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INTEGRATION OF GAMIFICATION AND DIGITAL TECHNOLOGIES IN THE SCIENCE TEACHING AND LEARNING PROCESS: PROMOTING THE ENGAGEMENT OF GENERATION Z IN A PUBLIC SCHOOL

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ABSTRACT

Generation Z education, characterized by digital connection and a preference for innovative methodologies, requires strategies that promote greater engagement and understanding. This study investigated the impact of gamification and immersive technologies in the teaching of Science/Biology, applied to students in the 6th grade of a public school. The objective was to analyze how these tools facilitate the understanding of complex concepts, such as cytology and body systems, in addition to stimulating students' motivation and protagonism. The methodology included gamified activities, such as quizzes, Battleship games and Escape Room challenges, integrated with Virtual and Augmented Reality resources. Engagement was measured based on the Four-Dimensional Scale of Student Involvement at School (E4D-EAE), which assesses cognitive, affective, behavioral, and agency dimensions. In addition, we used the daily teacher call and the record of correct answers in the activities developed to analyze academic performance. The results indicated adherence of up to 96% and significant improvement in performance, with an average of more than 85% in some stages. The survey showed that gamification stimulates curiosity, a sense of belonging, and collaborative learning, contributing to the assimilation of content and continuous engagement. The findings reinforce the transformative potential of active methodologies combined with technology, pointing to more specific pedagogical practices aligned with the needs of Generation Z.

Keywords: Gamification, Virtual Reality, Science Teaching, Active Methodologies, Generation Z.

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Revista ARACÊ
ISSN: 2358-2472

INTRODUCTION

Currently, the learning process has been accompanied by numerous and growing studies that point to the need to include the proposal of learning as an important and worrying factor, especially for individuals who were born between the 1990s and 2010s, classified as digital natives (Prensky M, 2001). These individuals were born immersed in the digital world, and this generation encompasses Generation "Z". These young people, deeply integrated into digital culture, demand teaching methods that engage and stimulate the development of essential skills for the twenty-first century (Green & McCann, 2021).

It is understood that the different teaching methods and methodologies are as important as the learning content itself for this generation. The use of active methodologies that make the teaching-learning process more attractive is a very important strategy for these new generations, since they seek protagonism within the teaching-learning process (Moran, 2000; Rocha, 2012; Kalena, 2014; Bacich; Grandson; Trevisani, 2015; Santos, 2015; Adam; Barros, 2015; Faria, 2015). Active methodologies are based on instructional activities, capable of engaging students and making them protagonists in the process of constructing their own knowledge, that is, they are methodologies that lead students to meaningful learning, based less and less on the transmission of information and more on the development of skills (Faria, 2015; Camargo, 2018). In view of this logic, new teaching techniques become part of the scope of theorists, not only in the area of education, but of the entire academic community, in the identification of deficiencies and in the proposition of new teaching-learning methodologies (Bacich & Moran, 2018).

Currently, gamification is one of the main methods of active learning, as it is a technological tool used on a large scale by audiences of different ages, especially school-age youngsters, incorporating game mechanics into the educational process (Erenli, 2012; Schmitz et al., 2012; De-Marcos, 2014). Essentially, it brings to teaching elements common to video games such as challenges, rules, narratives and *storytelling*. In this way, it is possible to expose students to problems based on different situations, making different resources available so that they can solve them. It is a practice that stimulates playful teaching and analytical thinking, developing skills previously unheard of in the classroom (McGonigal, 2011; Martins & Giraffa, 2015). In this way, gamification collaborates for a more dynamic and active study, taking advantage of natural human trends such as socialization, competitiveness, and the search for rewards to make learning more interesting and attractive (Muntean, 2011).

Revista ARACÊ
ISSN: 2358-2472

In this study we brought to light the need to consider this new technology aimed at enhancing talents and competencies, as well as pointing out and filling the gaps in the learning processes in the scope of the ideals of expanding the development and production of new didactic materials for the teaching of Science/Biology. A constant criticism in schools, especially public ones, for the teaching of this discipline usually refers to the few alternative didactic resources that motivate and enrich the classes, making the school environment discouraging students, which imposes on the teacher a great challenge to keep them attentive and motivated throughout the school year (Silva & Vallim, 2015). Thus, proposing activities that cover content ranging from cells to body systems with gamification, ranging from quizzes to games such as Naval Battle and Escape Room challenges, giving students a certain protagonism in the teaching of Science/Biology is one of the strategies proposed in this study as crucial for the teaching-learning process.

However, the use of gamification associated with the use of virtual reality (VR) and augmented reality (AR) can enable the student to feel more present in the study environment presented, in addition to providing him with the virtual manipulation of objects, thus minimizing the distance between the contents covered in the classroom, which is most often abstract (Mattar, 2007; Ramos Fonseca et al., 2022). Therefore, this study used the implementation of this methodological tool associated with gamification in the teaching of Science/Biology for Generation Z students, that is, for elementary school students. Innovative activities were proposed, such as 360° video shows on the YouTube VR platform and the use of AR software, thus aiming not only to expand knowledge, but also to arouse positive emotions and explore students' aptitudes.

Thus, this study intends to provide students of this generation with notes on some strategies that can facilitate learning in the discipline of Science/Biology, promoting the integration between the use of active gamification methodology technology and virtual reality, thus enabling students to be the active and transforming agents of their teaching-learning processes. It is believed that the predominant contribution of this study is to expand and impact the educational process of the Science/Biology discipline by integrating physical environments (aided by equipment) to virtual experiences, in addition to arousing positive emotions and exploring skills, retaining students' attention, thus promoting better use of the learning process of Generation Z students.

Since education is a process of human formation, the student must be guided by the educator in the promotion of freedom, solidarity, autonomy and ethics, as well as the

Revista ARACÊ
ISSN: 2358-2472

recognition of the individuality of the other and the responsibility for their actions. For this, it is necessary to resignify the ways of constructing knowledge, especially as a result of the new ways of living of this generation in society. Therefore, with the premise of analyzing the desires and expectations in the learning of this generation, this study proposes a reflection on the implementation of different tools, that is, gamification associated with virtual reality learning, in the academic sphere, as a way to motivate and facilitate learning in the area of Science/Biology. To this end, this research sought to analyze the perception of students in the 6th grade of Elementary School in the public school located in the city of Vila Velha/ES.

THEORETICAL FRAMEWORK

Although Karl Mannheim's (1893-1947) concept of generations represents a very complete explanation of the subject, the potential for analyzing the concept proposed by this author is still many, considering the different translations and productions on the subject up to the present moment. Despite the different meanings of the concept of generations that follow very diverse and even contradictory strands (Freitas, 2002), the relevance of the *Mannheimian* concept for sociological research on generations, as well as its interfaces with other fields, has been resumed and points not only to class differences, but also to gender inequalities. ethnic-racial, cultural and generational (Feixa & Leccardi, 2010; Parry & Weller, 2010; Urwin, 2011). For Mannheim, generation is an eminently cultural phenomenon and translates into a group of individuals who have in common a time of birth, the experience of social events and significant sharing of the same historical experience, which generates a permanent common consciousness in the course of life (Weller, 2010). Persisting in this perspective of social category, the concept of generations for Groppo (2000, p. 27) means: "[...] a socio-cultural creation of its own, striking and fundamental to the processes of modernization and the configuration of contemporary societies [...] arises alongside or in conjunction with other essential social categories, such as social structures and stratifications, gender relations, ethnic relations and others, as well as with crucial historical phenomena, such as capitalism, imperialism, Westernism, etc." (Jacques et al., 2015). Sarmento (2005) corroborates this idea that generation is combined with the effects of class, gender or race in the characterization of social positions, in a relationship that is neither merely additive nor complementary, and is exercised in its specificity, activating or partially deactivating these effects. This same author adds that generation can be a sociological construct that seeks to account for

Revista ARACÊ
ISSN: 2358-2472

dynamic interactions "[...] between, on the synchronic level, the age-group generation, that is, the structural and symbolic relations of the social actors of a defined age class, and, on the diachronic level, the group-generation of a defined historical time, that is, the way in which they are continuously reinvested with social statuses and roles and develop social practices differentiating the actors of a given age group, in each concrete historical period" (Jacques et al., 2015). For Weller (2010), generations can be understood from their relations with the social environment, the sexes, the age group, among others (cf. Bohnsack & Schäffer, 2002: 250-253 and Schäffer, 2003: 77-86). She points out that such a perspective is even more evident when a generation comes to be conceived not only in distinction from other generations or generational positions (cf. Bude, 2000), but also in relation to the common aspects existing among the members of a generational connection. Thus, the concept attributed to the study of generations is related to the behavioral impacts promoted, at a social level, through people born at the same time, who suffer the interference of the historical context, being influenced educationally, politically and culturally, or impressed by the same events that will probably share the same values and knowledge (Forquin, 2003). Corroborating this definition, Zemke (2008) reinforces these aspects when he states that generations are different in terms of beliefs, values and priorities and that generational groups become a direct consequence of the moment they experience.

On the other hand, there is no consensus on when a generation begins and ends, as well as the time interval between generations. Currently, there are three generations in a time span of about 40 years, and the determining factors to speed up the passage between generations were the radical changes in lifestyle and access to young people, technology and the media. Previous studies do not report a direct relationship between the emergence of new technologies and the acceleration in the emergence of generations, but it is very possible that access to new technologies has brought generations closer together. The fact is that there are more generations in a shorter period of time. Each of these generations has some specific characteristics and ways of thinking, acting, learning and behaving in different environments, such as school and professional. The observation of notorious differences between the aforementioned generations leads us to presume that these differences are strongly reflected in the teaching-learning process, with different characteristics, interests and ways of learning. It is necessary, therefore, that there be promotion, updating and greater teacher versatility in understanding generational

Revista ARACÊ
ISSN: 2358-2472

characteristics, so that teachers and educational institutions can, together, adapt to changes to improve student education. It is with these generations that we are dealing in the twenty-first century and there is a clear generational confrontation between teachers and students. The educational environment reflects the desires of the linear process of teaching and finds students hyper-connected, centered and adapted to the language of hyperlinks, which breaks with the traditional process of education based on text and orality (which seems archaic and unattractive) (Neto, 2010). Thus, it is understood that the different teaching methods and methodologies are as important as the learning contents themselves. Within this logic, teaching techniques become part of the scope of theorists not only in the area of education, but of the entire academic community that seeks to identify its deficiencies and seeks to propose new teaching-learning methodologies. The use of active methodologies has become a very interesting strategy, as it seeks to make the teaching-learning process more attractive to these new generations that seek protagonism within the teaching-learning process.

Parallel to the scientific, technological and consolidation advances of globalization, a time when there was development and dissemination of electronics and digital in the 90s, those born in this period began to experience and express the language of computers, cell phones, games and the internet. For Marc Prensky, American writer and lecturer in education, individuals who were born between the 1990s and 2010s are classified as digital natives. These individuals were born immersed in the digital world, and this generation encompasses Generation "Z". This "Z" comes from the term zap, that is, changing TV channels constantly and quickly. The term "Zap" comes from English and can be translated as "to do something quickly". Thus, called the Digital Generation or Next, whose members are those who emerged in the technological or knowledge era, the computer, the internet and the cell phone, this generation is classified as the speed generation. They learn fast, are dynamic, demanding, connected and self-taught, and were born following most technologies. For Green and McCann (2021), Generation Z students are "hungry" for fast and clear information due to the fact that since childhood they have had contact with the internet, the media, and other technological resources, factors that would explain why they show impatience in relation to day-to-day activities that do not involve the practicality of technologies. Thus, it is possible to conceive that this generation needs different learning methods, when compared to other generations (Silva; Patrick; Ribeiro, 2016; Ziede; Silva; Pegoraro, 2016; Kings; Tomaél, 2017; Carvalho et al., 2019).

Revista ARACÊ
ISSN: 2358-2472

Toledo, Albuquerque and Magalhães (2012) believe that Generation Z students need pedagogical practices that involve an instigating methodology, which use technologies in a motivating and creative way.

Given this scenario, the use of active methodologies becomes a very interesting possibility. Active methodologies present different models and strategies of operationalization, constituting alternatives for the teaching-learning process, with several benefits and challenges, at different educational levels, sharing the concern of stimulating the more active participation of students. Several studies (Bacich; Grandson; Trevisani, 2015; Santos, 2015; Adam; Barros, 2015; Faria, 2015; Kalena, 2014; Moran, 2000; Rocha, 2012) show that the use of active methodologies leads students to more efficient and effective learning. In this context, the use of technologies (tablets, notebooks, smartphones, digital tables, virtual reality, virtual laboratories, simulators, digital games, etc.) can play a crucial role by offering tools and resources that can help students with different needs and abilities in overcoming barriers faced in their daily school lives. With the creation of accessible virtual learning environments, students can participate in interactive, collaborative, and personalized activities, thus expanding their learning opportunities and promoting an inclusive and equitable education (Biazus & Rieder, 2019).

Generation Z is the first generation of the twenty-first century capable of benefiting from and experiencing this new form of learning, as it is closely related to the expansion of the internet and technological devices. Patela (2016) states that the age of generation Z born between the years 1995 and 2009, encompasses individuals around 13 years old, the youngest and 28 years old, approximately. The individuals of this generation live and move in an environment surrounded by the sharing of information and files, by smartphones and tablets, always involved by the logical network, or rather, by the internet, which keeps them connected to the world. An important observation in relation to those born in Generation Z is that individuals of this generation belong to a connected world and have probably never seen themselves without the presence of a computer.

At this moment, it becomes essential for us, teachers, to reflect and understand that we are facing young people with different experiences, skills, ways of thinking and learning compared to previous generations. The evolution of successive generations is a path of no return, it always exists and will continue to exist, however, changes will apparently occur at a faster pace, and we cannot fail to include this information in the educational environment. The constant search for more information about these profiles over the generations

Revista ARACÊ
ISSN: 2358-2472

focuses on the following questions: what is the best learning style for today's students? What are the main current styles and trends that we can use to increase student engagement and participation, inserting teachers in a new way of thinking and compensating the teaching-learning process?

The learning process in education seems to be individual and different for each student, generating cognitive and emotional connections. In active methodologies, there is also a conception that, in the teaching-learning process, there is the effective participation of students in the construction of their learning, characterized by a process at their own pace and time, leading them to a better engagement with the proposed curriculum. (Bacich & Moran, 2017). The use of games as part of the teaching-learning process has become a topic of debate among educators who envision active methodologies. According to the website Porvir (2015), curator of innovative content on strategies to improve quality in education at the national and international level, gamification "is the integration of game elements, such as levels, emblems, and competition, into the curriculum." (Almeida et al., 2016).

Gamification is a technique that uses the logic of games in other contexts and, in the teaching-learning process, stimulates students, making it more attractive by leveraging natural human behavioral processes such as socialization, competitiveness, the search for rewards, and the pleasure of overcoming challenges (Camargo, 2018). Fadel et al. (2014) present several definitions, application proposals, questions and solutions related to the theme of gamification applied to education. Schlemmer (2014) points out that gamification in education involves the application of the thinking styles and strategies present in games that make them pleasurable. Another contribution to studies on gamification in education was proposed by Jane McGonigal (2011), who describes gamification as a pedagogical strategy that, by incorporating typical elements of game dynamics, can meet the profile of contemporary students. In addition to aligning learning with the development of skills, it allows for personalized teaching, fostering innovation in education. Gamification becomes attractive because it is seen as a natural movement intertwined with human development (Martins; Giraffa, 2015).

Schlemmer (2014) highlights that gamification in education consists of applying the way of thinking, styles and strategies that are present in games and that make them fun. The basic elements of the game are: character (allows identification with the student), competition (Muntean, 2011) highlights that for success in gamification, the intensity of

Revista ARACÊ
ISSN: 2358-2472

student engagement is preponderant. Schmitz, Klemke and Specht (2012) highlight that the basic elements of the game are: character (allows identification with the student), competition (favors the students' focus and attention) and game rules (provide an immersion environment favorable to the student's involvement in the learning context) and that they have a direct effect on the student's learning process when applied to teaching contexts. Recent studies by Erenli, 2012 and De-Marcos, 2014 show that the gamification approach is becoming more efficient in relation to the more active participation of students, thus providing changes in behavior, interaction between them and cognitive development. In this way, the improvement in the educational environment becomes noticeable, bringing dynamism and facilitating problem solving and student engagement. It is arguable that the use of gamification in teaching awakens emotions in students through more intense and fundamental experiences to constitute memory, communication and knowledge itself. In this sense, Vianna et al., (2013) identified four characteristics in the mechanics of games, which are understood as essential when developing the gamification instrument, based on obtaining clear objectives, with a defined beginning and end: a) Rules of the game (reason for the performance of that activity by the individual); b) Game goal (function of determining how the individual should behave and act to meet challenges); c) Feedback system (guides the individual about his position in reference to the elements that regulate the interaction within the game, leading to better use in the game); d) Voluntary participation (main reason for interaction between individual and game, the motivation for participation must come from the individual himself). Therefore, the gamification technique emerges as a strong candidate to create possibilities to connect the students' universe with a focus on learning, through a playful system instead of focusing on traditional effects such as grades, aligned with the mechanics of games to promote experiences that emotionally and cognitively involve students.

Studies have shown the application of an active gamification methodology strategy in elementary and high school, that is, in generation Z, with the aim of motivating, engaging, involving, promoting learning actions in the areas of exact sciences, with an emphasis on mathematics (Silva et al., 2008; Webber et al., 2016; Shah; Azevedo; Alves, 2022); and others in interdisciplinary activity for the disciplines of Arts, Mathematics, Sciences, Geography and Portuguese Language (Venâncio; Mayan; Maia, 2023). The study by Costa et al., 2019, used the gamification method in the form of a quiz, in students, aged between 14 and 17 years, in high school computer courses, that is, in individuals

Revista ARACÊ
ISSN: 2358-2472

from generation Z, and the authors showed that more than 70% of students had a greater interest in carrying out an activity containing elements of gamification and 54.5% declared that if the subjects in the classroom were taught in gamified activities they would have better learning. In the study by Silva, Sales and Castro (2019), the efficiency of gamification in learning in Physics classes was positive, demonstrating considerable potential to stimulate the active participation of students in the learning process. In this scenario, gamification in science teaching is often proposed as an innovative strategy to address contemporary educational challenges. In the context of science education, technological tools provide an opportunity for students to explore and understand the world around them, allowing for a more dynamic and engaging interaction, where it is possible not only to unravel behaviors and phenomena, but also to make the learning process more interactive and accessible (Porto, 2022). In the study by Costa, Duarte and Gama (2019), the implementation of a didactic board game called "Botanical Trail" in a 7th grade class of elementary school, demonstrated a positive impact, capable of catalyzing interest and understanding and being effective in promoting an effective absorption of knowledge in specific disciplines as is the case of Botany.

It is worth mentioning that the discipline of Biology is a fundamental discipline for the development of essential knowledge related to the living world and the relationships between living beings and the environment, and that many of these concepts are abstract, as they are microscopic structures, which address everything from the basic structure of the cell to the intracellular and molecular mechanism. For the understanding of such contents, it is necessary that the teaching and learning process, especially in the context of Biology Teaching, which for this generation, is not sufficient for the understanding of the concepts, resulting in a reduced level of interest and motivation in learning (Diniz; Schall, 2001).

However, studies have shown that gamification in the teaching of Biology can improve student performance and contribute satisfactorily to the learning process (Silva & Vallim, 2015; Cointer, 2019; Coutinho, 2020; Marcel, 2021; Pantoja; Silva; Montenegro, 2022; Oliveira, 2022). The use of apps, digital platforms, serious games, and online resources allows students to explore biological content in innovative ways, providing immersive sensory experiences and facilitating the understanding of concepts. However, it is essential that students understand that "the game is not the end, but the axis that leads to a specific didactic content, resulting in a borrowing of the playful action for the

Revista ARACÊ
ISSN: 2358-2472

acquisition of information." (Silva et al., 2015, p. 4 apud Kishimoto, 1996). In this case, the game gains the aspect of a didactic tool for the practical class; In this situation, the theory already presented is used during the class and not just a dynamic to stimulate participation.

As recommended by the National Curriculum Guidelines in relation to the use of innovative strategies and support materials in the teaching-learning process (BRASIL, 2000) and, as proposed by the National Common Curricular Base (BNCC) for the skills of Natural Sciences and their Technologies in the Elementary and High School stages, the use of digital devices and applications, such as simulation and virtual reality software, should be used in order to analyze the multiple forms of manifestation of life at its different levels of organization, proposing the use of representations and simulations (Brasil, 2018, p. 557). In the educational sphere, Digital Information and Communication Technologies (DICT) have the potential to instigate students and teachers to think, question and create throughout the teaching-learning process (Da Cunha Alves; Heckler, 2018), in addition to enabling an environment with a diversity of information, where knowledge is shared through digital, interactive, and dynamic resources (Lopes et al., 2019). Among these resources, Virtual Reality (VR) defined by Sherman; Craig (2019, p. 16) as a medium composed of interactive computer simulations that detect the participant's position and actions and replace or enhance the experience back to one or more senses, giving the sensation of being mentally immersed or present in the simulation (a virtual world), has become known for its contributions in the most diverse areas.

Seeking to add innovation in educational environments, the use of VR and virtual learning environment allows to expand or complement the understanding of the real world, helping teaching through new ways of viewing objects of study. Through VR, the student visualizes and simulates the handling of microscopic objects such as cells and DNA molecules, in addition to exploring biomes through visualization, immersion and real-time interaction. In addition, VR can enable access to natural science museums, visits to national parks, laboratory simulation, etc. This approximation between abstract concepts and their presentation in real form collaborates with the development of investigative skills, the ability to create hypotheses, formulate explanations and relate them to concepts related to the discipline of Biology (Queiroz et al., 2015).

Considering the advent of these new technological, informational and communicational resources to the use of new possibilities of innovation and modernity in the area of education and, considering that these tools in combination with gamification

Revista ARACÊ
ISSN: 2358-2472

strategies for the teaching of Biology content can improve the acquisition of knowledge and learning for Elementary School students, the association of the use of Virtual Reality glasses, an innovative technology equipment for viewing VR simulation to gamification game could expand the educational process of the science/biology discipline by integrating physical environments (aided by equipment) into virtual experiences, in addition to arousing positive emotions and exploring skills, retaining the attention of Generation Z students.

Thus, the study in question will address the association of tools as a methodological strategy to innovate educational practices and serve generation Z, born between 1995 and 2010, since this generation deeply integrated into the digital culture, demands teaching methods that engage them and stimulate the development of essential skills demands for the twenty-first century. Gamification, incorporating game mechanics into the educational process, emerges as a crucial strategy in this context, taking advantage of natural human tendencies such as socialization, competitiveness, and the search for rewards to make learning more attractive. VR, bringing abstract concepts together and their presentation in real form, collaborates with the development of investigative skills, the ability to create hypotheses, formulate explanations and relate them to concepts related to the discipline studied.

OBJECTIVES

Use the active teaching approach through gamification, associated with the use of serious games and immersive digital technologies, in the academic context as a way of learning and interaction of Science/Biology content with 6th grade students, generation Z, from the full-time Public School in the municipality of Vila Velha - ES, to the different topics taught in the discipline of Science/Biology.

METHODOLOGY

The study was carried out during the 2023 school year with Elementary School II students, starting in May and ending in December of the same year. About 70 students, aged between 11 and 13 years, from two classes (class 1 and class 2) of the 6th grade participated. All participants agreed to the consent form, with the consent of their parents or guardians. The project was a partnership between the public school CEEFMTI Pastor Oliveira de Araújo, located in Vila Velha/ES, and the Laboratory of Biosciences, Innovation

Revista ARACÊ
ISSN: 2358-2472

and Technology (BioInov@Tec) CEFD/UFES. The study is registered and registered with the Espírito Santo Research Support Foundation (FAPES) under process number 132/2023 P 2023-RMRFD, through the Junior Scientific Initiation project, developed in partnership between Higher Education Institutions, the Federal University of Espírito Santo and the school of the Public Basic Education Network aiming to awaken in the students of the Network the vocation for science, for technological development, as well as for innovation actions.

NATURE AND APPROACH OF THE STUDY

From the point of view of its nature, the study is applied, as it proposed to generate knowledge for a practical application, seeking specific solutions to problems in the discipline of Science/Biology (Silva & Menezes, 2005). This practical application was innovative through gamified activities in a structural way (Cavalcanti & Filatro, 2018), organized in review activities, prepared by the school's teachers and by the team of the Laboratory of Biosciences, Innovation and Technology (BioInov@Tec) located at CEFD/UFES. The Science/Biology contents were reviewed weekly, three times a week.

As for the approach to the problem, the study has a qualitative character, the environment where the study was developed was a direct source for data collection, focusing on the process and its meaning (Milgran et al., 1994; Azuma, 2001; Tori; Hounsell; Kirner, 2018). Data collection took place through questionnaires with questions designed to collect the experience reports of Generation Z students in relation to the use of active gamification methodology and immersive VR technology in the teaching-learning process of Science/Biology. The measurement of engagement was based on the Four-Dimensional Scale of Student Involvement at School (E4D-EAE) by Veiga (2013), which covers the cognitive (Active Learning, Problem Solving, Self-Regulation, Challenge), affective (Fun, Incentive, Interaction, Support), behavioral (Persistence, Participation, Concentration, Commitment) and agency (Action, Initiative, Communication, Intervention) dimensions.

DATA COLLECTION INSTRUMENTS

Student engagement was measured using a multidimensional scale with 20 statements, using a response scale from 1 to 4, where; 1 (No), 2 (Almost never), 3 (Sometimes) and 4 (Yes).

Revista ARACÊ
ISSN: 2358-2472

METHODOLOGY AND TOOLS USED

The activities were developed using educational software for exercise and practice, whose main characteristic is content review, memorization and repetition (Oliveira, 2001). The gamification used for the development of the activities was of the structural type (Cavalcanti & Filatro, 2018), which uses elements of the games to motivate students without changing the content. The addition of VR aimed to create three-dimensional projections in the real world, facilitating and enriching learning.

STAGES OF METHODOLOGICAL DEVELOPMENT

PLANNING ACTIVITIES

It involved the selection of scholarship monitors (ninth grade students) to work directly with the participating classes. Initially, there was intensive training of these monitors in relation to the gamification methodology and the review of cell biology concepts. In this training, the scholarship holders implemented the activities and applied the peer learning methodology, promoting active collaboration among them.

In addition to the introduction to cell biology content, workshops on the development of digital platforms, the creation of narrative games and the elaboration of a banner representing the project, as well as a logo, the mascot, called SIA, were held as a continuation of the training of the monitors, which contributed significantly to the personalization of these scholarship monitors in the gamified environment. SIA is an investigative robot with cat-like features, possessing an articulated and stylized metal body, a TV-shaped head with a cat-like face and ears, as well as a tail with a plug, reinforcing its technological and friendly aesthetic. His dynamic and friendly posture represents the investigative spirit of the project. This phase was essential for the design of the project in the discipline, integrating gamification elements, including a reward system. At the end of each level of the games, students received personalized pins and star-shaped stickers to apply to a skills card representative of the completion of the level. In addition, each class received a number of 3D printed coins, called BioCoins, as an incentive to progress. At the end of the project, the class that accumulated the highest number of coins and reached first place in the ranking won a tour as an award to the Museum of Life Sciences located at UFES, which contains a collection of plastinated human and animal pieces.

Revista ARACÊ
ISSN: 2358-2472

FIRST ACTIVITY (PHASE 1)

The first activity was carried out through the Kahoot platform (https://kahoot.com), used to review and evaluate knowledge about cells. Kahoot uses multiple-choice questions, encouraging students to investigate, create, collaborate, and share knowledge about cellular structures and the history of microscopy.

SECOND ACTIVITY (PHASE 2)

The second activity was carried out through the ClassDash platform (https://classdash.aulaemjogo.com.br), in the free version, using the game "Battleship" to explore the types of cell phones and cell organelles in an interactive way. Each class was divided into two teams, and was presented on a screen, a board with several hidden ships was placed to represent the challenge and competition between the teams. Students had a maximum time of 15 minutes to answer questions that vary in difficulty levels. As they hit the answers, the teams gain ammunition to discover the opposing team's ships.

THIRD ACTIVITY (PHASE 3)

It happened through an innovative approach with the use of Virtual Reality (VR) glasses. This activity focused on the theme of histology, exploring human tissues, their formation and organization, and body systems. The students participated in an enigmatic activity, which consists of deciphering a text with inspection of cells and their functions in body tissues, where codes need to be replaced by letters. After solving the riddle, the students were directed to the virtual puzzle platform (https://interacty.me/pt/) to assemble an image that represented the deciphered content, with a timed time. Then, we watched 360º videos on the free YouTube platform (https://www.youtube.com), using VR glasses, deepening the knowledge about human tissues, with the theme "Where does blood come from? This combination of Virtual Reality and virtual puzzle provided an immersive and visual experience, making it easier to understand concepts related to the structure and organization of tissues in the human body.

FOURTH ACTIVITY (PHASE 4)

This activity marked the culmination of the project and was carried out by the Escape Room application, being entitled "BioEscape". This activity integrated digital culture with pedagogical practices, using elements of the metaverse, such as augmented and

Revista ARACÊ
ISSN: 2358-2472

virtual reality, to explore biological structures in an interactive way in the school's Science laboratory. The riddles were locked in boxes closed with padlocks, whose codes were alphanumeric and had their answers based on the content taught in class throughout the school year. The Escape Room used all technological resources (augmented and virtual reality) in addition to playful and attractive elements for student participation. Through BioEscape, it enabled the association of technological resources and playful elements, making the learning of these students more attractive.

Thus, the proposed activities were described and presented as a great trail game, with the science/biology discipline gamified in 4 phases as shown in Figure 1.

Figure 1: Representative scheme showing the 4 phases developed in the project

Source: Authors Themselves

FINAL PHASE - DATA COLLECTION AND STATISTICAL ANALYSIS

The organization of the study stages, referring to the analysis of each question of the data collection instrument and the treatment of the information collected, was detailed as follows:

Descriptive Analysis: The medians, standard errors, and frequency distribution were evaluated for each of the engagement dimensions (cognitive, affective, behavioral, and agency). The objective was to describe the general characteristics of the data, offering a detailed view of centrality and dispersion, facilitating the identification of possible outliers or asymmetric distributions.

Reliability Analysis: Reliability is the degree to which the measured result reflects truth, i.e., how free a measure is from the variance of random errors. The validity of a measuring instrument is the main characteristic to evaluate its efficiency (Hayes (1998). An

Revista ARACÊ
ISSN: 2358-2472

instrument is considered valid when it measures what is desired. To be valid, the instrument must be secure. The alpha coefficient (CRONBACH, 1951) is a statistical technique that measures the reliability of a questionnaire through the internal consistency of the items in each dimension studied, analyzing whether the dimensions evaluated are coherent and represent the constructions investigated.

Percentage Analysis: The percentages were presented to illustrate the distribution of responses among different categories or groups, allowing a quick understanding of the trends and occurrences observed in the collected data.

RESULTS AND DISCUSSION

It is well described that the Brazilian educational system, and especially in the state of Espírito Santo, faces a number of challenges and demonstrates a clear desire to improve its teaching approaches. Among these approaches, it seeks to overcome the traditional teaching model, which is often characterized by the fragmentation of knowledge and, in many cases, seems distant from the reality of students of the new generations, especially generation Z (Costa; Duarte; Gama, 2019; Coast; Cross; Marques, 2021). It is notorious that when it comes to complex and abstract subjects such as those related to Science/Biology, difficulties are encountered and playful activities are necessary, instigating a reflection on the adoption of new methodologies.

In this context, it is worth noting that this study faced some challenges in the implementation of gamification and Virtual Reality in the educational process of the selected public school. Initially, there was some resistance to the use of these new technologies, mainly attributed to the lack of familiarity with the methodologies and the fear of replacing traditional teaching methods with these new technologies. This obstacle of hesitation on the part of some educators who, although they have knowledge about some methodological strategies, including gamification, face insecurities when implementing them has been evidenced (Viana et al., 2021). On the other hand, many educators may not have been previously exposed to gamification practices and may feel uncomfortable or unprepared to implement them. Offering adequate support and training is essential to enable teachers to effectively integrate gamification into their pedagogical practices. To overcome this challenge, a training of the faculty was offered, showing and highlighting the importance of developing these digital skills among educators so that they could effectively facilitate the proposed activities.

Revista ARACÊ
ISSN: 2358-2472

In addition to these challenges in the sphere of the people involved, another obstacle found in this study was the school's technological infrastructure, specifically the internet network, which made it difficult to access the number of VR devices for the number of students and the use of gamification platforms. And, finally, there was a need for readjustment and reorganization of the curriculum to meet the particularities of these activities in the discipline of Science/Biology by the school.

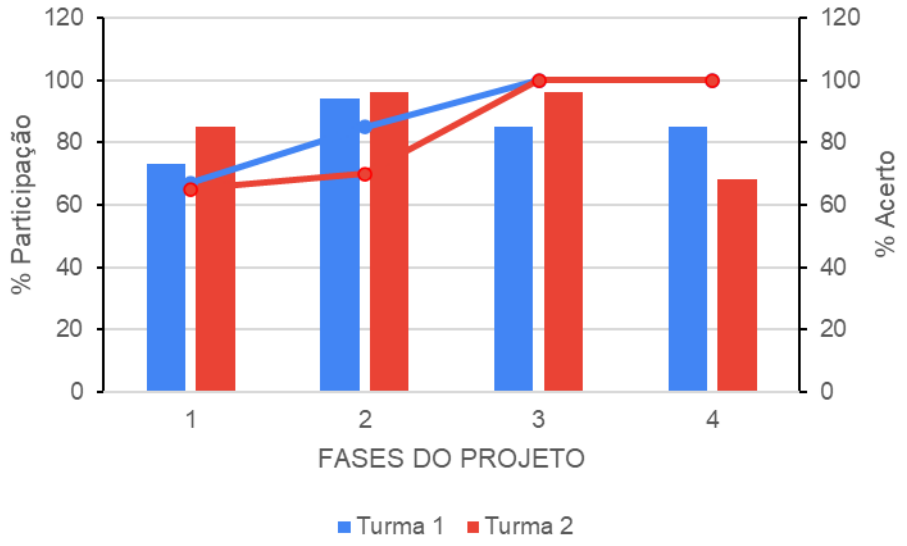
Thus, it is a central challenge for schools, since there is a need to adapt the curriculum to introduce new technologies, a fact that may require considerable adjustments in lesson plans and curriculum structure, thus representing a significant challenge, especially for educators accustomed to more traditional methods (SALVADOR et al., 2015).

However, despite these limitations that preceded the implementation of innovative technologies in education, specifically through gamification and Virtual Reality (VR), for the teaching of Science/Biology to Generation Z students, our results were significant on the effectiveness of these methodologies in the teaching-learning process in the educational environment were verified. From the beginning, there was a high expectation that the combination of these approaches could promote engagement in the teaching-learning process of Science/Biology in this school. However, this expectation was confirmed through the results obtained in relation to the implementation of new technological tools, the rate of adherence to the activity and the performance of students in digital games.

Graph 1 highlights the evolution of participation throughout the phases, evidencing the positive impact of interactive methodologies on the motivation and involvement of students in the educational context. The participation data showed remarkable progress in student engagement throughout the different phases of the project, with emphasis on the impact of the gamification methodology.

Revista ARACÊ
ISSN: 2358-2472

Graph 1: Percentage of participation and correct answers in the activities in the 4 phases of the project for classes 1 and 2 of students in the 6th year of elementary school II



Although the project was presented to all participants in the 6th grade classes, effective participation increased significantly after the second phase. In Phase 1, adherence was 73% for class 1 and 85% for class 2, with growth in Phase 2, reaching 94% in class 1 and 96% in class 2. This increase can be attributed, in part, to the use of gamification elements that stimulate student engagement. During this phase, participants received incentives such as skill cards, stars that symbolize their participation, and pins representing the completion of each phase. These positive reinforcements motivated the other members, who initially did not participate, to engage in the project's activities. In the subsequent phases, participation rates were high. In Phase 3, participation reached 85% in class 1 and 96% in class 2, consolidating student engagement. In phase 4, we observed unequal participation, with a decrease in participation, with the indices registering 85% in class 1 and 68% in class 2. This reduction was justified by the school's pedagogical coordination as a consequence of the period coinciding with the eve of a holiday, which impacted the presence of students.

Even bumping into this setback, a significant improvement in academic performance was observed for the proposed activities, reflecting not only in a greater engagement of the students, but also in a deeper understanding of the contents involved for the discipline of Science/Biology. The study carried out by Silva, Sales and Castro (2019), highlighted the positive effect on the efficiency of gamification in learning in Physics classes, demonstrating considerable potential to stimulate the active participation of students in the learning process. Alves and Brandt (2023) highlight the main advantages of gamification,

Revista ARACÊ
ISSN: 2358-2472

such as increased student engagement, improved information retention, and contextualization of science teaching. In addition, the authors mention that gamification encourages collaboration, healthy competition, and the development of socio-emotional skills.

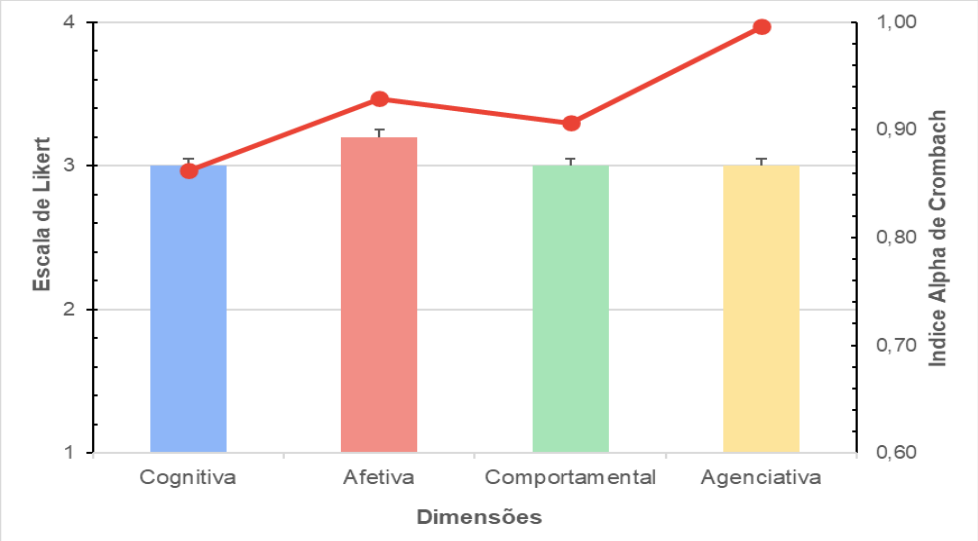
As shown in graph 1, in Phase 1, the average number of correct answers was 67% and 65% for classes 1 and 2, respectively. These results indicate that both classes had a similar starting point, with identical percentages of correct answers. On the other hand, in Phase 2, there was a significant increase in academic performance. The average number of correct answers in class 1 was 85%, while class 2 obtained 70%, showing a more marked progress for class 1 in this stage. This difference may reflect factors such as the pace of adaptation to activities or the specific characteristics of the groups. A very unusual and interesting fact occurred after this phase. The students were encouraged to seek additional information about the contents involved in the project activities, and it was found by the school managers and teachers that the students started to frequent the school library more in search of books that would facilitate the understanding of the contents. From this initiative and this relevant behavior of the students, an increase in student engagement was observed, evidencing the positive influence of the project in stimulating autonomy in the search for information and complementary learning resources.

These tools allowed students to explore complex aspects of the contents in an interactive and detailed way, enhancing the assimilation of concepts. The maintenance of high rates of correct answers between classes reinforces the effectiveness of the pedagogical strategies employed in the project to promote the understanding and application of Science/Biology contents. The consistent progress between the phases and between the classes evidenced in this study reflects the positive impact of the project both on the motivation and on the learning of students in this public school. In addition, the use of innovative technologies encourages autonomous study and research practices, expanding engagement and deepening the educational experience of participants. The results with the implementation of these tools are promising, since with the use of gamification and VR, curiosity, the search for additional knowledge and active participation in the learning process of Elementary School II students was verified. We can corroborate our results with the works focused on gamification research in basic education by Martins and Giraffa (2015); Gomes and Tedesco (2017); Pimentel et al., (2020).

Revista ARACÊ
ISSN: 2358-2472

In short, our results not only confirmed the effectiveness of active methodologies in learning, but also provided the creation of significant technological resources, highlighting the transformative potential of these tools in the educational environment. Thus, the technological results achieved with this study highlight the importance of continuing to explore and integrate gamification and VR in the teaching of Science/Biology in the educational environment, with the potential to significantly transform the teaching-learning process.

Graph 2: Presentation of the results of student engagement analyzed by the Four-Dimensional Scale of Student Involvement at School (E4D-EAE).



Student engagement in school is a multifaceted concept that refers to active participation and emotional, cognitive, and behavioral involvement in their educational activities. This phenomenon is crucial for students' academic success and personal development, since a high level of engagement is associated with better school results, greater satisfaction, and a sense of belonging to the school community (Nobre & Janeiro, 2010). The Four-Dimensional Scale of Student Involvement at School (E4D-EAE), developed by Veiga (2013, 2016), offers a framework for the analysis of engagement, divided into four interrelated dimensions: cognitive, affective, behavioral, and agency. Based on the engagement results obtained (Graph 2), we analyzed the four dimensions of the scale (E4D-EAE) of student engagement and the internal consistency of the scales used. The results obtained reveal small variations between these dimensions, allowing the identification of both strengths and aspects that need improvement in student engagement in the school environment.

Revista ARACÊ
ISSN: 2358-2472

The levels of cognitive engagement were intermediate, indicating that students have a moderate involvement with activities that require information processing, organization and knowledge management. This dimension reflects the students' effort to relate content and integrate new information, being essential for academic development. The use of gamified activities, which require problem-solving and logical reasoning, may have positively influenced cognitive engagement. For example, games that challenge students to apply cell biology concepts in practical situations may have stimulated both the processing of information and the organization of knowledge. Studies indicate that gamification can increase students' motivation and cognitive engagement, promoting more active and meaningful learning (Deterding et al., 2011; Hamari et al., 2016).

The affective dimension showed high levels of engagement, suggesting that students have a strong sense of belonging and emotional connection with the school. The results indicate that students feel welcomed and integrated into the school environment, which reinforces the importance of a positive school climate in promoting general engagement. This dimension is in line with the scale that highlights the role of interpersonal relationships and integration in the educational context. The creation of a welcoming and collaborative environment, where students feel valued and heard, may have been promoted through group dynamics and positive feedback during activities. The implementation of skill letters and pins as recognition of students' effort may also have contributed to strengthening the sense of belonging. Research shows that a positive school environment and emotional support from educators are fundamental for students' affective engagement (Fredricks et al., 2004; Wang & Eccles, 2012).

As for the levels of behavioral engagement, they were the lowest among the dimensions evaluated, reflecting challenges related to attendance, active participation, and discipline in the classroom. The low score suggests that a portion of the students face difficulties in adopting behaviors that favor learning, such as attendance and focus during activities. This data reinforces the need for targeted interventions to promote greater behavioral impairment. Introducing clear rules and expectations regarding participation and discipline during activities may have been an effective strategy to address these challenges. Additionally, utilizing gamification elements, such as rewards for active participation, may have encouraged more positive behaviors. Studies show that clarity in expectations and the implementation of reward systems can improve students' behavioral engagement (Skinner & Belmont, 1993; Reeve, 2012).

Revista ARACÊ
ISSN: 2358-2472

For the agency dimension, it stood out with high levels of engagement, showing that students perceive themselves as active agents in the learning process. The results indicate that students actively participate, raise questions and interact with teachers, demonstrating a high degree of autonomy and protagonism. This involvement contributes significantly to the construction of a collaborative and dynamic learning environment. The peer learning methodology, where students have the opportunity to teach and learn from each other, may have been fundamental for the development of student protagonism. Additionally, the use of technologies, such as augmented reality, may have provided interactive experiences that encourage exploration and curiosity. The literature suggests that the promotion of students' autonomy and protagonism is associated with better academic results and greater satisfaction with learning (Deci & Ryan, 2000; Reeve & Tseng, 2011).

The experience of the BIOGAMES project, which demonstrated the positive impact of educational innovation, serves as a model to be followed, reinforcing the importance of public policies that ensure the continued presence of technology in public schools as an essential tool for teaching in the twenty-first century. This approach highlights innovation in the teaching process aimed at digital generations and promotes a reflection on the importance of collaboration between basic education institutions and universities. This partnership proves to be an effective way to foster educational innovation, as it not only facilitates the exchange of resources and knowledge, but also creates an environment conducive to the implementation of new methodologies that meet the demands of the digital age.

As mentioned by Moran (2015), the use of technologies in education is essential to prepare students for an increasingly digital world, and the inclusion of media resources can enrich the educational experience. It is essential that the government is sensitized to invest in digital infrastructure in schools, ensuring that these innovations are sustainable and accessible to all students. In addition, the role of universities is crucial in this process. Intervention projects in schools can act as catalysts for innovation in teaching, offering technical and pedagogical support that enriches the educational experience. Gandin (2001) emphasizes that pedagogical renewal must include the problematization of teaching practice, which reinforces the need for a collaborative environment.

This synergy between basic and higher education is vital for the formation of critical citizens prepared for today's society, as emphasized by Freire (1983), who defends an education that promotes freedom and the active participation of students. By joining forces,

Revista ARACÊ
ISSN: 2358-2472

these institutions have the ability to develop creative and effective solutions that meet the contemporary needs of students, preparing them for the challenges of the future.

CONCLUSIONS

The activities developed and the results achieved by the project demonstrate the significant impact of gamification and virtual reality (VR) on student engagement and academic performance. The implementation of these active technologies has resulted in a remarkable increase in student motivation, facilitating the understanding of complex concepts and promoting the acquisition of knowledge in a more effective and pleasurable way. In addition, an improvement in collaboration and interaction among students was observed, contributing to the development of essential social skills and reinforcing the sense of community within the school environment.

Through the execution of the project, not only the potentialities of these innovative approaches were identified, but also the challenges associated with the adoption of new technologies in the educational context. Teacher training, the adequacy of technological infrastructure, and the effective integration of technologies into the school curriculum emerged as critical factors for the success of similar initiatives.

Based on the lessons learned, several opportunities arise for future work. Expanding the use of gamification and VR in other disciplines and levels of education presents a promising strategy to expand the reach and impact of these innovative methodologies. Exploring the potential of these technologies to cater to different learning styles and special educational needs can contribute to a more inclusive and personalized education.

Additionally, the development of an integrated platform that facilitates the creation, sharing, and implementation of gamified educational resources and VR experiences by teachers from different areas can help overcome some of the technical and pedagogical barriers identified. This approach not only reinforces the relevance of the project, but also paves the way for discussions on the continuity and evolution of pedagogical practices in the future.

Revista ARACÊ
ISSN: 2358-2472

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