include practice in analyzing gamified results.

The **Implementation** stage aims to perform the gamified assessment, allowing students to demonstrate their knowledge in a playful and non-pressured environment. The actions address students in a series of hands-on assessments of each concept (data, algorithms, pseudocode, etc.) on an interactive platform and provide instant feedback and rewards as they complete the evaluative activities. This requires a computer, interactive assessment platform, hands-on exercises for each

concept, reward system (points, achievements, and badges). In 10 hours. With the researcher, teachers, students as participants.

The **Evaluation** stage aims to monitor students' progress and provide clear and positive feedback. The actions are aimed at designing platforms to offer immediate rewards for achievement, helping to reduce the anxiety associated with traditional tests and facilitating a positive evaluative environment for students with ADHD. Also analyze the results of the gamified assessment to identify the level of mastery in each concept and the effectiveness of the strategy applied.

In addition to reviewing and analyzing the results obtained in the gamified assessment platform, identifying performance patterns in each programming area. Make adjustments in the teaching materials to improve future implementations. With the following materials: results analysis platform, progress tracking sheets, evaluation system by scores and achievements, computer, individual performance feedback material.

All of which will be developed in 3 hours and with the researcher, teacher as responsible. The results should be reviewed, to evaluate both individual performance and the effectiveness of gamification in knowledge retention and the final observations will help to adjust and optimize future evaluation phases to improve students' academic performance and adapt teaching strategies according to the observed needs.

Within the expert corroboration results, the relevance and effectiveness of the strategy is validated. Gamification improves motivation and academic performance in students with ADHD. The benefits of multimodal approaches to learning incorporate visual, auditory and kinesthetic stimuli that are particularly effective and help to concretize complex ideas.

Moreover, the strategy favors the development of autonomy skills and need education. Gamified learning systems not only help to capture attention, but also foster autonomy and reduce the stress associated with learning complex subjects. They contribute to increase retention and practical application of knowledge. In this sense, students are able to connect theory with practice more effectively, which supports the usefulness of gamification in knowledge consolidation.

At the time of discussion and analysis of the results, the impact of gamification on academic performance through the granting of rewards and achievements stands out, accounting for the development of their metacognition.

On the other hand, the relevance of the multimodal and multisensory approach is fundamental to capture and maintain the attention of students with learning difficulties. In addition to facilitating learning in students with ADHD, it also promotes active and motivating learning, increasing the likelihood of information retention and practical applicability.

Conclusions

The learning strategy supported by gamification has the potential to significantly improve the academic performance of students with ADHD by creating an interactive learning environment by offering immediate rewards and feedback, crucial factors to capture the attention of these students, who often benefit from active and visual learning methods, favoring their progress at their own pace and managing their learning independently.

To capture the attention of these students, who often benefit from active and visual learning methods, encouraging them to progress at their own pace and manage their learning independently. The study findings suggest that gamification can be an effective tool to improve understanding and retention of complex concepts, such as algorithms and flowcharts with the development of autonomy skills and self-management of knowledge.

Multimodal and multisensory approaches, which integrate visual, auditory and kinesthetic stimuli, have proven to be beneficial in achieving greater engagement and motivation, gaining special interest in the context of programming.

It is important to monitor each student's individual response, as not all students benefit in the same way from these methods. Therefore, the implementation of this proposal should include constant monitoring to evaluate its effectiveness and make adjustments according to the particular needs of the students.

The implementation of gamification and multisensory approaches requires careful planning and adequate resources. Customization of materials and activities can be a challenge, especially in environments with time and resource constraints.

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