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THE PLAYFUL APPROACH IN THE TEACHING AND LEARNING OF CHEMISTRY: APPLICATION OF CONCEPTS IN HIGHER EDUCATION

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ABSTRACT

Education has increasingly sought innovative strategies to make the teaching of complex subjects, such as Chemistry, more accessible and engaging. In this context, board games stand out as effective pedagogical tools, as they help in the visualization and understanding of abstract concepts. By providing an interactive experience, these games allow students to associate theory with practice through challenges and applied situations. This article presents the development of a board game focused on the study of inorganic substances

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and potentiometry, aiming to improve the teaching and learning process of pharmacy students, and this didactic instrument was tested, obtaining good results.

Keywords: Board Games. Chemistry. Teaching.

INTRODUCTION

Board games have become valuable tools in chemistry education due to their ability to make abstract concepts more tangible, accessible, and didactic to students. They offer a practical and playful approach to understanding its principles, transforming theory into practice through concrete situations.

A board game is a fun-oriented activity that involves the interaction between participants in a space delimited by a board, with rules that guide progress throughout the game. It can be competitive or cooperative, or both, and encompasses strategy, luck, or a combination of both.

Players use pieces, cards, dice, or other components to advance in the game, aiming to reach a specific goal: beat an opponent, solve an obstacle, accumulate points, etc. The eventualities are negligible. Board games are not only a form of leisure, but also an educational tool that makes it possible to improve skills such as analytical thinking, tactical organization and social skills.

Its origin dates back thousands of years, with ancient examples such as the Senet (Egypt, c. 3100 B.C.) and the Royal Game of your (Mesopotamia, c. 2600 B.C.), which had cultural, religious, and social significance. Throughout history, this type of hobby has evolved, where subsidies from different cultures and periods have been incorporated until it has become a popular form of distraction and habit in today's world (FINKEL, 2007).

Chemistry requires challenging skills such as abstract thinking, creativity, and experimentation. However, such skills are not always fully developed in the education of students, making learning difficult (Fontes et al., 2016). Discussions about the introduction of playful games in education 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.

It is relevant to consider teaching approaches that help facilitate study (Brandenburg; Pear tree; Fialho, 2019). This implies analyzing different methods, strategies and approaches that can make teaching more effective.

Games are relevant alternatives, as they promote changes in traditional methods, often centered on the passive transmission of content (Fontes et al., 2016). In this context, didactic games emerge as transformative agents, offering an engaging and dynamic approach to teaching.

Using a fun approach to teaching scientific concepts of chemistry 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. Playing and playing are essential in human development, crossing cultural and generational boundaries, allowing exploration and interaction with the environment.

By participating in games or play, people exercise creativity, imagination, socialization, and cognitive and motor skills. Play and play are present throughout life. For adults, games represent a form of relaxation, stress relief, strengthening of social relationships and also learning. Thus, play and play are an integral part of human nature, playing a vital role in the development, learning, and well-being of children and adults.

The present work aimed to elaborate and build a didactic game aimed at teaching Analytical Chemistry in an introductory course for students belonging to the sixth academic period of the bachelor's degree course in pharmacy at the Federal University of Pará (UFPA).

LEARNING FROM ENTERTAINMENT

INTENTION OF THE GAME

Originating from Latin, the word "game", which comes from *ludus*, is attributed to a playful activity that comprises leisure, fun and pleasure, but which also means "pastime subject to rules". The essence of this expression is completely compatible with the objective of "Neutralize!", by developing basic knowledge in chemistry in players in a didactic and exciting way. The highlighted importance of our board playground deals with the inclusion of people on the target subject of the dice game regarding the transmission of science on the study of the subject, as well as its daily applicability to more specific concepts, but which are potentially valuable information to understand, in particular, pH and its value in everyday life. In this case, learning needs to be connected to the social and intellectual context of each participant. Thus, teaching during the game must be based on the action of dialogue and critical reflection aimed at analyzing and solving problems (Freire, 2023), so that players can progress on the board without necessarily knowing deeply about the subject.

RECREATION AS A LEARNING METHOD

Games such as "Neutraliza!" are essential in the manifestation of competitiveness and self-evaluation, since learning about chemistry is only one of the nuances of entertainment and it is observed that others walk co-participating in this exercise, such as stimulating the physiological sensation, through the dopaminergic pathway, of the brain

reward mechanism (Schultz, 2015) which can be when winning the game, getting a question right or receiving a bonus.

Certainly, a process of gratification that can lead to the search for knowledge outside of contact with the board. In addition to the physiological response, the social interaction promoted during the performance in the game enriches elementary interpersonal skills, such as cooperativity, teamwork and communication (Kishimoto, 2018).

Furthermore, sharing strategies and expertise among the participants creates an enclosure conducive to the collective construction of chemistry learning, with the reasoning of investigation so that the challenge of the questions is overcome. This aspect reinforces the idea that learning does not happen only individually. In addition, there is an increase in the self-confidence and autonomy of those who play when facing the tests classified in different difficulties within the game (easy, medium, difficult and subjective), the participants need to make decisions, bear risks and deal with the outcomes, whether favorable to them or not (Alves, 2016).

The possibility of making mistakes and trying again in a space of their own, of safety and relaxation makes the learning process much less stressful and more inspiring, encouraging the persistence of practitioners.

CHEMISTRY TEACHING

The teaching and learning of chemistry can be effectively addressed by emphasizing preliminary concepts such as pH, potentiometry (potential difference, DDP), and basic reactions of inorganic chemistry in which they generate salts, oxides, bases, and acids, following Arrhenius' judgment. Such topics are crucial to the theoretical and practical understanding of analytical and inorganic chemistry. The concept of pH is central to the spectrum of chemistry, as it is directly related to the acidity or basicity of a solution (Haber, 1898).

pH is measured using pH meters, which are potentiometric instruments that detect the concentration of H+ ions in a solution. Therefore, these devices work based on the potential difference (DDP) between a reference electrode (such as the calomel electrode) and an indicator electrode (such as the glass electrode for pH measurement). Potentiometric titrations are an analytical method that uses the measurement of the electrical potential to determine the end point of a reaction, (citing an analogous case, a neutralization). For example, in titration of an acid with a base, the pH of the solution is monitored as the basic titrant is included. The endpoint is identified by a sudden change in potential, which corresponds to the point of equivalence (P.E.) of the reaction.

Inorganic chemistry encompasses the study of diversified compounds (acids, oxides, salts and bases) classified based on their properties and reactions. Acids release H+ ions in aqueous solution, while bases release OH^- ions. Salts result from the neutralization reaction between an acid and a base, as in the formation of NaCl from HCl and NaOH. Oxides can be acidic, base, or amphoteric depending on their reactivity with acids and bases. Neutralization reactions are fundamental in inorganic chemistry and involve the combination of an acid and a base to form salt and water. A practical example is the use of sodium bicarbonate (NaHCO) as an antacid to neutralize excess HCl in the stomach, resulting in NaCl, water, and CO2. The concepts of pH, potentiometry, and neutralization have wide applications, and we can mention: monitoring blood pH control, manufacturing of industrial products, and environmental enforcement. The integration of these definitions with analytical methods offers solidity to the study of complex chemical phenomena and their benefit in different areas of science and technology.

THE TEACHING OF CHEMISTRY FROM THE PERSPECTIVE OF A GAME

Teaching chemistry can be transformed into a dynamic and interactive experience by incorporating elements of board games. This playful approach allows the exploration of complex ideas (chemical reactions, ionic balance, properties of the elements, etc.) in an engaging way. By simulating having an organized entertainment in which data is used, the participants face stimuli that require the application of theoretical knowledge to solve practical problems (Vygotsky, 2007).

A game focused on chemistry that, in this case, includes dice, pawns and questions regarding the properties of substances and compounds and their reactions to each other. There are setbacks in episodes of error in answering the question, going back two places.

The inclusion of random events, such as spilling acids on the countertop, missing titrations, or failing to handle some equipment, adds a level of unpredictability and a nuanced context when falling into a trap house (beige). The game mechanics are designed to reinforce fundamental concepts, the game can include elements of competition and collaboration, where participants work as a team to achieve common goals.

The inclusion of rewards, such as lollipops on bonus squares with advances on the board, motivates participants to engage and deepen their understanding of the topics covered. This gamified approach is what makes instruction more appealing and pleasurable. By turning abstract conceptions into concrete challenges, board games can be a powerful tool for sparking players' interest in the discipline and strengthening their understanding of scientific facts.

MATERIALS AND METHODS

The board game developed was based on materials presented in the classroom and made available by the teacher of the discipline, in order to explore the concepts of inorganic chemistry and potentiometry. The sketch and the graphic part were produced on the computer by the graphic design program "Canva".

The name chosen for the dynamic was "Neutraliza!", which refers to reactions between inorganic substances, where it offers an association of everyday utensils with chemical practice. In the game, participants are immersed in a journey that in order to advance it is necessary to answer questions and challenges related to basic principles of chemistry, such as pH and neutralization of substances. Throughout the board, it is necessary to have a basic understanding of the subject, which is addressed both at the middle and higher levels.

The game consists of: board; cards containing questions about chemistry; cards containing "Bonuses" and "Traps"; plastic toys to identify the players; It is a common fact.

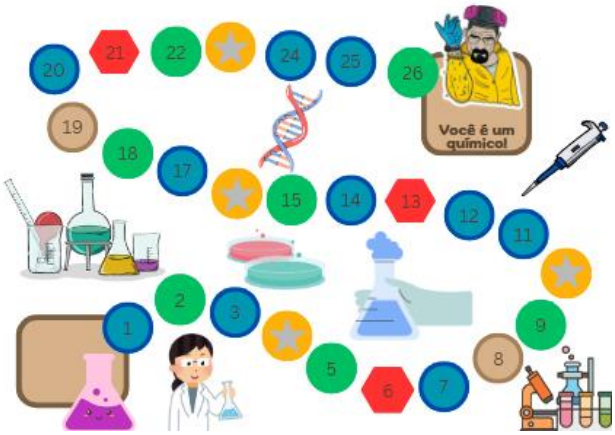
CONSTRUCTION OF THE GAME

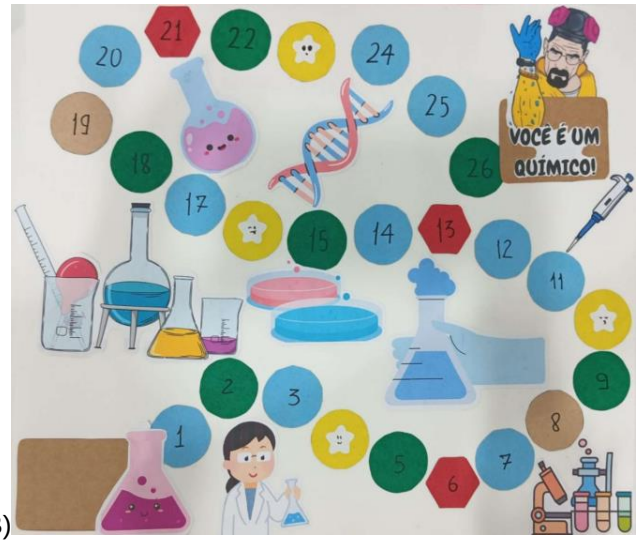
In order to construct the game board, a white E.V.A sheet, with dimensions 60 cm by 40 cm, was used as a base, a stylus, Styrofoam glue, card paper of various colors and A4 paper for printing the images that compose it and for the cards with questions.

For the composition of the board (Figure 1), cardboard circles were cut out with the colors green, blue, red, yellow and beige, each circle numbered from 1 to 26 (except the yellow ones), to symbolize the squares that symbolize the questions, bonuses or traps; To indicate the start and finish line, beige cardboard paper was also used.

Figure 1. Sketch of the board made in Canva (A); board ready (B)

(A)



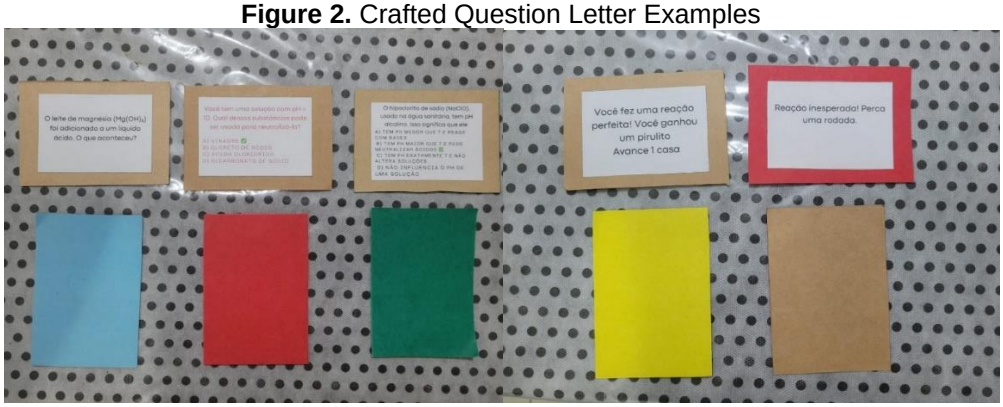
(B) 

Source: The authors (2025)

To make the game question cards, 46 questions were prepared (Chart 1) in the canva, then they were printed and glued on cardboard previously cut in dimensions of 6 cm by 10 cm, forming the set of game cards, and the cards have the same colors as the squares on the board. In addition to a question, the appropriate answer is present in each letter. Figure 2 illustrates examples of letters produced.

The pawns of the game were carts of different colors (Figure 3).

Figure 2. Crafted Question Letter Examples



Source: The authors (2025).

Figure 3. Game pawns (carts)

Source: The authors (2025)

Table 1. Questions designed for the game

Question	Alternatives	Resp.
Which of these substances is a strong acid?	A) Hydrochloric acid (HCl)B) Water (H_2O) C) Sodium chloride (NaCl)	The
A solution has pH = 12. How to lower pH?	A) Adding more baseB) Adding a weak acidC) Adding distilled water	B
Which of these everyday products contains an acid?	A) VinegarB) Table saltC) Soap	The
Milk of magnesia ($Mg(OH)_2$) was added to an acidic liquid. What happened?	A) Sodium hydroxide (NaOH)B) Carbon dioxide (CO_2)C) Sulfuric acid (H_2SO_4)	The
Which of these substances is basic?	A) VinegarB) Sodium chlorideC) Sodium bicarbonate	C
You have an acidic solution (pH 3). What happens if you add baking soda ($NaHCO_3$)?	A) IncreaseB) DecreaseC) Does not change	The
You have a solution with pH = 10. Which of these substances can be used to neutralize it?	A) VinegarB) Sodium chlorideC) Hydrochloric acidD) Sodium bicarbonate	C
What happens to the pH when we add more H^+ ions to a solution?	A) IncreaseB) DecreaseC) Does not change	B
What does the pH meter measure?	A) The acidity or basicity of a solutionB) The density of the solutionC) The temperature of the solution	The

Table 2. Questions designed for the game (continued)

Question	Alternatives	Resp.
You added lemon juice (citric acid) to a soap solution. What probably happened?	A) The solution became more acidic and the pH decreasedB) The solution became more basic and the pH increasedC) Nothing happened, because citric acid does not react with the base of the soapD) The solution became an insoluble salt and precipitated immediately	The
You have mixed calcium hydroxide ($Ca(OH)_2$) with sulfuric acid (H_2SO_4). What happens?	A) The acid is neutralized and a salt is formedB) The solution remains acidic, because sulfuric acid does not react with weak basesC) The acid reacts partially, because calcium hydroxide is insolubleD) A toxic gas is formed due to the reaction between the compounds	The
What is the pH of pure water?	A) 7B) 0C) 14D) 1	The
Why is it important to measure the pH of food and beverages?	A) To control its acidity and ensure food safetyB) To measure caloriesC) To identify artificial colors	The
What causes hydrogen peroxide to bubble in a wound?	A) Reaction with catalaseB) Fermentation of the skinC) Evaporation of the liquidD) Reaction with blood	The
What is table salt and what is it made of?	A) Sodium chloride (NaCl)B) Calcium carbonate ($CaCO_3$)C) Sulfuric acid (H_2SO_4)	The
What differentiates an acid from a base, according to Arrhenius' theory?	A) Acids release H^+ ions, bases release OH^- ionsB) Bases are always solid and liquid acidsC) Acids have pH above 7, bases below 7	The
What is different about salt water from fresh water?	A) Contains more dissolved saltsB) Is more acidicC) Is lighter	The
What is quicklime and what is it used for?	A) A compound used in construction and water treatmentB) A type of cooking saltC) A gas used to inflate balloons	The
What happens when we mix lye and water?	A) Releases intense heatB) Produces carbon dioxideC) Neutralizes pH	The
Which of these substances is considered a salt?	A) Sodium chloride (NaCl)B) Acetic acid (CH_3COOH)C) Sodium hydroxide (NaOH)	The
What chemical element is present in all acids?	A) Sulfur (S)B) Oxygen (O)C) Hydrogen (H)	C
Which of these compounds is used as an antacid	A) Calcium carbonate ($CaCO_3$)B) Sulfuric acid (H_2SO_4)C) Ammonium nitrate (NH_4NO_3)	The

Which of these acids is found in vinegar?	A) Acetic acidB) Citric acidC) Sulfuric acid	The
What is an electrolyte?	A) A compound that conducts electricity when dissolved in waterB) A metal that reacts with acidsC) A type of flammable gas	The

Table 3. Questions designed for the game (continued)

Question	Alternatives	Resp.
What substance is used to lighten clothes and disinfect environments?	A) Sodium hypochlorite (NaClO)B) Sulfuric acid (H_2SO_4)C) Vinegar	The
Which of these liquids is more acidic?	A) Sulfuric acidB) Sodium hypochloriteC) Sodium chloride	The
What happens to the pH of a solution when we add acid?	A) IncreasesB) DecreasesC) Stays the sameD) Becomes neutral	B
Which of these substances has a pH closest to 7?	A) Lemon juiceB) VinegarC) BloodD) Ammonia	C
A solution has a pH of 8. How can we classify it?	A) AcidicB) NeutralC) Slightly basicD) Strongly basic	C
Which of these substances can be added to an acidic soil to increase the pH and make it more suitable for planting?	A) Sodium chloride (NaCl)B) Potassium nitrate (KNO_3)C) Calcium carbonate ($CaCO_3$)	C
When a bee stings, its venom is acidic. What can be applied to relieve pain?	A) Baking soda ($NaHCO_3$)B) Vinegar (CH_3COOH)C) Distilled water	The
Sodium hydroxide (NaOH) is a substance widely used in soap making. Which of these statements about him is correct?	A) It is a strong base and has a high pHB) It is a strong acid and has a low pHC) It is a neutral salt and has a pH of 7	The
Which of these bases has the greatest strength?	A) Sodium hydroxide (NaOH)B) Ammonium hydroxide (NH_4OH)C) Calcium hydroxide ($Ca(OH)_2$)	The
When mixing calcium carbonate ($CaCO_3$) with hydrochloric acid (HCl), which gas is released?	A) Hydrogen (H_2)B) Carbon dioxide (CO_2)C) Chlorine gas (Cl_2)	B
What happens when you mix ammonium hydroxide (NH_4OH) with nitric acid (HNO_3)?	A) The solution neutralizes itself forming ammonium nitrate (NH_4NO_3) and waterB) The ammonium decomposes and releases hydrogen gasC) The mixture cools and forms a solid precipitate	The
If we add phosphoric acid (H_3PO_4) to a solution containing calcium hydroxide ($Ca(OH)_2$), what happens?	A) Calcium phosphate and water are formedB) The pH of the solution decreases dramaticallyC) The acid becomes stronger and releases oxygen gas	The
Which substance can neutralize an acidic solution containing carbonic acid (H_2CO_3)?	A) Potassium hydroxide (KOH)B) Nitric acid (HNO_3)C) Oxygen gas (O_2)	The
What substance can be used to neutralize baking soda ($NaHCO_3$)?	A) Citric acid ($C_6H_8O_7$)B) Sodium hydroxide (NaOH)C) Potassium chloride (KCl)	The
To neutralize ammonium hydroxide (NH_4OH), which substance can be used?	A) Sulfuric acid (H_2SO_4)B) Aluminum chloride ($AlCl_3$)C) Oxygen gas (O_2)	The
To neutralize sulfuric acid (H_2SO_4) in a solution, which substance can be used?	A) Calcium hydroxide ($Ca(OH)_2$)B) Nitric acid (HNO_3)C) Oxygen gas (O_2)	The
Which substance can neutralize aluminum hydroxide ($Al(OH)_3$)?	A) Acetic acid (CH_3COOH)B) Sodium hydroxide (NaOH)C) Oxygen gas (O_2)	The

Table 4. Questions designed for the game (continued)

Question	Alternatives	Resp.
Carbonic acid (H_2CO_3) is present in carbonated waters and soft drinks. What happens to the pH of the drink when it is opened and the CO_2 escapes?	A) The pH decreases, making the drink more acidicB) The pH increases, making the drink less acidicC) The pH remains constant, as the acid does not changeD) The pH rises to 7, making the drink neutral	B
What happens when a reactive metal (such as magnesium) comes into contact with a strong acid?	A) The metal dissolves and releases hydrogen gas (H_2)B) The metal hardens and becomes inertC) The pH of the solution increases	The
What happens when sulfuric acid (H_2SO_4) is added to water?	A) The acid releases H^+ ions and heats the solutionB) The acid becomes less acidicC) The solution cools and forms a toxic gas	The
What is a supersaturated solution?	A) A solution that contains more solute than it can normally dissolve at a specific temperatureB) A solution where the solute and solvent are in equilibriumC) A solution that contains only ionic compounds	The
If a buffer contains carbonic acid (H_2CO_3) and bicarbonate (HCO_3^-), what happens when you add HCl?	A) pH changes dramaticallyB) HCO_3^- ion reacts with H^+ and reduces pHC change) HCl is neutralized by H_2CO_3	B

Source: The authors (2025).

GAME RULES

The elaborate game features the following rules:

- Players can play 1 x 1 or 2 x 2;
- Participants position themselves with their chosen Pawn at the start;
- Each card is separated by color and face down;
- The game cards are divided into 5 sets of cards: blue (easy level question squares; green (medium level question squares); red (hard level question squares); yellow (bonus squares - advance two squares); and beige squares (trap - turn two squares/Lose one round).
- Determine the order of the players through the roll of the dice, with the one who rolls the highest number being the first and so on.
- The player rolls the dice to determine the number of squares he will advance, advancing his pawn along the course of the board.
- Do what is asked in the house that stopped. If it lands on one of the squares with questions, the judge will take a card from the pile of cards and read the question to the player. If the question is wrong, the player will go back 2 (two) squares.
- The first player to reach the finish line, after correctly answering the last question, is the winner of the game and becomes a "Chemist".

GAME TEST

The didactic game was tested, as recommended by Lozza and Rinaldi (2017), during an event held at UFPA, called ExpoFarma, with the participation of many people, including students, professors and other visitors. For the preliminary evaluation of the game, an evaluation sheet was prepared as shown in Figure 4.

Figure 4. Evaluation sheet of the game prepared

UNIVERSIDADE FEDERAL DO PRÁ
INSTITUTO DE CIÊNCIAS DA SAÚDE
FACULDADE DE FARMÁCIA

FICHA DE AVALIAÇÃO

JOGO DIDÁDICO: **Neutraliza!**

Você está sendo convidado a avaliar de forma voluntária o jogo didático "**Neutraliza!**", elaborado por uma equipe de alunos da disciplina Análise Farmacêutica (AF) com a finalidade principal de contribuir para o aperfeiçoamento do instrumento didático elaborado. Se aceita participar desta avaliação, por favor assine seu nome na linha abaixo e responda as perguntas seguintes.

---
assinatura

Perguntas

1- Qual sua faixa etária?
[ ] menos de 20 anos; [ ] 20 a 24 anos [ ] 25 a 29 anos
[ ] 30 a 34 anos [ ] 35 a 39 anos [ ] 40 a 44 anos
[ ] 45 a 49 anos [ ] 50 anos ou mais.

2- Qual seu sexo? [ ] Masculino [ ] Feminino

3- Qual seu vínculo com a Instituição?
[ ] Aluno de graduação (farmácia)
[ ] Aluno de graduação (não farmácia) Qual curso? _____
[ ] Professor (farmácia)
[ ] Professor (não farmácia). Qual curso? _____
[ ] Outro. Qual? _____

4- Para cada pergunta do quadro abaixo, atribua uma nota de 0 a 10.

Pergunta	Nota atribuída										
	0	1	2	3	4	5	6	7	8	9	10
4.1. Que nota você daria para a clareza das regras do jogo?											
4.2. Que nota você daria para o aspecto visual do jogo?											
4.3. Que nota você daria para a clareza das perguntas do jogo?											
4.4. Que nota você daria para a dificuldade das perguntas do jogo?											
4.5. Que nota você daria para dinâmica geral do jogo?											

5- Você gosta de jogos de tabuleiro? [ ] Sim [ ] Não

6- Você recomendaria este jogo como uma forma de aprendizagem? [ ] Sim [ ] Não.

Source: The authors (2025).

RESULTS

Table 1 shows the age distribution of the participants in the evaluation of the game, while Figure 5 shows the gender distribution of the evaluators.

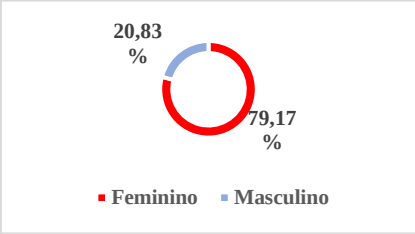
Table 1. Age distribution of evaluators

Age group (years)	Quantity	Percentage
< 20	1	4,17
[20; 24]	17	70,83
[25; 29]	5	20,83
[30; 34]	1	4,17
Total	**24**	**100**

Source: The authors (2025).

Table 2 shows the distribution of scores attributed to the five questions in item 4 of the evaluation form and Figure 6 shows the distribution of scores only for question 4.4.

Figure 5. Gender distribution of evaluators



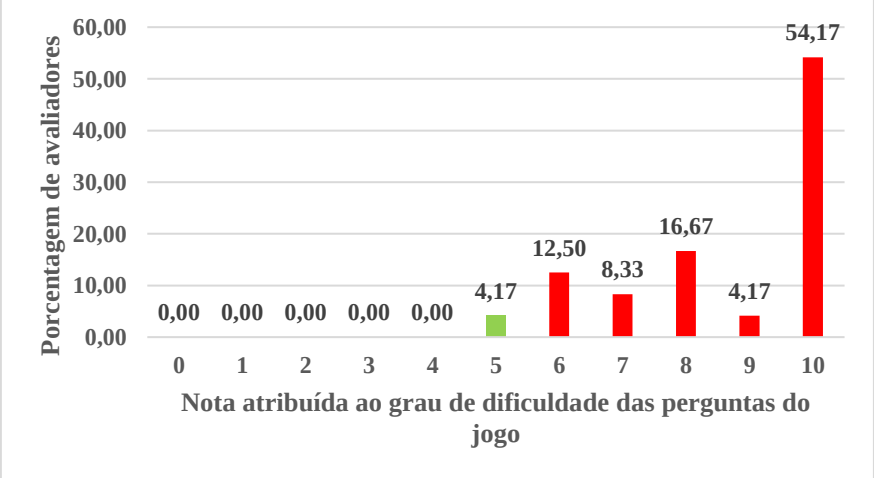
Source: The authors (2025).

Table 2. Distribution of grades given to the 5 questions in item 4

	Answers to Questions				
Note	**4.1**	**4.2**	**4.3**	**4.4**	**4.5**
0	0	0	0	0	0
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	1	0
6	0	0	0	3	0
7	0	1	2	2	0
8	3	0	1	4	0
9	1	0	2	1	2
10	20	23	19	13	22
Average	**9,71**	**9,87**	**9,58**	**8,67**	**9,92**

Source: The authors (2025).

Figure 6. Distribution of marks assigned to question 4.4



Source: The authors (2025).

DISCUSSION

Several paths can be adopted for teaching and learning, but there are also challenges that hinder these processes. Among the tools that help in teaching, didactic games play a prominent role, covering all age groups, from kindergarten to the academic level. Playfulness should be integrated into teaching, and not considered an element alien to the educational world (Kishimoto, 1998). One of the positive aspects of the use of didactic games is the development of cognitive skills in a relaxed and accessible way (Moratori, 2003).

The application of educational games can improve teacher training and the teaching of chemical concepts more effectively (Fontes et al., 2016). Interactive games provide students with opportunities to practice and solve problems, exercising critical thinking and applying the concepts of the discipline. Learning mediated by games proves to be more effective (Lopes, 2001). During a recreational activity, the student assumes the role of protagonist in the learning process (Kishimoto, 1994).

The research was conducted with 24 evaluators who were students of the Pharmacy course, covering age groups between less than 20 years old and 34 years old (Table 1), being a team of young people. Most participants were female (19; 79.17%, Figure 5) while only 5 evaluators were male.

When answering the questions in item 4 of the game's evaluation sheet (Figure 4), the evaluators assigned scores between zero (0) and ten (10) for each of the 5 questions, with the question "What grade would you give for the clarity of the game rules?" considered as question 4.1, the question "What grade would you give to the visual aspect of the game?", considered as question 4.2, and so on, and the results found are shown in Table 2, for the five questions.

The rules of the game were evaluated as being clear, as 100% of the evaluators gave a score above seven (7) for question 4.1 (What grade would you give for the clarity of the game rules?), obtaining an average of 9.71, and with a good visual aspect, as 100% of the evaluators assigned a score higher than seven (7) for question 4.2 (What grade would you give for the visual aspect of the game?), with an average score of 9.87.

Regarding the clarity of the questions (question 4.3; "What grade would you give to the clarity of the game's questions?"), these were considered to be clear, as there was a score equal to or greater than seven (7) for 100% of the evaluators, with an average of 9.58.

The difficulty of the questions in the game was assessed through question 4.4 of the evaluation form (Figure 4), and there was a wide variation in the result, between a score of five and ten, with an average score of 8.67, which is best seen in Figure 6.

For question 4.4 ("What grade would you give to the difficulty of the questions"), the lower the value of the assigned score, the easier they are, while the closer to ten (10), the more difficult the questions in the game will be. Thus, according to the average of 8.67 found and the grade distribution profile indicated in Figure 6, which shows 95.83% of the evaluators giving a score higher than five (5), the questions elaborated can be considered difficult for most students. However, when asked what grade they would give to the game (question 4.5), 100% gave approval scores (between 7 and 10), with an average score of 9.92, indicating its acceptance as a didactic mechanism.

In addition, 100% of the reviewers said they would recommend the game and stated that they liked games.

The playful approach proved to be promising, offering a practical and engaging way to understand the principles of Chemistry. Activities conducted in a fun way have greater appeal, stimulate curiosity and help demotivate students in relation to the discipline (Ferreira et al., 2021). Board games promote active and personalized learning, allowing students to learn at their own pace and skill level.

FINAL CONSIDERATIONS

In view of the elements mentioned above, it can be concluded that the execution of games as a resource for dynamic and objective learning is extremely helpful in the educational sphere, accompanying the student's development and encouraging more practices that improve knowledge and critical analysis.

The game is delivered with clarity and objectivity, facilitating the players' understanding, asking accessible questions about the topic and also in relation to the daily life in which it fits, enhancing performance and learning.

Therefore, the game continues as an example in order to add new forms of evaluation, aiming at positive results and entering educational environments as a form of fast and efficient learning, both for students and professionals in the field of education.

The game designed for the teaching of introductory analytical chemistry was developed for a class of the pharmacy course, but it is suggested that it be replicated in all courses that have some discipline of Analytical Chemistry in their curricula.

REFERENCES

1. Alves, F. (2015). *Gamification: How to create engaging learning experiences*. São Paulo: DVS Editora.

2. Alves, L., & Coutinho, I. J. (2016). *Digital games and learning: Foundations for evidence-based practice*. Campinas: Papirus.

3. Aranda, M. (2016). The importance of playing in child development. *Revista Científica Multidisciplinar Núcleo do Conhecimento, 1*(7), 63–78.

4. Brandenburg, C., Pereira, A. S. M., & Fialho, L. M. F. (2019). Reflexive practices of the reflective teacher: Methodological experiences between two higher education teachers. *Educational Practices, Memories and Oralities - Rev. Pemo, 1*(2), 1–16.

5. Brazil, Ministry of Education, Department of Secondary and Technological Education. (2006). *Curricular guidelines for high school - Natural sciences, mathematics and their technologies* (Vol. 2). Brasília: Ministry of Education, Secretariat of Basic Education.

6. Campos, M. C. R., Bortoloto, T. M., & Felício, C. M. (2003). *Games for the teaching of chemistry: Theory and practice*. São Paulo: FTD.

7. Felício, C. M., & Soares, M. H. F. B. (2018). From intentionality to playful responsibility: New terms for a reflection on the use of games in the teaching of chemistry. *New Chemistry at School, 40*(3), 160–168.

8. Ferreira, A. (2021). *Use of games and manipulable materials in the teaching of physics*.

9. Finkel, I. L. (2007). *Ancient board games in perspective*. London: British Museum Press.

10. Flach, G. I., & Ferreira, V. H. (2020). A systematic review of the literature on the evaluation of the use of games in education. In *XIX SBGames* (p. 4). Recife.

11. Fontes, A. da S., & et al. (2016). Games adapted for the teaching of physics. *Teaching, Health and Environment, 9*(3).

12. Freire, P. (2023). *Pedagogy of the oppressed* (70th ed.). Rio de Janeiro: Paz e Terra.

13. Grando, R. C. (2000). *Mathematical knowledge and the use of games in the classroom* (2nd ed.). Campinas, SP: Papirus.

14. Haber, F. (1898). Über die elektrolytische Oxydation organischer Verbindungen. *Zeitschrift für Elektrochemie und angewandte physikalische Chemie, 4*, 506–514.

15. Halliday, D., Resnick, R., & Walker, J. (2016). *Fundamentals of physics* (10th ed.). Rio de Janeiro: LTC.

16. Huizinga, J. (1980). *Homo ludens: The game as an element of culture*. São Paulo: Perspectiva.

17. Kishimoto, T. M. (1994). *The game and early childhood education*. São Paulo: Pioneira.

18. Kishimoto, T. M. (1998). *Game, toy, play and education* (3rd ed.). São Paulo: Cortez.

19. Kishimoto, T. M. (2018). *Children's games: The game, the child and education* (19th ed.). Petrópolis: Vozes.

20. Lozza, R., & Rinaldi, G. P. (2017). The use of games for learning in higher education. *Caderno PAIC, 18*(1), 575–592. Retrieved March 19, 2025, from https://cadernopaic.fae.edu/cadernopaic/article/view/264

21. Schultz, W. (2015). Neuronal reward and decision signals: From theories to data. *Physiological Reviews, 95*(3), 853–951.

22. Vygotsky, L. S. (2007). *The social formation of the mind: The development of higher psychological processes* (7th ed.). São Paulo: Martins Fontes.