Gamification software to support the learning process of children with emphasis on psychomotor, psychoanalytic and attention deficit disabilities.

Abstract. Education is the basis for the discovery of new knowledge and therefore the growth of society. Then, education must evolve at the same pace as technological advances, developing new educational strategies. This proposal implements a teaching-learning model that encourage the students' ability to concentrate, considering the lack of interest in traditional learning. Hence, this tool allows greater student participation, in which they acquire knowledge in an interesting and innovative way. Gamification is the basis of this tool, designed to have fun and at the same time to promote factors such as concentration, attention and motor skills. This tool is represented graphically as a video game of races, questions and ability. Its impact has a pedagogical approach so that teachers can identify in their students the different capacities of concentration and analysis that they possess and at the same time the students learn in a more didactic and interesting way based on gamification.

Keywords: Academic engagement, Education, Teaching, Learning, Gamification software.

1 Introduction

The world has been going through different changes that have promoted the advancement of civilization in different fields of social insertion. These changes have generated problems and solutions that are currently still being experienced in each of the globalized countries and even more with the rise of technologies, affecting the implementation of classical education. In Colombia, despite being a developing country, the progress is noticeable in certain aspects, but never reaches the real background of the problems that lead to generational decline and low progress of the community, which is education [1].

The primary education system is not very effective and almost not updated to the current demands of children. Regardless of having strategies in place for the implementation of advanced education, the implementation of this in the classroom has been ineffective. Consequently, the study developed in [2], analyzes that it is inconvenient to continue with classical models that are replicated indiscriminately throughout the territory, because the best educational process is the one led by a qualified teacher who understands that pedagogy must be adjusted to the learning models of the students and that each human being learns in a particular way. This is not only recognized by the Colombian Ministry of Education but also by the United Nations (UN), where one of its Sustainable Development Goals (SDGs) states: "Build and adapt educational facilities that take into account the needs of children and persons with disabilities and gender differences, and that provide safe, non-violent, inclusive and effective learning environments for all" [3].

However, teachers are not the only ones responsible for imparting knowledge; there must also be teaching-learning models for the establishment of a relationship between

study, academia, teachers and students [4]. Therefore, education must be strongly connected with the psychoanalytic and psychomotor capacities that the student has, so that his academic training is particularly successful. So, one of those skillful methods for the constitution of the quality education model adapted to the needs of children and emphasized on concentration deficits and others, and which has been widely studied worldwide is Gamification in the classroom.[5].

It is a myth dispelled that with a video game you cannot learn, focus and address problems that affect the learning of children in classrooms, as Trujillo defends in [4] "the game is inherent to the human being and is part of their learning, but has often been expelled from formal education, relating it only to the moment of leisure". According to research of the Pontificia Universidad Javeriana de Cali [6], video games used for an educational purpose and for problem solving leads us to be more analytical people and develops skills for the solution of logical problems, since it stimulates creativity and critical thinking. This creates people who can solve problems and concerns with ease, objectivity, certainty and speed from an entertaining environment. In this way, gamification works in two ways, first as a fundamental axis where the student becomes the protagonist of a game in which he/she can identify and reason about topics of general interest that can be learned in a satisfactory, novel and non-frustrating way [7]. As well as these, a tool to measure how high and formed are the factors of concentration, communication and motor skills of the student at the moment of establishing himself in the game.

Therefore, taking into account all the shortcomings on the implementation of a technological gamification strategy and the need to establish a useful teaching-learning model adapted to children in Colombia, this project stands out for implementing an innovative educational tool that capitalizes on the power of gamification. Providing an exclusive feedback system for teachers and thus being able to particularize the education of each student, making them learn by playing without them perceiving it. Improving the learning process of children with emphasis on psychomotor, psychoanalytic and attention deficit disabilities.

The article is structured into eight sections. In Section 2, related works are consulted to support the development of the methodological proposal presented in Section 3. Afterward, Section 4 outlines the proposal's planning, while Sections 5, 6, and 7 address the software design, architecture, and implementation, respectively. Finally, Section 8 presents the conclusions reached in this research.

2 Related Work

Gamification has emerged as a powerful strategy to motivate, engage and improve people's performance in different fields. However, in this report, we explore some related works that highlight the application of gamification in the learning process.

One example of gamification is reported in [8] where it is evidenced the evaluation of the accuracies of the Conners Scale, which yields results about hyperactivity, conduct problems, emotional lability, anxiety-passivity, antisocial behavior, sleep difficulties and time management. On the other hand, it evaluates the diagnostic accuracy of the application of an interactive game called "GroundsKeeper" used specifically to identify child patients with and without attention deficit hyperactivity disorder (ADHD). These two processes are compared to determine whether video games are useful to work and identify patients with or without this disorder, and the results show that the diagnostic accuracies made by the Conners test and

GroundsKeeper are high in both cases. These results indicated that video games are useful tools not only for entertainment, but, since they also generate motivation, young people, children, adults, teachers and researchers benefit from the given approach. Such is the case of gamification and the diagnosis and identification of people with attention deficit hyperactivity disorder.

On the other hand, gamification has been attributed to popular games such as Minecraft. In [9] its application is shown where an edition dedicated to education was created, called "Minecraft Education Edition" opting for an education methodology different from the traditional one through pens and paper. To test the effectiveness of the proposed program against the classical teaching method, different contents adapted to the corresponding ages were created, with basic topics such as mathematics, physics, history, literature and science, taking the educators to speak the same language as the students within the game, generating motivation in the students to learn. As Jiménez and Diez [9] confirmed how the video game brings several advances in the academic field by providing varied vocabulary which is acquired in the context of the game, thus contributing to the improvement of fluency and mental agility of students. They affirm that this is given at the moment in which short sentences appear with a limited time, motivating the quick reading of these and the contribution of new words supports the recognition of these inside and outside the game apart from positively impacting reading fluency.

Following the idea of teaching in a different way over the traditional one, which imparts more interest and motivation to students, there is a tool called "Adjective Monster Kit" which bets on a new way of learning grammar. In the research [10] they explain how several fourth-grade students had problems when trying to master the use of comparative and superlative adjectives, so they came up with the "Adjective Monster Kit" which is based on three main elements: the family of adjective monsters, the game and the corresponding worksheet. The objective is to investigate the use of the Adjective Monster Kit to improve the mastery of comparative and superlative adjectives. The subjects of this research were 30 fourth graders from an institution in Terengganu, Malaysia. Where results from previous tests and the results of the post research tests were collected. After a descriptive analysis a positive response was reached, demonstrating the improvement of reading comprehension of the adjectives said above, apart from resulting in increased motivation and interest of the course to participate in a fun learning environment.

After exploring several studies and seeing the positive results given thanks to gamified environments, we propose the academic and gamified software tool ABLE, with which teachers can have a better vision of each of the students and thus be able to generate more commitment and interest in students learning the routine.

3 Methodology

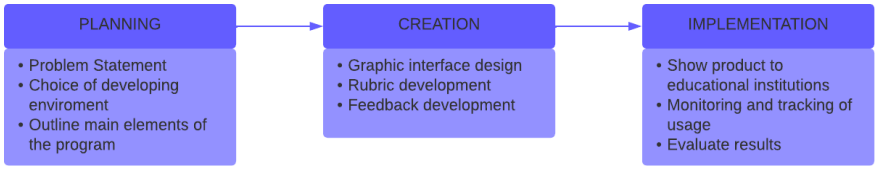
In this work we approach the problem about the implementation of gamification in the educational field in infants to promote learning from an interesting, entertaining and novel mechanism for children such as games applied in indoor spaces. According to Perrota [11], games help to experiment with new identities, to explore options and consequences, and to test our own limits. Consequently, it is possible the development of social skills, motivation to learn and an improvement in the attention and

concentration of children also developing critical, complex, abstract and strategic planning thinking [11]. It becomes evident that this teaching-learning strategy offers imminent and undeniable benefits for children and their educational process, however, it not only benefits the students but also the teachers, providing tools that show the rates of factors such as concentration and attention of their students, which generates the implementation and requirement of this strategy for the creation of a video game that integrates this concept and improve the learning process of children.

In this way, considering the scope that our project requests to recreate, we involve the population to be part of the acquisition and use of the project. Considering that, the teachers and the academic institutions are the consumers of this to distribute the education with emphasis in a successful way and that it has a positive repercussion in the academic, social and reputational indexes that count in the market.

To develop our gamified software, we considered three main phases to achieve a tool oriented to the users' needs. The phases followed in the development of the program are shown in Fig. 1. The first one includes a study of the context, the potential users and requirements analysis. The second phase is the creation of the software, considering the functional and non-functional requirements and the academic focus of our tool. The final stage is the implementation, where the tool was proved and tested in a real context.

Fig 1. Developing phases of the software tool.



4 Proposed approach

The software for the implementation of gamification ABLE consists mainly of three carefully designed games, each one focused on measuring and evaluating different factors. Once students have completed the games, their scores obtained during the process are collected and recorded. This data is used as a basis for providing individualized and comprehensive feedback to each teacher. Through a special access to the system, teachers review their students' scores and performance in detail. This feedback will allow teachers to have a clear view of each student's progress, identify areas for improvement and adapt their teaching approach according to their needs. Providing a significant experience for teachers and institutions.

4.1 Preliminary study about the context

To ensure the effectiveness and validity of the proposed gamification solution, a close collaboration with professional psychologists was established and an extensive research and rigorous studies were jointly conducted. These studies focused on measuring and establishing appropriate assessment standards for students who would participate in the implementation of the gamification solution in their learning process. Some of the

rubrics created are shown in Fig. 2. This rubric shows a scale to measure the performance of students considering the results in the games.

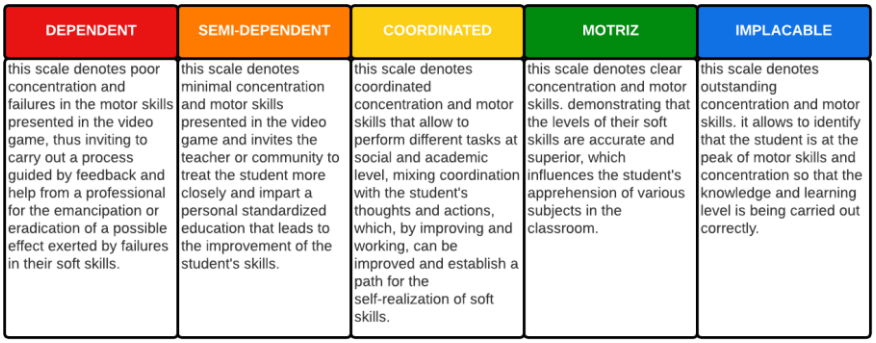


Fig 2. Proposed rubric for game one and two.

4.2 Requirements analysis

In the requirements analysis process of this project, the FURPS model was used to evaluate and specify the different functional (Functionality) and non-functional (Usability, Reliability, Performance and Supportability) aspects that must be taken into account in software development [12]. Quality is an essential part for any person or organization that is going to use it, a poor performance can cause several problems. Therefore, we completed each section proposed by the FURPS model for our software development and shown in Table 1.

Table 1. Requirements according to the FURPS model

Quality Factor	**Attributes**
Functionality	● Show the lives and scores obtained in the dynamics used in the project. ● Show the respective analysis based on the results of the games. ● Present the different dynamics presented by the video game. ● Carry out instructions of the different dynamics.
Usability	● User-friendly interface. ● Simple and easy to understand interface. ● All 3 games have easy to use controls.
Reliability	● Scores cannot be manually altered. ● A teacher account is required to access the feedback.
Performance	● The platform used for the game development ensures adequate performance. ● Validation of unit tests, verifying their performance.
Support capacity	● Contains clear and complete instructions and documentation.

4.3 Risk assessment

In the specific case of this project, we achieved a detailed planning in which the potential risks and their corresponding impacts have been considered. These risks have been compiled and recorded in Table 2, to have a clear and organized record of possible adverse events that could affect the development and success of the project.

Table 2. Software risks and their potential impact.

Risks	Impact
Security breach leading to score manipulation	Low
Vulnerability of user data	Low
Error in providing scores to feedback	Moderate
Score reading	Low
User difficulty in using the applications and show resistance to change.	Low
Possible software failures during development	Moderate

5 Software design and architecture

The software design has been adopted by using Unified Modeling Language (UML), block and case diagrams for analyzing software design and software functionality. The software design and the architecture consider the requirements mentioned before.

5.1 UML diagram

Fig. 3 presents a class diagram UML that describes the boundaries, structure and behavior of the system and the objects ABLE contains. This diagram can connect and establish relations between the objects making up ABLE, and also inform about software architecture, design and system implementation.

Fig 3. UML diagram of ABLE.

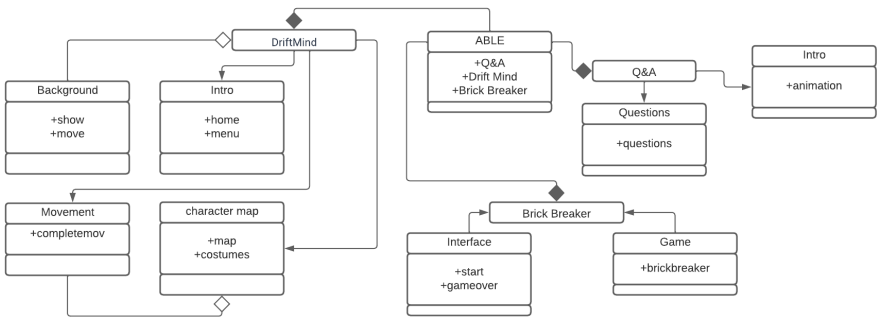


Fig 3. UML diagram for ABLE software architecture

5.2Block diagram

Blocks diagrams are used for designs software, hardware and processes. They represent concepts and systems in a higher level, less detailed overview. This diagram on Fig. 4 represents the program organization and how the user watches and uses the software; it contains user-program interactions.

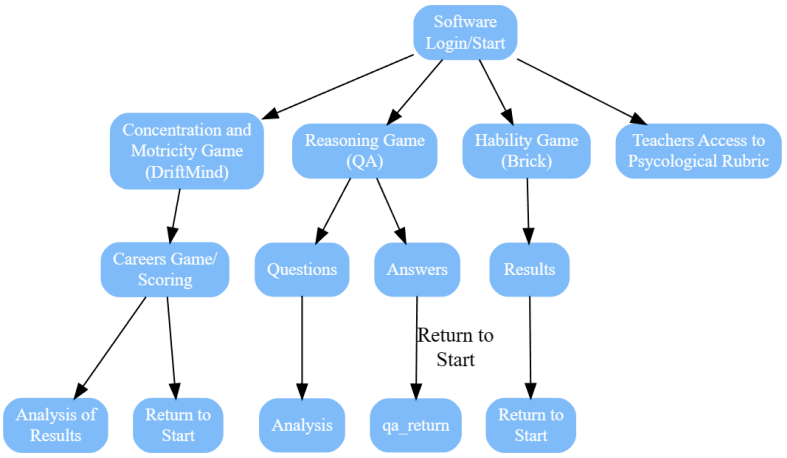


Fig 4. Block diagram for ABLE system software

6 Software implementation

Once the planning and creation stages were completed, we moved on to the implementation phase of the gamification-based game "ABLE", of which positive results were obtained in unit tests complying with the functional requirements shown in Table 1. The percentages of compliance of the preliminary version are shown in Table 3.

Table 3. Evaluation of the software functionality.

Attributes	**Implementation**	**Percentage of fulfillment**
Show the lives and scores obtained in the dynamics used in the project and show the respective analysis based on the results of the games.	Teachers have a special access to the feedback that correctly complies showing the lives and scores obtained.	100%
Present the different game dynamics	An intuitive menu was implemented showing the different dynamics offered.	100%
Carry out instructions of the different dynamics	The general instructions of the game are an option that can be accessed by the user.	60%

The games are meant to enhance different skills, e.g., the first game in Fig. 5 promotes motor skills and concentration like the third game in Fig. 7, while the second game of questions and answers in Fig. 6 influences logical thinking and reasoning.

Fig 5. Brick - breaker game.

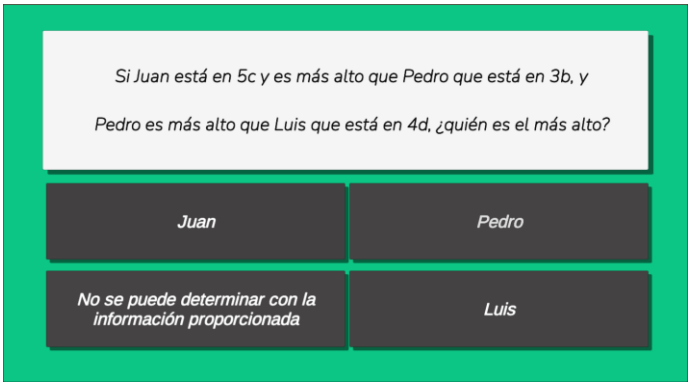


Fig 6. Q&A game.

Fig 7. DriftMind game.

In addition, a study was conducted to examine the effectiveness of a gamification session based on the software consisting of 3 games and a post-test survey of 4 questions designed by the authors with the advice of a professional psychologist in a private school of stratum 4 in Barranquilla, Colombia. The sample consisted of 140 students between 8 and 10 years of age, of which 57% were male and 47% female. These students came from 5 different grades within the institution. Each student participated in a 30-minute individual session to interact with the software; during this activity, several teachers were present in the back to observe the students' responses. Subsequently, a survey designed to evaluate the students' experience and collect their opinions about the session was administered. It should be noted that the survey was administered by the Universidad del Norte, thus ensuring rigor in the data collection process.

These data were analyzed in collaboration with a Psychology team, using statistical methods and content analysis techniques. All questions were created to evaluate the usability of the software and the users' opinion. In summary, this study focused on analyzing the effects of a gamification session in a specific educational context. The diverse sample of students, the presence of teacher observers and the collaboration of a recognized academic institution contribute to the robustness and relevance of the results obtained.

The questionnaire has the following questions:

1. How interesting did you find the gamification video game as a learning method?
   a. Not interesting b. Kind of interesting c. Very interesting
2. How would you rate from 1 to 5 the effectiveness of the video game to improve your concentration and attention during educational activities? 5 is the highest rate and 1 the lowest.
3. Do you think the game was flexible and adaptable to fit your skills and prior knowledge? Yes/No
4. Would you recommend the use of this gamification video game in other educational institutions? Yes/No. Why?

The results obtained from this study were essential to adjust and refine the pedagogical approach of the video game. Areas for improvement were identified: modifications made to the game mechanics, the difficulty of the challenges, the feedback provided and other key elements. In addition, clear criteria were established for the assessment and monitoring of student progress over time. The Fig 8, Fig 9 and Fig 10 expose several results.

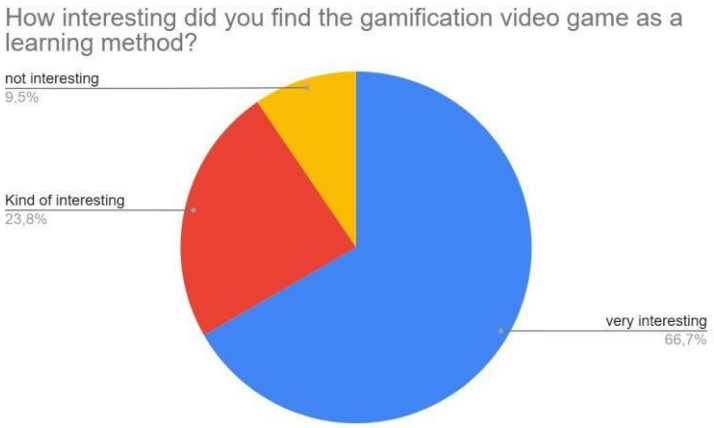


Fig 8. Results Question 1

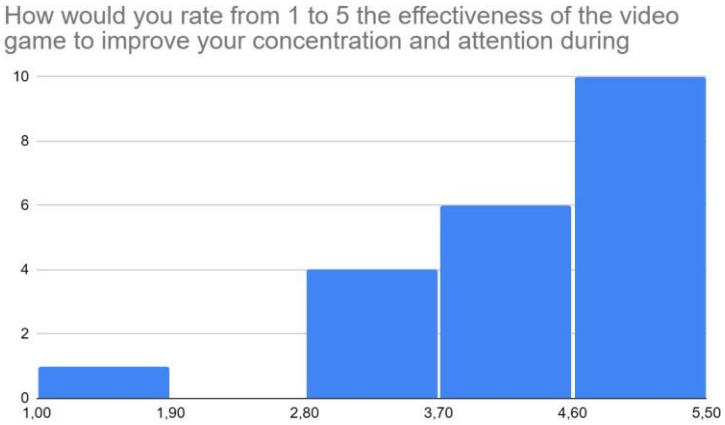


Fig 9. Results question 2

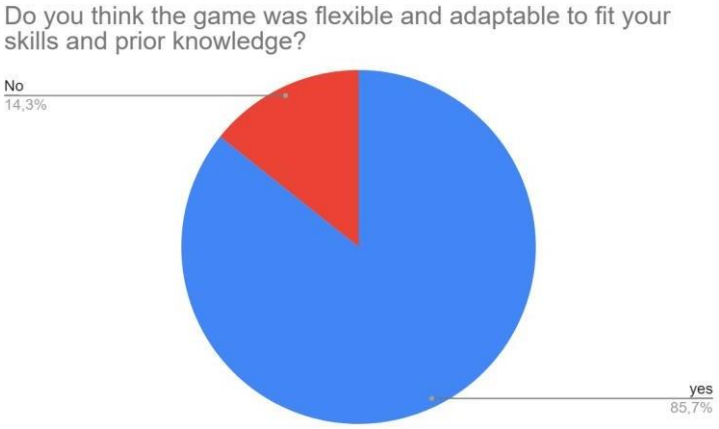


Fig 10. Results question 3

Question 4 was an open question, therefore users answered the question based on what they consider, here are some of the users answers:

- It is a good tool for different institutions, especially those specialized in students with ADHD, for example.
- Yes, it seems to me a very complete tool.
- Yes, as a teacher I really liked the application of the ability level measurement questions with the established rubric.
- Yes, my friends like it.
- Of course! we would all like to play.
- Everyone sees that it is a good method of skill development.
- No, there's no point in your approach.

Considering the results of the survey, more positive than negative responses were received, which indicates a positive acceptance of the software by students and users who tested it.

7 Conclusions

In this study, we have demonstrated that the implementation of the gamification strategy project in the teaching-learning process is highly effective and beneficial for students. Through the video game designed with an innovative pedagogical approach, it was possible to increase the students' commitment, motivation and interest in learning. The dynamics of the game is playful and attractive which improved students' concentration and attention, as well as strengthened their problem-solving skills. The joint work with Psychologists scientifically supported the effectiveness of gamification as a pedagogical approach. The studies have provided solid data and empirical evidence on the positive impact that gamification can have on student learning.[13] Thus, the results obtained from the application of the gamification video game meet the requirements established above and have proven to have a positive impact in the educational area.

To improve the gamification project, some actions can be considered. One of them is the incorporation of more detailed data analysis to assess individual student progress and adapt the game experience accordingly. In addition, the library of games and challenges could be expanded to provide a wider variety of educational activities. Also, collaboration with specialists in various areas, such as educational psychology and pedagogy, could enrich the pedagogical approach of the project.

In summary, the application of the gamification video game has proven to be successful and has the potential to transform the educational experience of students. Although some limitations were identified, these can be addressed and improved in future implementations. The positive impact in the applied area, the improvement in academic outcomes, and the fostering of key skills support the importance of gamification as an innovative pedagogical approach. By implementing continuous improvements, such as incorporating a wider range of interactive and intuitive games, targeting specific education, more personalized adaptations, and a more solidly patented rubric, gamification can maintain its potential as a powerful tool in education. In this way, students will continue to be motivated and engaged in their learning process, while strengthening the ability of teachers to provide meaningful and effective feedback throughout the project.

Acknowledgments

We would like to express our sincere thanks to psychologist María del Carmen Fontalvo, whose valuable guidance and experience were fundamental to the development of the rubric studies in this project. Her expert advice in the research design and analysis significantly enriched our approaches and results. We also extend our appreciation to the Universidad del Norte for their support and collaboration, which provided a solid academic framework for this study. We also thank the Colegio for allowing us to conduct the studies and surveys in their educational environment, which made an essential contribution to obtaining relevant data. We are deeply grateful for their contribution to this project.

References

1. Radinger, T. *et al.* (no date) *Oecd.org*. Available at: https://www.oecd.org/education/school/OECD-Reviews-School-Resources-Summary-Colombia-English.pdf .
2. Lucía, A., Rueda, P. (n.d.). (2022) Documentos de trabajo de la Escuela Pensamiento Creativo Ruta flexible para acompañar su desarrollo desde procesos educativos. doi: 10.18046/edukafe.2022.20
3. Sustainable Development Goals UNDP. Available at: https://www.undp.org/sustainable-development-goals/quality-education?gclid=CjwKCAjw-IWkBhBTEiwA2exyOyKU1gxtcdmL28XEoy_PMnwZZmNikIvjB74EUQ3DkUqkoBuEbkgwoRoCxSsQAvD_BwE
4. Valda Sánchez, F. and Arteaga Rivero, C. (2015) "Diseño e implementación de una estrategia de gamificación en una plataforma virtual de educación," Fides et Ratio

   Revista de Difusión cultural y científica de la Universidad La Salle en Bolivia, 9(9), pp. 65–80. Available at: http://www.scielo.org.bo/scielo.php?script=sci_arttext&pid=S2071081X2015000100006&lng=es&nrm=iso&tlng=-
5. Marrero Sánchez, O., Mohamed Amar, R. and Xifra Triadú, J. (2018) "Habilidades blandas: necesarias para la formación integral del estudiante universitario," *Revista Científica ECOCIENCIA*, 5, pp. 1–18. doi: 10.21855/ecociencia.50.144.
6. Casas Salgado, W. et al. (2022) El videojuego como recurso educativo : un acercamiento entre percepción docente y el videojuego Minecraft como recurso educativo, para potenciar el trabajo colaborativo en estudiantes de grado cuarto. Edited by M. L. Brijaldo Rodríguez. Editorial Pontificia Universidad Javeriana.
7. Cornellà, P., Estebanell, M. and Brusi, D. (2020) "Gamificación y aprendizaje basado en juegos," Enseñanza de las Ciencias de la Tierra, 28(1), pp. 5–19. Available at: https://raco.cat/index.php/ECT/article/view/372920
8. Faraone, S. V. *et al.* (2016) "The groundskeeper gaming platform as a diagnostic tool for attention-deficit/hyperactivity disorder: Sensitivity, specificity, and relation to other measures," *Journal of child and adolescent psychopharmacology*, 26(8), pp. 672–685. doi: 10.1089/cap.2015.0174.
9. González Pérez, J. D. and Schewalie, N. L. (2019) *Minecraft Education Edition*. Universidad de La Laguna.
10. Hui, S. M., Yong, T. S. and Md Yunus, M. (2022b) "Using adjective monsters kit to improve the pupils' mastery of comparative and superlative adjectives," *International journal of academic research in progressive education and development*, 11(1). doi: 10.6007/ijarped/v11-i1/12292.
11. Contreras Espinosa, R. S. (2016) "Presentación. Juegos digitales y gamificación aplicados en el ámbito de la educación," RIED Revista Iberoamericana de Educación a Distancia, 19(2), p. 27. doi: 10.5944/ried.19.2.16143.
12. Arsana Rahman, "Quality Models in Software Engineering Literature: An Analytical and Comparative Study," *Journal of American Science*, vol. 24557, 2
13. Gamarra, M., Dominguez, A., Velazquez, J., Páez, H.: A gamification strategy in engineering education—A case study on motivation and engagement. Computer Applications in Engineering Education. 30, 472– 482 (2022). https://doi.org/10.1002/CAE.22466.