Revista Brasileira de Ensino de Ciência e Tecnologia
ISSN: 1982-873X

https://periodicos.utfpr.edu.br/rbect

Minecraft Education Edition as a Possibility of Educational Resource Applied to the Theme of Energy Production[1]

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ABSTRACT

In recent years, digital games have evolved considerably, going from two-dimensional and simplistic experiences to realistic and complex games that can last more than 30 hours. These games fascinate children, teenagers and adults. Children are fascinated not only by the entertainment, but also by what they can learn within them. Digital games are part of the Digital Information and Communication Technologies (DICT) and can be used in the teaching-learning process. The objective of this study is to evaluate the contributions of the Minecraft Education Edition game in the teaching-learning process of 36 students from a high school class at a private school in Curitiba. For this purpose, a didactic sequence was developed involving the game Minecraft and the content "Transformation and production of electric energy". The instruments used to produce data were an initial questionnaire, digital portfolios produced by the students in a virtual environment and a final production, also digital, on the guiding questions that were proposed at the beginning of the didactic sequence. The analysis was performed based on the procedures of Bardin's Content Analysis (2011). The results showed that the use of the digital game increased the student´s interest on the topic addressed, enabled the creation of knowledge networks among the research participants as well as with the content available on the internet and in books, demonstrating the concepts of connectivism and of digital wisdom.

KEYWORDS: Digital games. Connectivism. Minecraft.

INTRODUCTION

Over the past 40 years, digital games have evolved from simple experiences with pictographic graphics to nearly realistic images and deep, rich experiences that last thirty, fifty, or even a hundred hours, attracting boys and girls, young people, and adults. However, they particularly captivate children and adolescents.

Essentially, the fascination of children and adolescents with digital games is not due to the violence contained within them, nor the apparent themes of building, driving, or shooting. The true essence lies in the knowledge acquired while playing. Prensky (2010) describes that children and adolescents, by using digital games, are training themselves in skills demanded for the future; instinctively recognizing that the knowledge and power of technology will increase exponentially during their lives, and that the skills they will need in the future are not the same as those of the past, nor are they the same skills currently being taught in schools.

Parents and teachers, if they truly want to educate these children and adolescents, must accept the fact that they need to use new ways of teaching, new tools, and new strategies, such as digital games, as Prensky (2010) suggests. This possibility is supported by the National Common Curricular Base (BNCC) (BRASIL, 2017), which encourages the use of digital games from elementary through high school.

The document notes that, for the final years of elementary school, the use of digital games in teaching is related to understanding technological evolution, as well as understanding the behavior of different social groups regarding their use for entertainment, education, or professional reasons. In high school, the use of digital games is a foundational part of building educational paths, aimed at deepening mathematical, linguistic, and analytical concepts.

All these aspects of learning are related to the general competencies of the BNCC, whose intention is to form a citizen capable of having attitudes and values to solve complex demands of daily life and citizenship, as well as to critically, significantly, and reflectively understand various forms of digital information and communication technologies.

This is where research in school environments on the use of the internet, cell phones, computers, virtual assistants, multimedia equipment, digital games, among others, gains space and relevance. According to Morran (2007), humanity is increasingly connected, with information at their fingertips, solving problems differently from previous generations, as the virtual and physical worlds become progressively more integrated. This connection offers students a network of available information, and it is up to them to connect the information contained in various places to build their knowledge, according to Siemens (2004) connectivism. Schools cannot afford to overlook these resources, especially because doing so would go against what students encounter in society.

According to Kenski (2003), Digital Information and Communication Technologies (DICT) are expressed in multiple languages, including digital games. As Prensky (2012) advises, it is necessary to prepare students for the digital wisdom that results from using DICT, enabling them to access cognitive power beyond their innate capacity. Mattar (2010) asserts that today's massive multiplayer games have more opportunities to motivate apathetic learners or transfer information in an engaging way, as various skills are practiced during their use.

When engaged in a digital game, players are led to explore the depths of the game's logic to understand it, much like in real-life situations where outcomes can be achieved through trial and error or intuitive problem-solving. Furthermore, Mattar (2010) points out that the physical exploration of the virtual world involves all the steps of scientific exploration: exploring, hypothesizing, testing, and reformulating hypotheses - essentially, the player is learning the scientific method.

In line with these arguments, the digital game Minecraft presents an opportunity to be used as a resource in the teaching-learning process. It is a game widely used by children and adolescents. From its release in 2011 until 2021, according to Microsoft data, the game had sold 238 million copies. To understand the game's relevance to its users, one only needs to look at the number of YouTube views for content related to it: in 2020 alone, there were 201 billion views, making it the most-watched game category (WYATT, 2021).

One way to utilize Minecraft in the teaching-learning process is to integrate the game with the methodology known as Problem-Based Learning (PBL). According to Souza and Marques (2016), PBL is extremely suitable for working with digital games, as it is a student-centered didactic strategy aimed at promoting self-learning collaboratively through real problems proposed by teachers. They argue that solutions to these problems are not simply addressed by a single discipline, leading students to make interdisciplinary connections and develop skills related to reasoning, creativity, innovation, and solving real-world problems.

In this sense, it can be assumed that the digital game Minecraft has the potential to bring students closer to DICT and motivate them to learn topics related to the Sciences. Thus, the guiding question of this research is: what contributions can the digital game Minecraft, integrated into a didactic sequence grounded in Problem-Based Learning, bring to the learning of the theme of electric energy production for students in a mixed-grade high school class?

In line with this question, the general objective of this study was to evaluate the contributions of the game Minecraft to student learning in science education.

USE OF DIGITAL GAMES IN TEACHING AND THE TEACHING-LEARNING PROCESSES

Technologies have always influenced humanity, expanding new possibilities for well-being, developing better ways of transmitting and storing information, and improving communication (KENSKI, 2003). Through digital technologies, it is possible to process and represent any type of information within digital environments (transmission and reception) of all types of data.

With increased storage and transmission capacity, it is possible to connect with anyone in any country via video, sound, or text; it is also possible to exchange high-quality information in real time, regardless of the distances between the sender and the receiver.

There is a shift in the format of communication: with the internet, new collaborative software, which no longer operates on just one computer but can be accessed by multiple people, as well as the network format, brings agility in obtaining information.

> [...] digital technologies offer attractions that facilitate perception, contribute to the evolution of cognitive development, socialization, and connection with others, especially those that provide a familial bond (SILVA; FAGUNDES; MENEZES, 2018).

For information to be disseminated through DICT, a continuous educational effort by each individual is necessary to acquire specific knowledge for its use and updating. As described by Kenski (2003), lifelong learning becomes a natural consequence of the social and technological moment we live in. This means that people must be in constant learning to adapt to technological changes.

This learning should also be present in basic education. According to Kenski (2003), technologies today are used as aids in the educational process, neither as objects nor substances nor as their end. They need to be present at all times in the school's pedagogical process, from the planning of subjects and the development of the curricular proposal to the certification of graduating students.

The presence of technology in schools induces profound changes in the way teaching is organized. New possibilities for thinking and doing education through the use of DICT are opened. To achieve this, it is necessary to rethink education not in a traditional way based on expository classes but in a way that technology is used as a resource that assists the educational process, thus inducing changes in the way teaching is organized.

A tool that can assist this process is digital games, which have been around since the 1950s. Today's digital games have become deep, rich experiences that last thirty, fifty, or even a hundred hours, attracting boys and girls, young people, and adults. However, they especially captivate children. The fascination children have with digital games is not due to the violence within them or the apparent themes of building, driving, or shooting. Instead, the true essence lies in the knowledge acquired while playing (PRENSKY, 2010).

Superficially, children may appear to be learning various things through digital games, such as flying planes, driving fast cars, being warriors in battles, building civilizations, or defeating alien invaders. But this is superficial; what they are really learning is much deeper. They are learning to think through experimentation, to overcome challenges posed by the games by creating strategies based on complex reasoning, to make decisions while assuming calculated risks, to multitask, and to act collaboratively towards a common goal (PRENSKY, 2010).

But why are children willing to spend so much time playing? There are several factors, and Prensky (2010) lists some of them: the first is the feeling of improvement as the player levels up; the second characteristic is "adaptability," or the game's ability to adjust to each player's skills and capabilities. The third characteristic is the game's objectives: they must be worthwhile, meaning the players want to achieve them; and the fourth and final characteristic is the player's ability to make meaningful decisions that help them reach their goals. With these characteristics in mind, teachers can choose the most suitable digital game for the skills they want to teach their students.

The use of digital games in the classroom can significantly contribute to cognitive development, social development (with the chance to share information and experiences related to the game), and student motivation to learn. According to Mattar (2010), digital games are effective training for students of any age in many situations because they are highly motivating and communicate concepts and facts very efficiently across many areas. They create dramatic representations of the real problem being studied. Players take on realistic roles, face problems, formulate strategies, make decisions, and receive quick feedback on the consequences of their actions.

Exploring digital games is not just a means to an end or a technological toy aimed at distracting and calming children. Instead, it is a resource with potential that enables children to pay attention to details and have the autonomy and initiative to build knowledge based on what they already know (SILVA; FAGUNDES; MENEZES, 2018).

There are initiatives involving various commercial and educational games that have all the necessary characteristics for application in the classroom by teachers. Among these, one that stands out today is Minecraft. There are numerous YouTube channels showing people playing or creating stories, capturing and narrating game screens, and various reports on its use both in and out of the classroom.

Minecraft was conceptualized by Markus Alexej Persson and created by his company Mojang AB in 2009, officially entering the gaming market in 2011. The game revolves around open-world construction, where players can move and create with a high degree of freedom, using blocks to develop scenarios and objects creatively, with unlimited resources. In survival mode, players can discover and extract raw materials and tools across various landscapes, build structures to modify the landscape, or combat enemies depending on the game mode (MINECRAFT WIKI, 2020). In creative mode, players have a vast range of resources available and can interact and cooperate with other players to build or accomplish anything within the game.

In 2014, Mojang was acquired by Microsoft, along with the rights to Minecraft. Its success extended to platforms beyond the computer. In 2016, Microsoft released an educational version with features that make the game accessible and effective in the classroom, in addition to creating a virtual community where educators worldwide can learn from one another and provide immersive learning experiences for students. Notably, even before the educational version was available, many teachers globally were already designing instructional sequences to use the game in the classroom. The educational version emerged as a response to this demand (GONÇALES, 2017).

The game offers special features for educators, such as tools for managing classrooms and secure login. The community page provides easy-to-follow tutorials, a global network of mentors, technical support, and a space to access and share lesson plans, scripts, and environments created by educators worldwide.

Working with Minecraft with students is not just about having fun. It requires understanding their world and being a part of it, using their motivation since it is a resource they are proficient in. Conversely, the teacher brings expertise and uses it to guide the activity (GONÇALES, 2017). This process involves meticulous planning by the teacher to use Minecraft as an educational resource (GONÇALES, 2017). The game possesses all the elements that captivate children and includes management tools that assist teachers. As an open-world game, the possibilities for its application in the classroom depend on the teacher's imagination in planning the lesson.

To effectively use digital games in the classroom, it is essential to reflect on educational theories and pedagogical practices. Numerous authors describe theories about Digital Information and Communication Technologies (DICT). It is crucial to select the most appropriate educational theory for the resources to be applied in practice, one that brings student engagement and protagonism.

In the search for the most suitable theory, having the student take on an investigative role reveals an ideal learning experience with the student at the center of the educational process. To achieve this, active learning methodologies, combined with connectivist theories, are the most effective. One such methodology is Problem-Based Learning (PBL).

In the late 1960s, a group of professors at McMaster University in Canada implemented a learning method in the medical school based on using problems as the starting point for mobilizing and acquiring knowledge. This method was called Problem-Based Learning (PBL).

The idea behind PBL was to promote the development of students' abilities to contextualize theoretical knowledge, meaning possessing theoretical knowledge and knowing how to apply it in a practical situation. PBL is a methodology that uses a problem or problem situation as the starting point for learning, leading the student to an investigative process.

According to Souza and Dourado (2015), this problematization enables an interdisciplinary perspective and begins with raising questions and seeking solutions to problems identified in the curricular themes of each discipline to produce knowledge.

One of the focuses of this methodology is to stimulate in students the ability to learn how to learn, work in teams, listen to other opinions, even contrary ones, and develop critical thinking. Thus, the student becomes the protagonist of their learning (MALHEIROS; DINIZ, 2008).

The construction of PBL occurs in four stages: the first is choosing the context. In this stage, the teacher identifies the content to be taught and selects real-life contexts for these concepts to emerge from the problems. According to Souza and

Dourado (2015), a good context should have a title that grabs the student's attention and immediately identifies the object of study.

After receiving the scenario containing the informative elements of the problematic context, students, in groups, begin the second phase, which is identifying the missing information to formulate the questions that will guide the investigative process and determine what needs to be deepened (SOUZA; DOURADO, 2015).

In the third phase, the investigation process takes place as planned in the previous phase. At this point, the team conducts research and seeks answers to the questions constructed in the previous phase. These answers are built collectively through debates within the team, with the teacher acting as a mediator. It is important to note that PBL encourages interdisciplinary solutions as it deals with complex real-life problems.

In the fourth and final stage, the solution to the problem is constructed and presented, which may involve building a prototype or product but can also be a theoretical answer to the guiding question. At this stage, students can verify if all the questions constructed in the second phase have been answered. The idea is for learning to be "hands-on," involving and developing student autonomy and protagonism.

Another important aspect is how students learn. In this regard, this research is based on two educational aspects: digital wisdom and connectivism.

When children enter school today, they already possess significant skills and even digital literacy acquired through observing parents, siblings, and other members of their social environment. Learning happens through manipulation and observation, even when using websites and applications in other languages (this also applies to non-literate children). These children can find effective ways and strategies to use these tools through the recognition of images and pictograms (SILVA; FAGUNDES; MENEZES, 2018).

According to Prensky (2001), the problem with teaching this generation is that teachers use outdated language and are struggling to teach a generation of students who speak a completely new language. These students were born immersed in an environment where access to information can occur anywhere through the internet, and the ways of creating, sharing, and consuming information to generate knowledge are vastly different.

Prensky (2012) uses the term "digital wisdom" to refer to an individual's capability arising from using technology to access cognitive power beyond innate capacity. It is the wisdom in the prudent use of technology to enhance capability. Therefore, the generational divide does not matter; what matters is the human ability to be digitally wise, making ethical and moral decisions using digital enhancements to complement innate abilities.

According to this concept of digital wisdom, when a thought process is no longer used or is optimized, the brain is freed to process other things. Intense use of GPS, spell checkers, or calculators might create a generation of people who cannot navigate, write correctly, or perform mental calculations.

However, we must consider that each enhancement comes with a trade-off. When using clocks, humans no longer think of telling time by observing the sun, abandoning the capability other generations had. In return, however, we gain a better understanding of time, knowing how to quantify smaller units of time (minutes, seconds) with greater precision. Thus, what the unenhanced mind loses by outsourcing mundane tasks is more than compensated for by the acquired wisdom (PRENSKY, 2012).

These students, were born into a new culture surrounded by technology and who quickly learn a new language of instruction, exhibit resistance to using the old language and traditional teaching formats (PRENSKY, 2010). In this sense, the task of today's teacher is to understand this new context in order to teach and modify their practices.

Siemens (2004) supports Prensky (2010) by highlighting that knowledge today, due to digital technologies and scientific discoveries, has increased significantly in recent years. Much of what is known today was not known ten years ago. The amount of available information is vast, necessitating a higher level of specialization for individuals to utilize this information, which demands a very different level of learning from traditional teaching. At this point, technology can help by providing alternative means to learn and think.

Thus, Siemens (2006) introduces the concept of connectivism, describing that knowledge does not need to reside solely in an individual's mind but can be distributed across a network. According to the author, this network operates on two levels. The first is the neural network, distributed throughout the human brain and not confined to one part. The second is the external networks formed by available knowledge, connections with people, technology, and information accessible on the internet.

Therefore, for Siemens (2004), connectivism is based on the idea that learning for each individual can exist outside of them, in the individual's ability to connect specialized sets of information located in various places, to make distinctions between this information, and to be critical. The capacity to judge, be critical, seek necessary information using technology or not, and make connections to enhance one's knowledge are characteristics found in both digital wisdom and connectivism, which supports the notion that these two theories seem complementary.

METHODOLOGICAL STRATEGY

This research adopts a qualitative approach to evaluate the contributions of digital games in science education, combined with teaching practices and the use of educational resources, specifically the digital game Minecraft. It focuses on understanding aspects of reality that cannot be quantified, aiming to describe, comprehend, and explain the phenomenon (GERHARDT; SILVEIRA, 2009).

Regarding the research objectives, it is exploratory in nature, as it analyzes the practical application of a didactic sequence aimed at exploring the possibilities of using Minecraft. This approach aims to provide greater familiarity with the problem, making it explicit and constructing hypotheses (GERHARDT; SILVEIRA, 2009).

The technical procedure adopted in this research is a case study, using a real didactic sequence implemented in the classroom to observe the context in detail. It is an empirical research procedure that explores variables in a current phenomenon within its context of reality (GIL, 2008).

The study was conducted in mixed-grade[2] classes of high school students aged between 14 and 19 years, of both biological sexes, in a private school in Curitiba, Paraná. The school's teaching format includes "learning workshops," emphasizing interaction among peers, negotiation of meanings, exchanges, respect for others, and collaborative problem-solving.

The classes are mixed-grade and consist of up to 42 students seated in teams of 6. Every trimester, the teams are reformed based on students' initiative and with teachers' validation. A total of 96 students participated in the didactic sequence, with parental consent[3] obtained for 36 students who were organized into 9 different teams. Students were assigned numeric codes from 1 to 36 to maintain anonymity

During the fieldwork period, the COVID-19 pandemic was still ongoing, and restrictive measures were implemented to contain the spread of the Sars-Cov-2 virus. The didactic sequence was applied between August and September 2021, a period when pandemic-related restrictions were more lenient. At the school, classes followed a hybrid model, with a restriction allowing up to 40% of students to attend in person and up to 60% to participate remotely in the same class.

The school chose to rotate students weekly between in-person and remote models. Students attended school in person two days a week and remotely on other days, ensuring that everyone was physically present at least one day a week.

The didactic sequence was implemented for both in-person and remote students. Students present at school used computers provided by the institution. Due to the school's contract with Microsoft for Office 365 licenses, which includes Minecraft Education Edition, students accessed the game remotely using their own accounts on any computer where the Minecraft software was installed. Conversely, students at home accessed it through their personal computers, but they needed to install Minecraft Education Edition for free and access it using the Microsoft account provided by the school.

The first stage of the research began with introducing the topic through the guiding question outlined in Table 1.

Table 1 – Guiding question of the didactic sequence

Between 2001 and 2002, Brazil faced a water crisis due to scarce rainfall throughout 2001, which led to decreased water levels in Brazilian hydroelectric reservoirs. At the onset of the crisis, there was speculation that long, forced power outages might become necessary nationwide. These forced outages, or blackouts, were dubbed "*apagões*" by the press. The crisis was caused by a combination of factors: low rainfall, inadequate planning, and insufficient investments in energy generation and transmission. With the water scarcity, reservoir levels dropped, and Brazilians were forced to ration energy. In 2020, a new water crisis hit Brazil due to the La Niña effect, a cyclical alteration of average Pacific Ocean temperatures, particularly affecting the central and eastern Pacific waters. This phenomenon can alter various weather patterns, including heat distribution, rainfall concentration, drought formation, and fishing conditions. Since 2001, have actions been taken to address a new energy problem? Could this new water crisis lead to power outages again? What actions can be taken to minimize its effects?

Source: Author (2022).

After the introduction, students answered the initial questionnaire, which aimed to collect information and was structured into three sections: the first part gathered data about the research participants; the second section consisted of questions designed to diagnose students' knowledge of Minecraft Education Edition and its gameplay; and the third section aimed to identify students' prior knowledge about how electrical energy is produced, stored, and transmitted.

The second stage began by explaining the sequence of activities to be carried out. Students were instructed to enter the world called Lumen: Power Challenge, which can be found in the Minecraft library. Within the Lumen world, there were five proposed challenges related to electricity-generating sources. During these challenges, students learned about each type of energy source presented in the game through information provided during gameplay. These challenges included: Challenge 1 - installing offshore wind turbines, Challenge 2 - placing solar panels on house roofs, Challenge 3 - preventing a nuclear reactor from overheating, Challenge 4 - powering a house off-grid generator, and Challenge 5 - clearing obstacles in a hydroelectric plant.

Following this stage of the activity, students created a digital portfolio. In this portfolio, students described everything that was accomplished in each lesson. They could include texts, research, photos, screenshots from the Minecraft game, or any other relevant materials. Students were encouraged to raise questions or provide additional comments they considered pertinent during this phase.

In the penultimate stage, the research returned to the guiding question identified in Table 1 to prompt students to reflect on the relationship between the water and energy crisis in Brazil and what they learned during the Lumen: Power Challenge activity. Each team was asked to find technological or engineering solutions (products) that could help resolve the water and energy crisis in Brazil. The solution found should be represented within a new world in Minecraft. After completing the final production, each team recorded a video of up to 5 minutes explaining the identified problem and describing the technological solution devised by the team.

In the fifth and final stage, teams presented their final production videos to the class and engaged in a discussion about the work produced by each team.

The responses to the initial questionnaire, the digital portfolio, and the final production in a Minecraft world were the research instruments that generated the data analyzed. Initially, a pre-analysis of the data was conducted to systematize initial ideas for developing an analysis plan, organizing the participants' data in a table format along with links to their digital portfolios and final production videos related to their teams.

All data from these instruments were reviewed to identify elements that could be organized into units of analysis and subsequently into categories. The next step involved exploring the material, where data were classified into codes and themes, identifying prominent or most relevant themes to create an interpretation of the data.

To do so, it was necessary to conduct a floating reading of all materials and group them based on contextual similarities. These evidences were grouped into larger analysis groups that demonstrated a stronger relationship with the categorized context. The first category is the **participants' interaction with available resources**, which considered students' relationship with the physical infrastructure for conducting the activity and their interaction with DICT resources. From the perspective of digital wisdom, this category seeks evidence of how technology was used to enhance cognitive capacity, and from the perspective of connectivism, it examines the connections established in the use of resources.

The second category focuses on **interactions established among participants** from the perspectives of connectivism and digital wisdom. This category considers the external network built by research participants through interactions among students themselves and with the teacher. It grouped reports of interactions among participants and with the teacher, highlighting connections created with specialized information sources to facilitate learning.

The third category addressed students' **perceptions of how Minecraft can contribute to evolving concepts about energy production**. It grouped reports on how students progressed in their knowledge of energy production during game development and their responses regarding prior knowledge described in the initial questionnaire.

The fourth and final category grouped evidence **of interdisciplinary relationships shown in the final production**, demonstrating interdisciplinarity. It organized concepts used in final productions, identifying their content and related disciplines, as well as how each content related to the construction of the final production. From the connectivist perspective, this category sought evidence of students' decision-making in choosing what they needed to learn and their ability to build connections between areas of knowledge. From the perspective of digital wisdom, it looked for evidence of decision-making based on research and team discussions to define a solution reflecting the knowledge acquired by team members. Under the PBL methodology perspective, its use brought the investigation process, as well as evidence in the final production of relationships between various disciplines.

ANALYSIS OF RESEARCH RESULTS

Analyzing the data from the initial questionnaire regarding participants' knowledge of the digital game Minecraft, 97% of them were already familiar with the game. It was also observed that 17% of the research participants had never played it, which demonstrates its widespread popularity among young audiences. Regarding self-declared levels of game knowledge, a significant portion of participants rated themselves as having basic or advanced skills. During the application of the didactic sequence, it was noticeable that students who were more familiar with the game promptly assisted those who were not.

Upon analyzing the research instruments (initial questionnaire, digital portfolio, and final production in a Minecraft world) concerning participants' prior knowledge of how electrical energy is obtained, transformed, and transported, it was evident that the vast majority of students knew that most electrical energy in Brazil comes from hydroelectric plants. They could characterize renewable energy and had basic knowledge of different types of energy generation. Only four students showed limited knowledge of the operation of different types of power plants.

The infrastructure was a problem for two students when they were at home, attending classes remotely. They reported in the digital portfolio that they did not have a computer at home, attended class via their cell phones, and did not possess any console or other equipment besides their cell phones that they could use for Minecraft. All others managed to use Minecraft both at home and at school.

Another relevant finding was that 28 students, at some point during the activity, either to facilitate the completion of challenges or to take screenshots of the game, switched the game mode from adventure to creative (which allows flying and access to the entire game inventory). This action illustrates concepts such as digital wisdom, as students had autonomy to choose a path using different game modes, knew how to use resources like the internet or other students to learn how to do so (such as activating cheats to switch game modes), and thereby enhanced what they were learning not only about energy production but also about performing necessary tasks within the game. An example of this is seen in the account of Student 8: "*Since I had never played Minecraft before, I decided to research how it worked and some tips to solve the challenges proposed during the game.*"

Further evidence of connections established with DICT is when students describe conducting research to understand how to tackle challenges, or conducting additional research on energy generation sources, or even in the research conducted for the creation of the final production. As advocated by connectivism, learning occurs through connections with specialized sources and in the act of choosing what one wants to learn, as well as in the meaning derived from received information. The applied problem-based learning (PBL) methodology can also motivate students to seek necessary information, thereby deepening their knowledge.

In all videos showcasing the final productions of the teams regarding the water and energy crisis, it was possible to observe complex constructions that faithfully portrayed the solution found by the team. This interaction, in all situations, is advocated in the application of PBL in which teams research, debate, discuss wisely and ethically in order to build the most appropriate solution to address the presented problem. It was observed that there was not a single answer to the guiding question: each of the teams, through debates, raising questions, and research, chose a way to approach the guiding question and solve it, developing student protagonism and the ability to work as a team to find a solution that the team agreed upon. It was evident that, to build the solutions, team members needed to seek the necessary information in order to demonstrate the best solution for the guiding question. That is, they created external connections (through research and discussions) and internal connections in the act of choosing the most suitable solution from what was researched, as advocated by Siemens' connectivism (2004).

In other words, students created connections with available and researched sources of information, and by dialoguing to find the solution, they converged these connections into nodes of information, that is, information that connects in order to converge towards the same purpose, which in these cases is the construction of the final production. The research conducted by the teams also demonstrated the digital wisdom of the students, as they used technology to seek ideas for constructing solutions, thereby expanding their cognitive capacity.

In relation to the interaction demonstrated by the research participants, among themselves and with the teacher, during the application of the activity: the teacher reported that students asked for guidance on what to do, how to enter the game, and in the Lumen activity. The teacher informally reported that, in the construction of the final productions, there was intense mediation work to ensure that the most relevant issues for each team, according to her, were highlighted in a way that would facilitate decision-making for each of them. The teacher's account precisely aligns with the principles of PBL in which the teacher should be a mediator of student work and participate in discussions within each group, assisting in the organization and planning of the next stage of work. In this sense, we can also observe the teacher as a source of specialized information who knows the game and can assist students in using it to facilitate the learning process, as well as guide them on the guiding question to demonstrate connections between areas, ideas, and concepts to develop critical thinking about what is known at a given moment (SIEMENS, 2004).

The interaction among students was also quite intense, and it was possible to see that students with more knowledge about the game were able to help those with less knowledge. In all reports, it is evident the support network created by the students. Some assisted in using game commands, others in solving challenges. In this sense, there was an exchange of information, experiences, and, as described by Siemens (2006), knowledge is not solely in the mind of a single individual; in this case, there is an external network formed by the knowledge available through connections with other students. Some reports are presented in Table 2.

Table 2 – Reports of interaction among students

Report	Participant
Firstly, I had difficulties completing the first challenge because I didn't know the location of the wind turbines, but I got help from my friends to find them and complete the first challenge.	Student 6
I had difficulties in almost all missions because I didn't know how to play correctly and had never had contact. The mission I enjoyed the most was placing solar panels on houses and flying to the propellers to open the chests. I had help from some classmates who knew how to play, and they assisted me during the game, helping me complete the challenges.	Student 8
Overall, the challenges were easy to complete, especially because one classmate helped another.	Student 9
I had doubts about how to clean the channels of the hydroelectric plant and refill the off-grid house, but luckily, I have competent classmates who helped me.	Student 33

Source: Author (2022).

During the construction of the final production, the connections established were facilitated through mediation among the teams of students in order to build the necessary knowledge to address the guiding question, utilizing PBL principles. Another way to observe the interactions established by the participants is by analyzing their critical thinking reflected in the final production. This involves assessing whether students mobilized their ability to judge, drawing from their research to find solutions that, in the team's view, answer the guiding question. This critical capacity is central to the theory of digital wisdom, where students conduct research on a topic and must be wise in selecting pertinent information that can be effectively utilized, as advocated by Prensky (2012).

This ability is evident in the solutions of all teams, as they judge which information is relevant for creating and presenting the solution found. For example, the seventh team, in explaining their solution, highlighted the issue of pollution in their video and judged it to be a serious problem that must be addressed, seeking existing solutions from the literature. Moreover, within Minecraft, they successfully constructed a representation of the water table under a farming area and where the proposed solution could be applied to achieve the expected results.

For the research participants, using Minecraft in a learning context helped them realize that there are alternative ways to approach content, as evidenced in some of their statements. According to one student, "*we concluded that this educational map is perfect for those who are novices in this subject, as it addresses the topic in a simple and easily understandable way, not to mention that you learn practically by solving challenges!*" This statement reveals that the student perceives there are alternative learning methods beyond reading and memorization. The students' accounts showed they were satisfied with the use of the digital game in the activity, which made the class more engaging, dynamic, and interactive.

The implementation of the Lumen activity also familiarized students unfamiliar with the game with its commands and mechanics, enabling them to construct complex final productions to showcase the solutions found by their team. The final productions also demonstrated the students' level of abstraction in using Minecraft as a tool for virtual construction, with each construction in the final productions showing a high level of detail.

Some evidence showed the relationships built between the contents of various disciplines. Not all solutions created involved the energy sector and its relation to the water crisis, but it was possible to observe in all of them the additional research conducted regarding the water crisis and its consequences on the problem raised by the team. It was also possible to verify that, in the vast majority, the solutions found involved research on technological applications and engineering to promote solutions that could be applied in everyday life.

The first team developed a solution involving covering the terrain with a greenhouse-like acrylic structure to collect evaporated water. Without delving into judging whether the solution was good or not, it was possible to identify concepts from the physical states of matter studied in physics and chemistry, biology concepts related to plant growth and development, the water cycle, and geography concepts related to agricultural production.

The second team's production was also related to agriculture. It was possible to identify biology concepts regarding plant development and water needs, as well as mathematical concepts related to the financial viability of the solution in an implementation scenario.

In the third team's production, which involved a smart house solution, various engineering concepts were observed, such as the use of solar panels and rainwater reuse systems.

The fourth and fifth teams developed solutions to prevent water waste in agriculture. Concepts related to food production methods studied in geography, demographic statistics, and chemistry concepts related to water treatment were identified.

The sixth team described the production of electricity from piezoelectric crystals. Physics concepts were identified, particularly in relation to energy generation in Brazil, the predominant models in each region, and the environmental impacts of using renewable energy sources. These concepts are present in physics, chemistry, and geography. Discussions on the social impacts of the proposed technology also involved concepts from sociology and society.

The seventh team demonstrated strong concepts from biology, chemistry, and geography. In their production, students described the water cycle, the impact of pesticide use on soil, lakes, the water table, and primarily studied cyanobacteria like spirulina and how they absorb these water toxins during reproduction and photosynthesis.

The eighth and ninth teams presented concepts of global warming, the environment, and sustainable food production. These concepts are present in biology and geography. Furthermore, they showed concepts of energy generation and transformation present in physics.

In all the solutions presented for the final productions of the teams, it was possible to identify the pursuit of solutions within curriculum themes from various disciplines, as analyzed in the previous paragraphs. As an example, we have the seventh team, whose highlighted problem was soil, lake, and water table pollution by pesticides. This team needed to research this type of pollution, investigate existing methods to eliminate it, and brainstorm to find the best solution. After exploring the possibilities, the team then had to develop the solution. Because it's a complex real-life issue, the solution itself is also complex and can genuinely be applied to water purification using cyanobacteria like spirulina, which absorb these toxins from water during their reproduction and photosynthesis.

In this context, interdisciplinary learning is evident when considering that students needed to understand agriculture, the water cycle, cyanobacteria, and how they absorb toxins. These concepts are not confined to a single discipline but intersect across geography, biology, and chemistry.

It's important to highlight that, according to Souza and Dourado (2015), PBL can motivate students to deepen their knowledge. Upon analyzing each of the final productions, it was apparent that most solutions were not simple. On the contrary, they all required extensive research before being proposed and described in the production videos.

FINAL CONSIDERATIONS

This research aimed to evaluate the contributions of the game Minecraft to student learning in Science education. To achieve this goal, a didactic sequence on electricity production based on the Problem-Based Learning (PBL) methodology was developed, utilizing the Minecraft Education Edition digital game.

During implementation and subsequent data analysis, it was possible to verify that students already had knowledge of the topic and that the didactic sequence could enhance this knowledge. Moreover, the use of the Minecraft digital game made the lesson more attractive, enjoyable, and stimulating.

Each research instrument provided data to identify students' narratives during the activity. They allowed for the identification of elements that could be analyzed through connectivism and the concept of digital wisdom.

The initial questionnaire was suitable for bringing students' knowledge on the topic and for assessing whether students' knowledge of the game assisted them during the didactic sequence. The digital portfolio, on the other hand, was appropriate for bringing students' impressions regarding the game's use and whether new knowledge was acquired by students. The students' final productions also highlighted various aspects of the teaching-learning process and showed that students, through their knowledge networks, connections with others, and access to information available in digital media, can exceed expectations and create solutions not imagined by the teacher, which add knowledge beyond the expected in the teaching-learning process.

Therefore, we should revisit the question that guided the research: what contributions can the Minecraft digital game, integrated into a Problem-Based Learning (PBL) didactic sequence, bring to learning about electricity production among interdisciplinary high school students?

Upon returning to this question and after analyzing data from the research instruments, it is possible to confirm that the use of the Minecraft digital game supported by the PBL methodology made the activity more attractive to students than an activity using traditional teaching methods. Similarly, it is possible to observe in the final productions that students developed concepts beyond the basic content on electricity production, showed critical solutions that took ethical decisions into account in their constructions, and demonstrated that the network of connections created and digital enhancements available in the digital game and on the internet can expand each student's pursuit of knowledge.

MINECRAFT EDUCATION EDITION COMO POSSIBILIDADE DE RECURSO EDUCACIONAL APLICADO AO TEMA DA PRODUÇÃO DE ENERGIA

RESUMO

Nos últimos anos, os jogos digitais têm evoluído consideravelmente, passando de experiências bidimensionais e simplistas a jogos realistas e complexos que podem durar mais de 30 horas. Jogos estes que fascinam crianças, jovens e adultos. As crianças ficam fascinadas não só pela diversão, mas também pelo que podem aprender dentro deles. Jogos digitais são parte das Tecnologias Digitais da Informação e Comunicação (TDIC) e podem ser utilizadas no processo ensino-aprendizagem. O objetivo deste estudo foi avaliar as contribuições do jogo *Minecraft Education Edition* no processo de ensino-aprendizagem de 36 estudantes de uma turma interseriada do Ensino Médio de uma escola particular de Curitiba. Para isso, foi desenvolvida uma sequência didática envolvendo o jogo *Minecraft* e o conteúdo "Transformação e produção de energia elétrica". Os instrumentos utilizados para a produção dos dados foram um questionário inicial, portfólios digitais produzidos em um ambiente virtual pelos estudantes e uma produção final, também digital, sobre as questões norteadoras que foram propostas no início da sequência didática. A análise foi realizada tomando como base os procedimentos da Análise de Conteúdo de Bardin (2011). Os resultados mostraram que o uso do jogo digital despertou o interesse dos estudantes sobre o tema abordado, possibilitou a criação de redes de conhecimento entre os participantes da pesquisa, bem como com o conteúdo disponível na internet e nos livros, demonstrando os conceitos do conectivismo e da sabedoria digital.

PALAVRAS-CHAVE: Jogos digitais. Conectivismo. *Minecraft*.

NOTES

1 Article derived from a work presented at the VII SINECT - National Symposium on Science and Technology Teaching held on November 9, 10, and 11, 2022. Available at: https://sinect.pg.utfpr.edu.br/index.php/anais/.

2 In interserial classes, students from different grades share the same classroom, teachers, and work on the same subjects in each discipline.

3 Ethical Review Report from CEP number 5,049,875 (Certificate of Ethical Appreciation Presentation - CAEE number: 52141421.9.0000.0165).

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Received: May 19th, 2023.
Approved: May 01st, 2024.
DOI: 10.3895/rbect.v17n2.16976
How to cite: NADOLNY, V.; LEITE, Á. M. Minecraft Education Edition as a Possibility of Educational Resource Applied to the Theme of Energy Production. **Brazilian Journal of Science Teaching and Technology**, Ponta Grossa, v. 17, Special Edition, p. 1-22, 2024. Available at: <https://periodicos.utfpr.edu.br/rbect/article/view/16976>. Access on: XXX.
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