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CHAPTER 10

USE OF PLAY FOR THE TEACHING AND LEARNING OF PHYSICS (HYDROSTATICS) IN HIGHER EDUCATION

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ABSTRACT

The search for innovative strategies in the educational field has focused on the introduction of more dynamic approaches to improve the teaching of challenging subjects, such as Physics. Board games have been recognized as valuable tools in physics education due to their ability to make abstract concepts more tangible and accessible to students. They offer a practical and playful approach to understanding physical principles, transforming theory into practice through concrete situations. In this article, a board game involving Hydrostatics is proposed in order to facilitate the teaching and learning of students.

Keywords: Board Game. Teaching. Physics.

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INTRODUCTION

Physics requires challenging skills, such as abstract thinking, creativity, and experimentation, but they are not always fully developed in the students' education, making learning difficult (Fontes *et al.,* 2016).

Discussions about the introduction of playful games have gained strength in recent years (Flach *et al.,* 2020). In an ever-evolving educational landscape, incorporating innovative approaches becomes essential to inspire student learning.

Brandenburg, Pereira and Fialho (2019) emphasize the relevance of thinking about teaching approaches that help make learning easier. This entails analyzing and considering different methods, strategies, and approaches used to teach and assist students in absorbing knowledge more effectively.

The games are relevant because they present alternatives that indicate changes in teaching methods centered on the transmission of content (Fontes *et al.,* 2016). Within this context, didactic games emerge as transformative agents, offering an engaging and dynamic approach to the teaching of challenging subjects, such as Physics.

From this perspective, in this work a board game was produced involving Hydrostatics, a subject of Physics present in the discipline Bases of Physics and Chemistry Applied to Pharmacy, in order to facilitate the teaching and understanding of students on this subject, bringing in a playful way important topics about this aspect of Physics.

PLAY IN TEACHING

DEFINITION OF PLAYFULNESS

According to Sant'Anna and Nascimento (2011), the etymology of the term "ludic" derives from the Latin word "*ludus*", whose meaning refers to the idea of fun and play. We can say that using a fun approach to teach scientific concepts of Physics can be achieved through the incorporation of recreational activities, such as games.

The act of playing is inherent to the human being. Through games and toys, he replicates and reimagines the environment that surrounds him (Roloff, 2010). Playing and playing are essential in human development, crossing cultural and generational boundaries, enabling exploration, learning and interaction with the environment. By participating in games or play, people exercise creativity, imagination, socialization, and even cognitive and motor skills.

Play and play are present in the life of human beings in childhood, but not only in childhood, because they play and play throughout life.

Games and play are essential for children's development, offering fun and teaching

about rules, cooperation, and problem-solving. In addition, they are powerful educational tools. For adults, games are a form of relaxation, stress relief and strengthening of social relationships, and why not learning?

In short, the act of playing and playing is an integral part of human nature, playing a vital role in development, learning, and well-being, for both children and adults.

PLAYFULNESS AS A TEACHING TOOL

There are several paths for teaching and learning, however, there are also numerous challenges that slow down these factors. Among some all the tools to help teaching, and didactic games take a prominent place, for all age groups, from kindergarten to academic education. For Kishimoto (1998), playfulness should be allied to teaching and not be placed as an alien aspect of the educational world.

According to Moratori (2003), another positive aspect in using didactic games as a teaching tool would be to bring to people, through playfulness, and in a more relaxed way, the development of cognitive skills. The educational game needs to create an environment conducive to reflection, encouraging students to become aware of the construction of their own knowledge, offering pleasant opportunities for the development of their cognitive capacities.

Active learning leads to a better absorption of ideas, subjects and educational content, from more practical activities that offer people a closer contact with the content studied. According to Vygotsky (1998), at birth the human being lives in a constant process of knowledge and thus develops his psychological functions. With this, the experiences that people go through are fundamental for their development.

The difference in the pace of learning varies between students, this would be another advantage of inserting this teaching method in schools, colleges and similar educational institutions, the fact that it can regulate the difficulty of the games allows students to learn at their own pace and level of learning.

In summary, educational games represent a powerful tool in the context of teaching and learning. By incorporating playfulness into the educational process, they provide opportunities for the integral development of students, promoting not only the acquisition of knowledge, but also the strengthening of cognitive skills and the creation of an environment conducive to active and personalized learning. Therefore, by recognizing and implementing the potential of educational games, education can become more dynamic, engaging, and effective, catering to the individual needs and rhythms of students.

BOARD GAMES

Several types of games are available, and among the most common are board games (Fontes *et al.,* 2016), such as chess, checkers, various races, among many others.

Board games are entertainment activities that involve players using a physical board as a basis to perform moves, make decisions, and compete with other participants and that usually include pieces, cards, dice, or other tools to represent elements of the game and their rules determine goals, strategies, and interactions between players.

These games can range from classic games like chess and checkers to modern games that require strategy, decision-making, and social interaction. Board games are a form of entertainment that has been enjoyed by people of all ages and cultures throughout history. In addition, they have also been widely used in science teaching in general, such as the game entitled "Playful Strategy Applied to the Teaching and Learning of Analytical Chemistry", developed by Martins *et al*. (2024) for the teaching of Analytical Chemistry in higher education classes.

PHYSICS TEACHING

Teaching physics is critical to providing an in-depth understanding of the fundamental principles that govern the world around us. It covers a variety of topics, from mechanics and thermodynamics to electricity and magnetism, seeking to explain natural phenomena through scientific laws and theories.

As it is an experimental science, which seeks to understand the behavior of matter, Physics uses abstract models that seek to relate the macroscopic world with the microscopic atomic-molecular universe. This exercise is of great value for the development of the student's reasoning in any area of knowledge, but, at the same time, this abstraction is often one of the obstacles to its understanding.

We live in a society where the educational focus is on assessments, commonly recognized as teaching focused on tests (Moreira 2020). This approach often focuses more on memorizing information to meet the requirements of the tests than on developing critical thinking skills, creativity, and deep understanding of concepts.

The culture of "*teaching for testing*" can negatively impact the educational process. Students may feel pressured to memorize information without actually understanding the content, leading to superficial and temporary learning. Additionally, it can limit students' ability to apply knowledge in real-world situations, as the focus is more on test scores than on understanding subjects.

PLAYFULNESS IN THE TEACHING OF PHYSICS

Physics presents content that may seem a little complex and even daunting to some people, such as mechanics, electricity, optics, and hydrostatics. The presence of didactic games in studies can transform this experience into a moment of distraction and fun for students of the subject, making the content more accessible and understandable.

The application of educational games as drivers of the teaching and learning process, which can be used not only to improve teacher training, but also to teach physical concepts more effectively (Fontes *et al.,* 2016).

According to the study by Silva *et al*. (2021), it is feasible to attribute meaning to the knowledge acquired in the classroom through playful activities. Playful practices not only complement, but also enrich the understanding of the contents covered, providing a dynamic and interactive approach to the assimilation of concepts. Thus allowing students to experience physical phenomena through interaction with games, facilitating the understanding and practical application of the principles of Physics.

Interactive games offer students the opportunity to practice and solve physical problems, exercising critical thinking and analyzing and applying the formulas and laws of this discipline. Lopes (2001) emphasizes more forcefully the use of playful resources for the learning process, expressing the conviction that the assimilation of knowledge through games is considerably more effective.

According to Kishimoto (1994), during a recreational activity, the student assumes the role of protagonist in the learning process. Having more diverse and fun challenges brings the student greater motivation to learn subjects that previously seemed more complex.

Teamwork and knowledge sharing are other reasons that make cooperative games a more effective tool for teaching. Miranda (2002) points out that the game promotes the development of other facets, by suggesting "a work aimed at the exercise of skills such as group integration, mutual trust, leadership spirit, cooperation, decision, initiative, self-knowledge".

Thus, educational games not only complement traditional teaching, but transform the way students perceive and interact with the concepts of Physics, creating a more engaging, motivating and effective learning environment.

MATERIALS AND METHODS

The game developed in the present work was conceived with the educational purpose of exploring the principles of hydrostatics. Its focus lies in the practical understanding of concepts such as pressure, thrust, density, among others. The artistic part

was done on the computer by the design program "Canva".

Titled "The Race of the Droplets," the elaborate board game offers a unique approach to learning Hydrostatics. In this game, participants are immersed in a course where they face challenges and answer questions related to fundamental concepts of Hydrostatics. By advancing across the board, players not only strive for victory, but also deepen their understanding of pressure, thrust, and other aquatic principles.

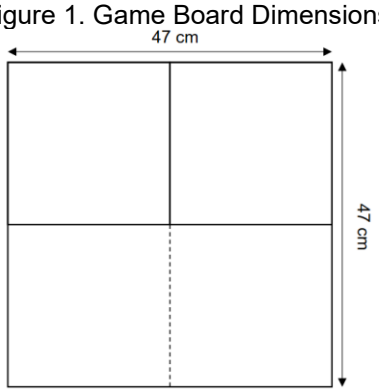
CONSTRUCTION OF THE GAME

For the construction of the game, the following were used: a sheet of Paraná paper; acrylic paint; brush; stylus; instant glue; sheets of A4 180 g paper to assemble the letters with the questions; adhesive paper to print the tray; a cardboard box to store the game; transparent adhesive plastic paper to customize the box; a dice and modeling clay to make the pawns.

In the preparation of the game, the following steps were followed:

1- To build the game board, a sheet of Paraná paper was used, and with the help of a ruler, a square area of 47 cm x 47 cm was measured (Figure 1) and then the stylus was used to cut the square of the board and make cuts to enable the folding of the board (Figure 2), after that, the back of the board was painted black (Figure 3). Figure 4 shows the ready-made tray.

Figure 1. Game Board Dimensions

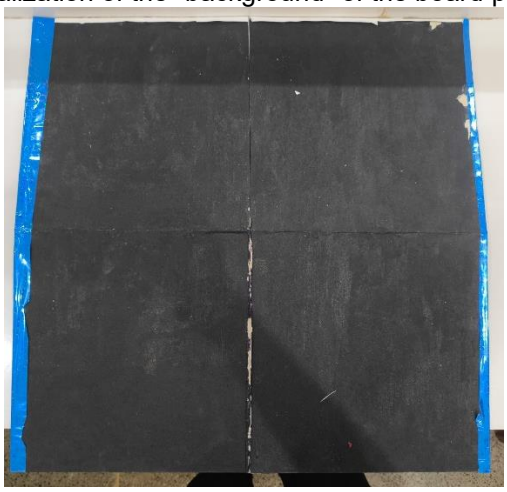


Source: The authors (2024).

Figure 2. Tray with its folds

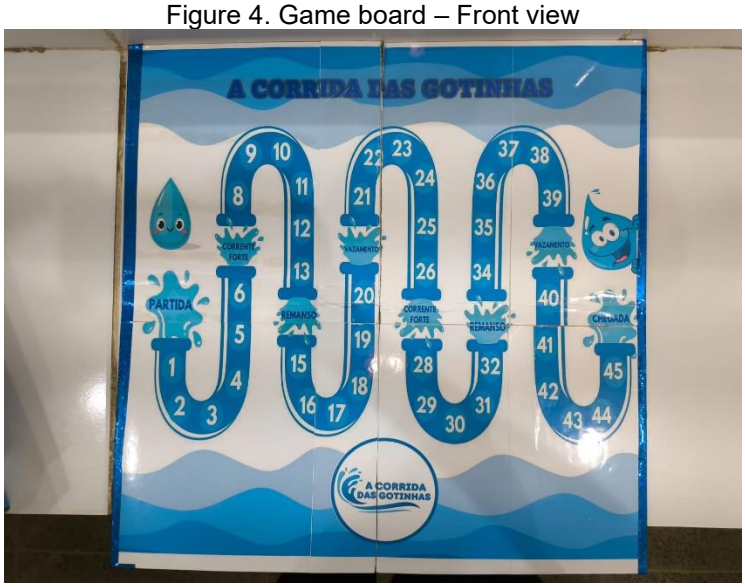
Source: The authors (2024).

Figure 3. Visualization of the "background" of the board painted in black



Source: The authors (2024).

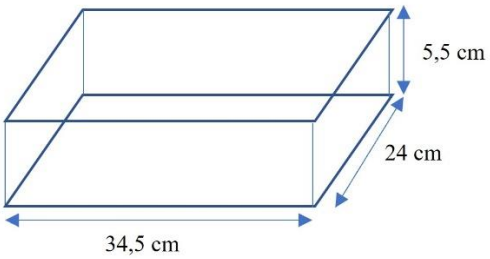
Figure 4. Game board – Front view



Source: The authors (2024).

2- To store the game board, as well as the other pieces of it, a box was produced in the dimension of 34.5 cm (length) x 24 cm (width) x 5.5 cm (height) (Figure 5), with cardboard paper, and transparent plastic adhesive paper was used to customize the game box (Figure 6).

Figure 5. Game box sizing



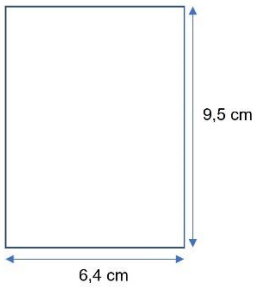
Source: The authors (2024).

Figure 6. Game box ready

Source: The authors (2024).

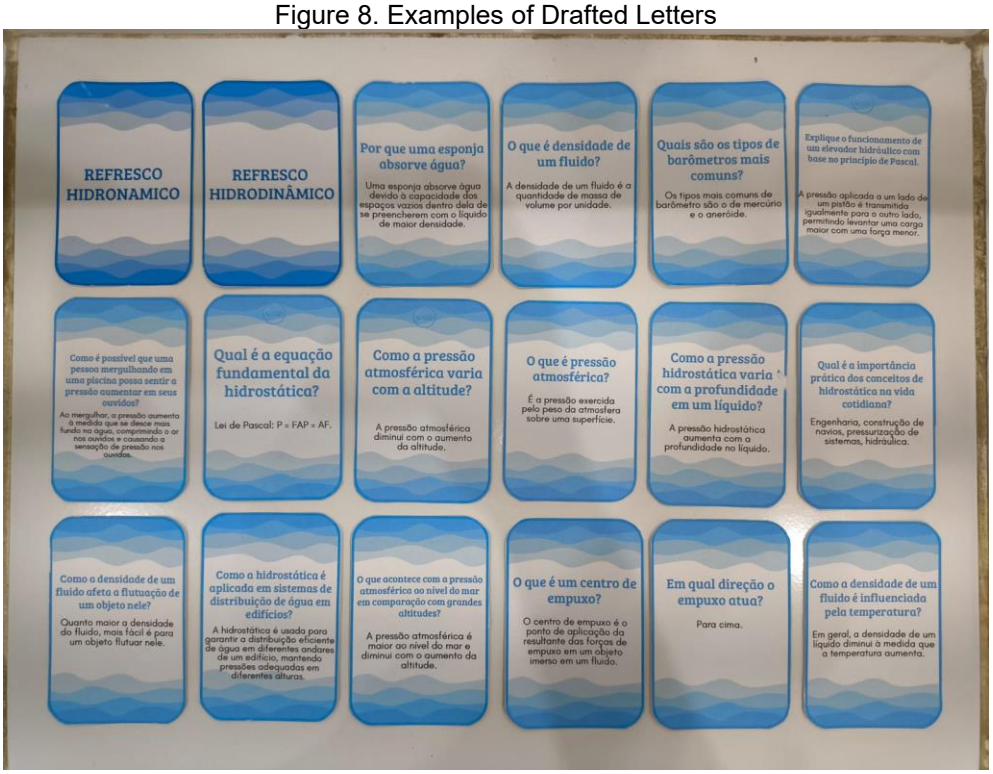
3- A total of 55 cards were prepared, in the dimension of 9.5 cm (length) x 6.4 cm (width) (Figure 7). The cards were printed on sheets of A4 180 g paper and cut out, the board art was printed on adhesive paper and then glued to the already cut board. Figure 8 presents examples of game cards. On each card there is a question and its answer.

Figure 7. Sizing of game cards



Source: The authors (2024).

Figure 8. Examples of Drafted Letters



Source: The authors (2024).

4- The four pins were made with modeling clay and painted in different colors (Figure 9).

Figure 9. Game Pins

Source: The authors (2024).

GAME RULES

Game components

The game is made up of the following parts:

- Board representing the water course;
- Challenge Cards with questions about hydrostatics;
- "Hydrodynamic Refreshment" cards for players who get three questions right in a row.
- Four pins.

Early Game

The game starts with the following rules:

1- Position the pawns/pins at the start.

2- Choose a player, apart from those who will be the pawns/pins, to be the judge of the game.

3- Shuffle the Challenge Cards and place them face down.

Player Turn

1- Roll the dice to determine the number of squares you will advance.

2- Advance the pedestrian along the route.

3- Do what you ask in the house you stopped.

4- If it lands on the common squares, the judge will take a card from the pile of cards and read the question to you.

5- If you get the question right you can walk 1 (one) more extra house, if you get it wrong you will go back 1 (one) house.

6- If you accumulate 3 (three) consecutive correct questions, you will win the Hydrodynamic Refreshment, so you can advance two extra squares in the next turn.

Judge of the Game

The judge will help maintain the integrity of the answers and provide fair play. The judge will also monitor each player's hits, ensuring that those who achieve three consecutive hits are duly rewarded with the Hydrodynamic Refreshment

House Types

The game features three types of house on its board:

• **Common Houses**: Take a Challenge Card and answer the question. • "Strong Chain" squares: advance 2 (two) squares.

• **"Backwater" houses**: Lose a turn.

• **"Leak" Houses:** Choose a player to go back 2 (two) squares.

Winner

The first player to reach the finish line after correctly answering the last question is the winner of "The Drop Race".

GAME TESTING

Lozza and Rinaldi (2017) point out that, when proposing to use playful activities in the classroom, four important precautions must be taken, the first of which is the prior testing of the didactic resource with the intention of avoiding unpleasant surprises at the time of its execution in class. Thus, after the pieces and rules were elaborated, the game was tested with all students of a class of the discipline Bases of Physics and Chemistry Applied to Pharmacy to evaluate it, perceiving the applicability of its rules and collecting possible modifications favorable to the good progress of the game and acquisition of knowledge (Figure 10).

Figure 10. Application of the game in the classroom

Source: The authors (2024).

DISCUSSION

The main result of the present work was the elaboration and elaboration of an educational tool aimed at learning Physics (Hydrostatics), to be possibly used in classes of introductory or conceptual disciplines, as is the case of the discipline for which the resource was elaborated (Bases of Chemistry and Physics Applied to Pharmacy).

For the elaboration of the didactic game, simple materials were used, easy to acquire, and cheap, which allows its reproduction in various academic spaces.

Studies indicate that most students have difficulties in learning Physics content and consider it an extremely boring subject with many formulas and calculations. However, when the discipline is not worked through playful methods, the chances of the student being interested in the content is much greater. Thus, the use of educational technologies such as the one described in this work makes the learning of Physics more effective and interesting since activities that are normally associated with leisure can also be associated with the classroom and studies.

Didactic games usually provide students with a competition to define the winner, and this leverages interest in the game and consequently learning, since to win they will have to make an effort to remember and learn the knowledge taught in the classroom. These tools are opportune for both students and teachers who can also relax when playing games (Dos Santos, 2018).

Felício (2018) points out that there is another applicability for a didactic game, which is the assessment of students' learning of the subject, since studies show that traditional assessment through tests does not correspond to the student's actual learning. Therefore, new methods of learning assessment have been sought and one of them is through didactic activities in which the teacher closely monitors the performance of his students.

The testing of a playful resource is important for it to be improved and so that there are no unpleasant surprises at the time of its actual execution (Lozza; Rinaldi, 2017). Therefore, a test was carried out by the team that developed the game, first only among its components and then with the other students of the discipline, with suggestions to improve the game being noted.

FINAL CONSIDERATIONS

Throughout this study, the importance of applying strategies for improvement and effectiveness in teaching and learning was seen. Therefore, board games proved to be a great teaching proposal.

The game created in this work aimed to test and bring knowledge of hydrostatics in a light and fun way to physics students. This innovative approach did not seek to impose a single method or replace traditional classes, but to be used as an extra resource to fix the contents of this area of the subject.

The playful approach, through games, has shown promise, offering a practical and engaging way to understand the principles of Physics. Activities conducted in a fun way have greater appeal and complexity, stimulate curiosity and interest, helping to absorb the concept more easily (Ferreira *et al*. 2021).

The use of educational methods based on playfulness has been shown to be highly effective in building more attractive learning environments for students. By incorporating games and playful activities into the teaching process, a dynamic space is created that arouses the interest of students, leading them to participate in a more engaged and motivated way.

A passive/expository model of the contents covered has contributed significantly to the demotivation of students in relation to Physics (Silva *et al*. 2019).

Board games, as highlighted throughout the study, provide an environment conducive to active and personalized learning, allowing students to learn at their own pace and skill level. In addition, these games not only complement traditional teaching, but transform students' perception and interaction with the concepts of Physics, creating a more dynamic, motivating and effective learning atmosphere (Kishimoto, 1998).

In view of this, the need to continue exploring and deepening the potential of board games as educational tools becomes evident. New research and pedagogical practices are fundamental for the development and creation of new games, as well as for their effective application in school environments.

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