Nanotechnology Perceptions
ISSN 1660-6795
www.nano-ntp.com

Bridging Play and Learning: Integration of Video Game Tools in K-12 Programming Education

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In recent years, there has been a growing recognition of the potential of video game tools to revolutionize K-12 education, particularly in the field of programming. This paper explores the integration of video game tools into K-12 educational activities aimed at teaching programming skills, presenting a synthesis of current research, emerging trends, and highlights the influence of videogames in K-12 students, in order to improve communication, problem-solving skills, among others in this domain. Drawing upon principles of game-based learning and educational technology, the paper examines the unique affordances of video game tools for engaging students in programming concepts. By leveraging interactive environments, gamified challenges, and hands-on experiences, educators can create dynamic learning experiences that foster creativity, problem-solving skills, and computational thinking among K-12 learners. It reviews a range of video game tools and platforms suitable for programming education, including block-based programming environments like Scratch. In this way, an alternative is presented that takes advantage of students' interest in video games; guiding them into the world of programming, and prevailing that ingenuity and creativity of playing to programming their own games, lessons and educational projects through new games based learning platforms that offer teachers a transformative mechanism to engage students.

Keywords: Gamification, K-12 Education, Learning, Programming, Video Game

1. Introduction

Education is a fundamental element for the creation of a society, it allows human beings to develop their potential abilities, complete personal goals, generate solutions and ex- pand their options, as well as transform the environment that surrounds them into a better one [1]. In the XXI century, one of the problems in which it is debated worldwide is related to education (children and adolescents), since the training of students in schools is debated year after year,

in order to improve their education systems , so that innovation and other tools such as information and communication technologies be- come favorable alternatives for these improvements [2].

In a society where technology has been introduced into everyday life, the use of digital materials for learning has improved teaching both in schools and universities, one of these methods being video games, considered a socializing agent that has a great influence on the cultural values that children and adolescents are acquiring [3-4].

For many, normally the term "videogames", they associate it as a synonym for lei- sure and fun [5]. Certainly, these entertainment industry programs were created for such action, entertaining and relaxing their users. It is remarkable how in recent years, the video game industry has expanded worldwide, with a large number of categories, avail- able to suit the user, consumption has grown immeasurably [6].

Although for the World Health Organization, video game addiction is a mental disorder, regardless of its origin (social inclusion, anxiety, work, etc.), they affirm that the excessive use of these technologies is a disease and should be treated as such [7]. However to apply video games as educational material has more advantages than disadvantages [8], and questions like what is an educational video game and what do you learn from it? How can this be applied to education and programming? and how to get the most out of it? Questions that need to be clarified in order to pose videogames as educational tools.

It is quite true to say that Communication and Information Technologies (ICT) are natural elements of everyday life, especially at an early age [9], as well as highlight the importance of developing new methodologies and preparing teachers to be able to teach children computer science and videogame engineering [10-12]. In this sense, the purpose of this paper is to identify in an exploratory way, the preference of K-12 students to create and develop video game engineering as an educational tool.

This paper is structured by sections, thus in section II the current applications of videogames in the educational field are described. In section III, video games are defined as material for educational activities and everything that must be taken into account for the design of one of these. Section IV shows some platforms or programs dedicated to educating through video games. For its part, section V details key aspects of the importance of video games as tools for education, based on surveys carried out with K-12 students. Finally, the conclusions and corresponding.

Background Related to Videogames in the K-12 Students Field

The use of video games as educational material has been widely discussed, various research works have been carried out and commercial products have been launched to educate through this medium [13]. Another issue addressed is related to training strat- egies, such as those focused on developing projects in video games using virtual reality with open source platforms [14]. Thus, in [15] a video game design and evaluation is presented as a tool to obtain emotion recognition under experiments on human-computer interaction scenarios. Another research that stands out on the subject is that which emphasizes that the development of the linking of video game content is an element of value to be incorporated into the classroom methodology by the teacher [16].

On the other hand, [17] shows studies on the exploration of educational potential with the application of techniques, elements and tools of interactive games. Also, in [18] the use of a gamified approach for programming learning in K-12 students is pro- posed, varying the resource used (teacher, Blockly, Blockly + video game), highlighting the current use of video games in the field educational, where they represent an alternative to obtain better attention and learning from students.

Various countries have included programming education in the curricula of K-12 students, for this reason mechanisms are currently being evaluated to strengthen programming capacities. Thus, in [19] it has been identified that a key aspect is to promote computational thinking (CT) skills within the educational curriculum using technology. In the same way, in [20] a study is carried out of the guidelines on the programming of education in K-12 that can be used by the education sector in the process of curriculum development and teaching where the focus is gamification of programming education.

Video Games as an Educational Tools

Educational video games also known as "serious games" or "applied games" have an optical illusion, which presents a duality, that is, on the one hand, it is an educational resource that can be applied to various concepts and on the other it is a content by itself itself, an object of study with numerous branches [21-22].

More directly, any video game (educational or not) contains an educational part and a playful part, since just by playing, one is already learning. A good example is games dedicated to sports. People who have not practiced or known any sport have been seen for most of their lives, they learned the basic rules by playing only video games.

However, the process is not as simple as it sounds. It is not enough to choose a game that looks educational and tell teachers to use this material to educate children and bring them into computer culture. To make video games productive in the educational field, or in any case, to design one exclusively for learning, two vitally important aspects must be taken into account: the balance of the game and the training of the teacher [23].

Game Balance

As explained above, a game, or video game, contains two parts: the educational concept and the entertainment concept. Fig. 1 shows the balance that must exist between both parties is the critical point of a video game. If the balance is tipped towards the playful part, the game will be focused on capturing the user's attention without any benefit if it is educating. In contrast, if you lean towards the educational part, the video game will have more focus on displaying information in order to teach the user the usefulness of said data.

That said, that a game leans towards the educational component, does not mean that it is ideal to educate. The issue is more complex than it appears.

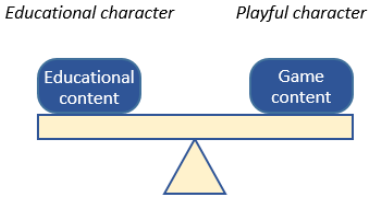

Figure 1. Balance distribution of a video game

One of the main problems that one has when using educational video games, designed exclusively for teaching, contain a high educational character, a fact that differentiates them from normal games. The problem here is that, on repeated occasions, students lose interest in this type of program (especially in primary grades), because they significantly differentiate the games at school from those they have at home and that they enjoy so much [24]. Fun is a key point in video games, if you cannot combine the objective of the game, which is to teach, with its main actor, you will not get any benefit.

When using video games as tools for educational activities, it is necessary that the programs or designs preserve the beneficial characteristics of video games, which is to entertain their users, in this case the students. By achieving an excellent balance be- tween the educational and playful part of a game, students will be able to learn and have fun at the same time.

The Role of the Teacher for the Use of Educational Videogames

In the educational field, one of the fundamental pillars is the teaching staff. At school, teachers are the key subject of training. In charge of suppressing ignorance, the teacher or teacher is not a mere transmitter of knowledge, but is also a strong socializing agent and that, through their teaching, transmits a series of values that will penetrate, directly or indirectly, in the training of the youngest [25].

For video games to be useful educational tools, teacher intervention is vital. If they are not trained, the didactic objective that is had with these technologies will not be possible, therefore for a teacher to use video games as a means of education, there are two main factors: knowledge of the subject and the ability to analyze and improve their current situation [26].

Generally, for a teacher to be able to teach, he must carry out previous sessions on the subject in question and identify the aspects that are relevant to the educational con- tent that will reach the students. Therefore, if a teacher is to use video games as an educational tool, he must know exactly what this program defines and for what purpose it is used. Know how a simple game can entertain and teach your students and complete the educational objectives that are set. On the other hand, there is the skill that any teacher must acquire, especially in those of the primary and secondary education area.

In this perspective, in order to use video games as an educational medium, it should be borne in mind that teachers should be trained beforehand with this material, so that a didactic approach can be achieved and a balance can be struck between the playful and educational content of the games. Likewise, to design video games dedicated to learning, the need to incorporate the teacher is determined, since they facilitate the inclusion of adequate and timely educational content to be taught, since they are the ones who live with the students and know a certain their preferences and how it can be used in favor of teaching [27-28].

2. Methodology

Fig. 2 shows the methodological process followed in this study. Firstly, the educational platforms are identified. It involves selecting and evaluating appropriate educational platforms that can be used to teach programming through video games. These platforms are chosen based on their relevance, usability, and educational value. Then, a framework for integrating video games and programming into students' educational activities is developed. Also, a study is designed that involves K-12 students to test the effectiveness of the integration framework. This includes selecting participants, designing interventions, and planning how the study will be conducted.

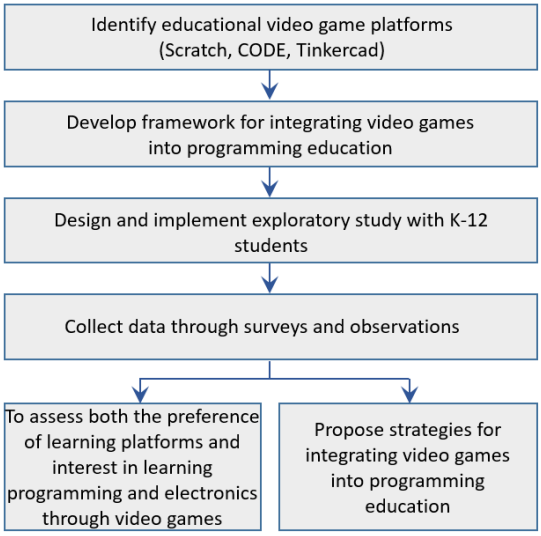

Figure 2. Research methodology

During the study, data is gathered through various methods such as surveys of students and teachers, as well as observations of classroom activities. The collected data is analyzed to determine the effectiveness of the video game-based programming education. This analysis helps in understanding the outcomes and drawing meaningful conclusions. In addition, based on the findings, strategies for integrating video games into the programming curriculum are proposed. These strategies are designed to maximize the educational benefits while addressing any challenges identified.

Aspects for the Design of Educational Videogames

It will seem simple to say that video games of this type involve making programs that expose mathematical, historical, geography, science content, etc. However, reality shows the opposite, creating these types of games are more difficult than everyday ones. Therefore, when designing video games, it is essential that the game meets at least the following academic criteria:

- The content of the video game, which must cover the didactic units programmed in the course teaching guide
- The video game must allow the development or exercise of general and specific

competences

- It must demonstrate the learning results corresponding to the course curriculum.

Likewise, with regard to the level of play, this must maintain its engagement throughout the game session [29].

In the process of designing these educational games, the aspects, or in short, the stages, are similar to those mentioned above. First comes the design of the educational content, then the design of the playful content, the relationship of both components, and finally the adaptation or interpretation of the user [30]. Of course, the intervention of the teacher is vital during the development of the game. His theoretical and pedagogical knowledge will help the designer create a video game according to the profile of the target audience.

To understand, in summary, Fig. 3 shows the stages for the design of educational video games. It should be noted that the inclusion of the teacher during the journey is important.

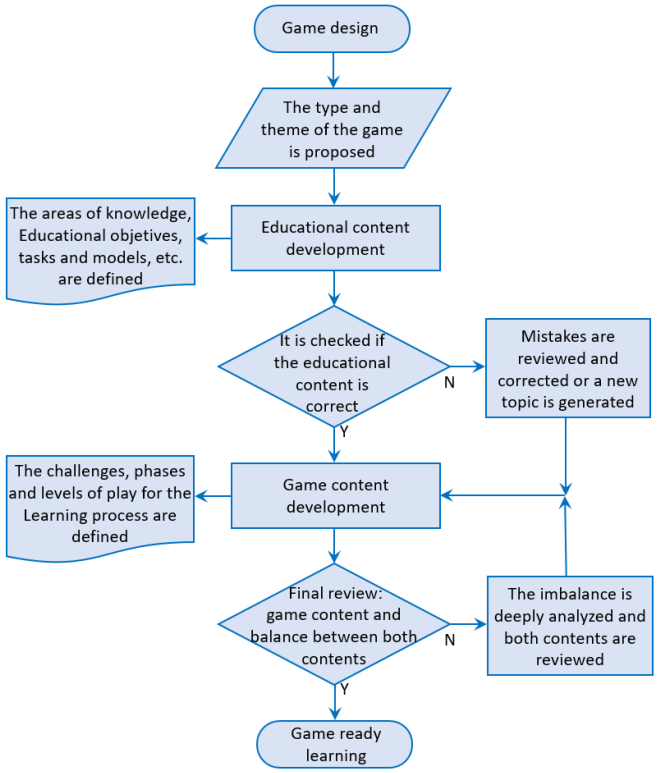

Figure 3. Flowchart of the video game design

In this way, the stages that are taken into account when designing educational games are clearly exposed, highlighting the importance of defining the subject or area of knowledge based on the problem that students want to improve is where everything begins.

Software Platform and Applications

The important thing about using video games as educational tools is that the student becomes

interested in the subject and learns. To do this, the teacher must consider what he wants to teach and based on this, use games that contain everything necessary to meet his didactic objectives.

For this purpose, there are very popular games that have been used for teaching, as mentioned above. MinecraftEDU, one of the most popular, is the educational version of the famous Minecraft game. However, this program does not contain so many educational or programming elements, but rather mental activities and teaching students teamwork [31]. In this way, platforms or online programs arise in order to educate and entertain children, different areas of knowledge. Below are the most popular platforms related to the culture of computing and programming, given the great benefits that have been shown in schools.

- Scratch: Many of the advances in technology in the last twenty years have favored the development of the use of ICT in education. Today, globally, technology has entered everyday life naturally and almost everything requires the use of programming [32]. This leads schools to include disciplines such as electronics and programming in their curricula, in order to engage and prepare students in the fundamentals of technology and computing from a very early age.

Scratch arises as a result. Designed to teach programming (block or graphic programming) in a fun and didactic way, through the creation of video games, animated stories, etc. Scratch worldwide is the most widely used and extended programming education tool [33]. With an environment that allows you to easily create animations and interactive elements, Scratch made it possible for many schools to teach graphic programming to children and adolescents. Due to its simple graphic interface with a classic HCI (Human Computer Interaction) design, screen, keyboard and mouse, making it easy for anyone who operates a computer to learn [34].

- CODE and Hour of Code: There is no doubt that Scratch is a great tool to teach programming, the idea that students learn by playing or creating their own video games, had many benefits in education. However, as technology advances, so does the training media. In this new generation where technological equipment (cell phones, tablets, etc.) are available to anyone, I push children and young people to lose interest in these programs, and as mentioned above, because they learned to differentiate programs or games from school to those they had at home. This is where CODE becomes momentous.

CODE, an online platform, is an initiative to learn to program from children, in a similar way to Scratch, guiding students with different levels of difficulty. It has several tutorials and courses by age for children and adults to start programming [35]. The novelty of CODE is that it presents interactive games and uses well-known characters or media such as Angry Birds, Star Wars, Plants vs Zombies, Minecraft, Legos, among others. This immediately caught the attention of the younger ones and made them interested in learning to code. Directly they are playing video games, but indirectly they are learning Blockly graphic programming (Google Visual Language).

- 3D Design and Basic Electronics with Tinkercad: If we want to encourage children to learn programming or other subjects through video games or interactive programs, Tinkercad is a good option. Tinkercad is free and online software developed by Autodesk. What most distinguishes this platform is its easy handling and the quality of educational content that it

delivers especially for those who want to get started in the world of 3D design, programming and electronics. It is very useful in schools that teach from a very young age to enter electronic engineering (handling Arduino and electronics) and systems (block programming and 3D design).

3. Results and Discussions

In order to know and verify that video games contribute to learning as educational tools, a survey was conducted with 60 third-grade students of the Bertolt Brecht School – Lima. From the data collected, two fundamental aspects are highlighted: the preference for the use of the three platforms mentioned above and the interest or taste to learn programming and electronics through this medium.

Preference for Using Learning Platforms

Fig. 4 shows the trend about the preferences towards Scratch, CODE and Tinkercad. The following was obtained.

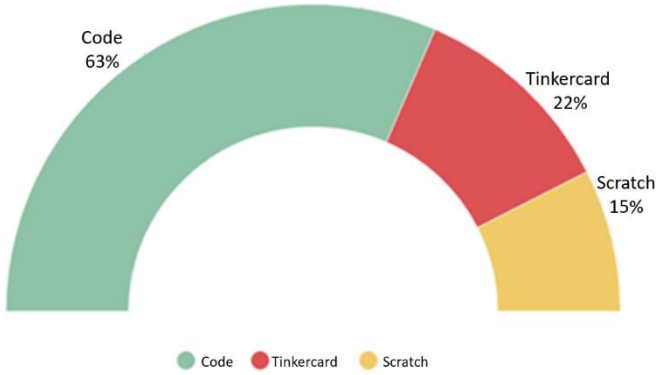

Figure 4. Preference of learning platforms

It is notable that more than 60% of students chose CODE, indicating that video games are the best way to lead students towards the culture of computing, among other disciplines. Since CODE uses games with characters that are well known to children, which consequently manages to obtain interest and achieve the proposed educational purposes, which is to learn and have fun at the same time.

Interest in learning Programming and Electronics through Videogames

Fig. 5 shows the trend of the important criterion of interest in programming for K-12 students. From these results, it is understood that it is natural for most children to take up video games. After all, they enjoy this form of entertainment, but it also generates a desire to learn about how it is designed, programmed and executed, among other things. Therefore, if this result is taken advantage of, the benefits of using video games as educational tools will bring with it an opportunity to train human resources in programming and other engineering fields such as electronics, thus enabling future solutions in these fields of study.

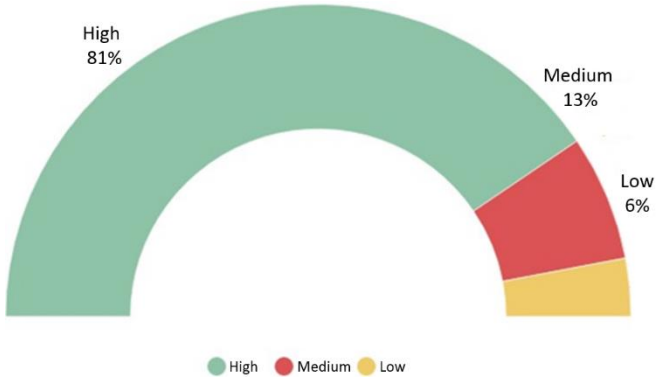

Figure 5. Level of interest in learning programming and electronics

Proposed Strategies for Promoting Programming Through Video Games

The integration of video games into K-12 school activities should motivate students to program their own games, lessons and educational projects. Fig. 6 proposes identified strategies that can be implemented in the classroom. These require a strategic pedagogical approach that combines playful learning with the development of programming skills. These strategies are designed to foster a dynamic and engaging learning environment, where students not only learn to program, but also develop key skills for their academic and professional future.

Game-based programming projects involve students developing projects by creating their own video games using tools such as Scratch, CODE, or Tinkercad. Likewise, gamification of the classroom allows for the introduction of game elements into the learning process to increase motivation and engagement. Also, collaborative learning through games encourages teamwork and collaboration among students to solve programming problems in the context of video game creation. It should be noted that the curricular integration of programming and video games makes it possible to incorporate programming with video games into traditional subjects, using educational games to teach concepts of science, mathematics, history, etc. However, this process requires teacher training, which involves training teachers in the use of educational video games and programming tools so that they can guide students effectively.

The implementation of a programming club can be attractive to students. In this extracurricular club, students interested in programming can explore the creation of video games in depth. It should be noted that the use of commercial video games for educational purposes means the incorporation of commercial video games that have educational value, using them as platforms to teach programming and other skills. Also, that the development of transversal competences such as creativity, problem solving, and critical thinking can be achieved by using video game programming.

The implementation of continuous assessment and feedback systems allows for measuring students' progress and adjusting pedagogical strategies as necessary. Finally, the design of interdisciplinary projects enriches knowledge, where several disciplines are integrated using video games as a central tool.

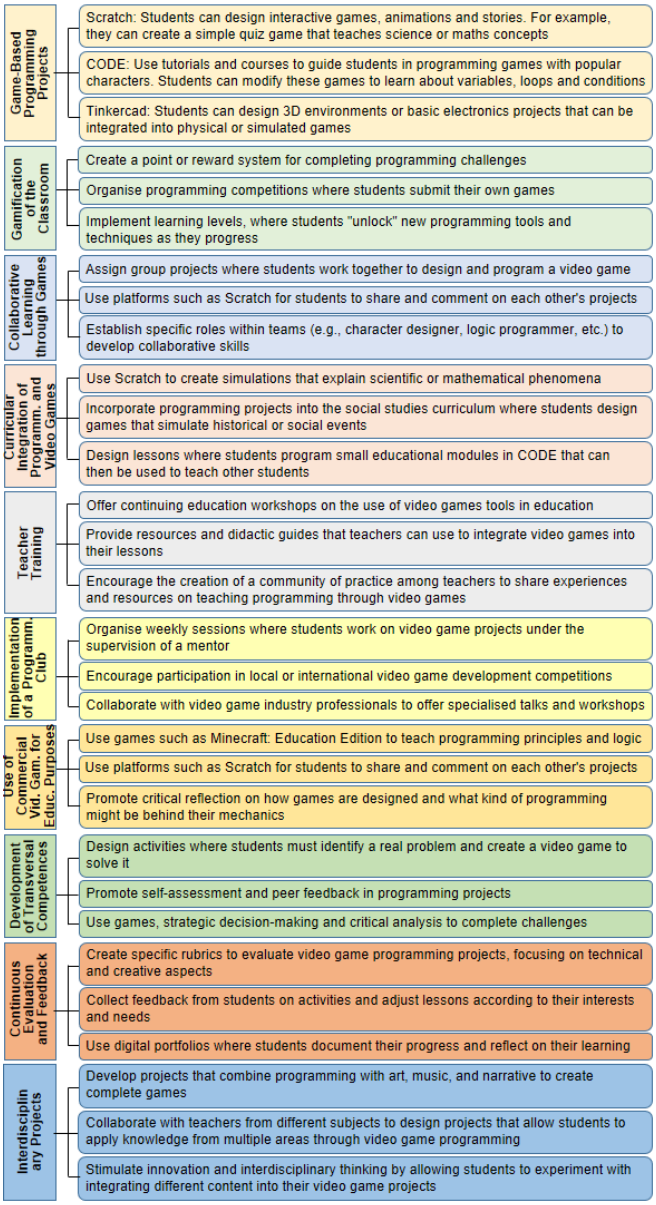

Figure 6. Strategies to integrate programming into video game activities

4. Conclusion

The study demonstrates that integrating video game tools such as Scratch, CODE, and Tinkercad into K-12 programming education significantly enhances student engagement. The use of familiar and interactive gaming environments captures students' attention and sustains their interest in learning programming concepts. Video games serve as an effective medium for developing computational thinking skills among K-12 students. The hands-on, interactive

nature of game-based learning encourages students to apply logic, problem-solving, and algorithmic thinking, which are foundational skills in programming.

The research indicates that the gamification of programming education positively impacts students' motivation to learn. Students are more likely to participate actively in programming activities when they perceive the learning process as fun and rewarding. This, in turn, leads to improved learning outcomes. The findings highlight the importance of achieving a balance between educational content and entertainment in educational video games. Games that are too focused on education may lose their appeal to students, while those that are too focused on entertainment may not effectively convey the intended educational content. A well-balanced game design is crucial for maximizing the educational benefits.

The research suggests that the benefits of using video game tools in education extend beyond programming. The skills developed through game-based learning, such as problem-solving, creativity, and collaboration, are transferable to other academic disciplines, making these tools valuable across the broader curriculum. The findings advocate for continued innovation in educational technology, particularly in the development of new game-based learning platforms. As technology evolves, there is a need to explore new ways to integrate these advancements into education to keep pace with students' changing interests and learning styles. The research identifies areas for future study, including the long-term effects of game-based learning on student achievement and the exploration of additional gaming platforms that may be effective in different educational contexts. Further research could also investigate the scalability of these methods in diverse educational settings.

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