Chemical Bingo: A playful approach to teaching the Periodic Table

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ABSTRACT
Educational games currently play a very important role in education, offering an innovative approach to learning, facilitating the retention of knowledge. In view of this, it was sought, through the present work, to evaluate the acceptability of the use of games for the teaching of chemistry in the undergraduate course (pharmacy course), more specifically, the teaching of the periodic table. For the analysis, a bingo-type game was used, which was applied and then evaluated through a questionnaire. As a result, an average score attributed to the game of 9.7 was obtained, and positive answers to the other questions were 100%. Thus, good perspectives of this methodology are proven by the students and its effectiveness and efficiency in pedagogical practice.

Keywords: Learning, Playful activity, Basic chemistry.

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INTRODUCTION

Playfulness conquers space and importance in the approaches to the development and learning of skills, especially cognitive, social, affective and motor skills, where such development "exceeds" the usual world, detaching itself from the most classic methodologies.

In education, this playfulness is used through games and games in order to work on the creative sense, not only of the student, but also of the teacher. Given that this action induces collaboration among the participants so that they work together, with a view to the game from the educational perspective, conceiving the development of specific skills, as well as their improvement.

According to Tessaro and Jordão (2007), educational games play a crucial role in contemporary education, offering an innovative approach to learning, facilitating the absorption of knowledge and it is worth noting that the individual who plays and plays is the individual who also acts, feels, learns and develops, and, thus, pedagogical games are innovative tools for education (Robaina, 2008, p. 15).

Thus, in the academic context, as a focus on the area of Basic Chemistry, the use of this dyadic resource is an alternative, since Soares, Okumura and Cavalheiro (2003) already stated that the development of new strategies is recommended to boost the teaching of chemistry.

As much as the use of playful strategies in the teaching of Chemistry, as well as other disciplines, in Basic Education, is already widely reported and practiced, in Higher Education it is still very infrequent, especially in courses that are not literature.

In view of the facts presented, the present work sought to make a chemical bingo on the periodic table (chemical symbols) and to analyze, through a questionnaire applied to students, the acceptability of this methodological strategy for the teaching of Basic Chemistry, in a class of the pharmacy course, of the 2nd academic semester, of the Federal University of Pará.

LITERATURE REVIEW

PLAYFUL PRACTICES IN TEACHING

The term "playful" has its origin in the Latin language, *ludus*, originally meaning game, but with the passage of time, and with the advances in educational psychology and other areas of human knowledge, the term ludic became more comprehensive, coming to be considered as an essential trait of the psychophysiology of human behavior, so that its definition ceased to be the simple synonym of play, as the implications of the ludic need went beyond the demarcations of spontaneous play (Almeida, 2009; Martins *et al*., 2024).

Playful strategies should be seen as facilitating forms that contribute to the construction of concepts, content reinforcement, sociability among students, creativity and the spirit of competition and cooperation, in such a way that these strategies lead the teaching-learning process to be transparent, ensuring mastery over the proposed objectives (Fialho, 2011; Martins *et al*., 2024).

Through playful practices, students become more attentive, more motivated, and engaged in the tasks developed in the classroom, and, thus, the anchoring of new knowledge ends up being more significant (Martins *et al*., 2024).

Lobo *et al*. (2024) report that there are four criteria that must be observed to choose a game to be applied in the classroom, so that such a playful activity can guarantee the essence of the game and the educational process. These four criteria are:

1- **Experimental value**, which leads the student to explore and manipulate, and in this way, teaches chemical concepts through the manipulation of some type of toy, space or action;

2- **Structuring value**, which corresponds to freedom of action following specific rules, and supports the structuring of personality that appears in strategies developed by the student and in the way of playing;

3- **Relationship value**, which corresponds to the ways of relating to the environment and other human beings (social life);

4- **Playful value**, which evaluates whether the objectives have the qualities that stimulate the appearance of playful action.

Lobo *et al*. (2024) also remind that four very important precautions must be taken when applying a playful activity in class, and these precautions are:

1st Caution: prior testing of the didactic resource to avoid unpleasant surprises at the time of its execution in class.

2nd Care: make a brief synthesis of the content to be worked on through the playful activity, as this content must have already been worked on and must be reviewed before the application of the activity, for a better use of the resource employed.

3rd Caution: checking the rules with the students, so that they can clearly understand the activity.

4th Care: elaboration of subsequent pedagogical activities related to the activity to ascertain the value of the ludic activity as a teaching tool, that is, evaluation of the activity developed.

PERIODIC TABLE AND PLAYFUL TEACHING

Chemistry is one of the disciplines that is considered difficult and of little interest by students, whether they are in Elementary School, High School or even Higher Education, because it involves many abstract concepts and is taught in the classroom in a very decorative way and without great attractions to students. However, this reality has changed in recent decades, and playful activities have contributed a lot to changing this situation, especially in Basic Education. Table 1 presents some existing works on the teaching of the Periodic Table in a playful way.

Table 1. Some works of teaching Periodic Table in a playful way

Title	Authorship	Level
Spelling Brazil with Chemical Symbols.	Franco-Mariscal e Cano-Iglesias (2008)	EB
Periodic Table - A Super Asset for Elementary and High School Students.	Godoi, Oliveira and Cognoto (2010)	EB
Exploring Elements: Play as an Ally in the Teaching of the Periodic Table.	Lobo et al. (2024)	ES
The Use of Playful Activities for the Teaching of the Periodic Table.	Dos Santos et al. (2024)	ES
An educational card game for learning families of chemical elements.	Franco-Mariscal; Oliva-Martínez e Márquez (2012)	EB
Developing and playing chemistry games to learn about elements, compounds, and the periodic table: Elemental Periodica, Compoundica, and Groupica.	Bayir (2024)	EB
An effective method of introducing the periodic table as a crossword puzzle at the high school level.	Joag (2014)	EB

Legend: EB = Basic Education (Elementary and High School); ES = Higher Education.

Several researchers in the Teaching of Chemistry, such as Joag (2014), Bayir (2014) and Franco-Mariscal *et al*. (2016), have addressed the importance of working on the various aspects related to the periodic table of chemical elements in introductory Chemistry disciplines. For example, Joag (2014, p. 846) points out that "the periodic table of elements is the cornerstone of the edifice of conceptual chemistry". The periodicity and predictability of the properties of chemical elements, evident from the similarity in a group and gradual variation over a period, are important characteristics of the modern periodic table. These characteristics make the modern periodic table one of the most fascinating topics in chemistry education, if introduced properly.

METHODOLOGY

ASSEMBLING THE GAME PIECES

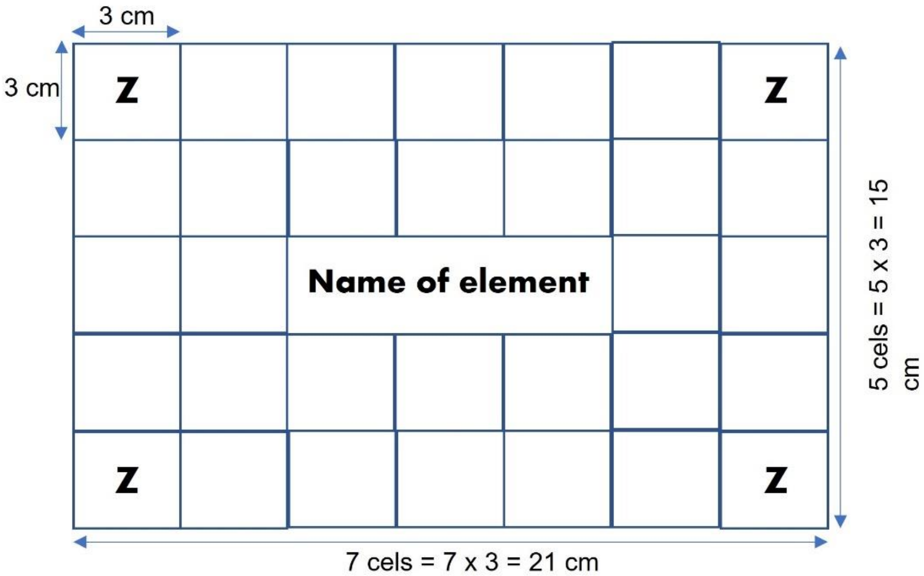
The Chemical Bingo was prepared by the monitors of the Laboratory of Physics Applied to Pharmacy (LAFFA), of the Faculty of Pharmacy of the Federal University of Pará (UFPA), in January 2023.

The elaborate game consists of 118 cards; 118 "stones" of the game, in addition to a box to store the cards and another box to store the "stones" of the game.

The assembly of the 118 cards was carried out only with white cardboard paper and marker pens, in addition to pencils and a common ruler to trace the cards.

The cards made have dimensions of 15 cm x 21 cm, divided into 3 cm x 3 cm caselles, except for a central one that is 3 cm x 9 cm (Figure 1). In this way, there are a total of 30 houses of 3 cm x 3 cm and a central house of 3 cm by 9 cm.

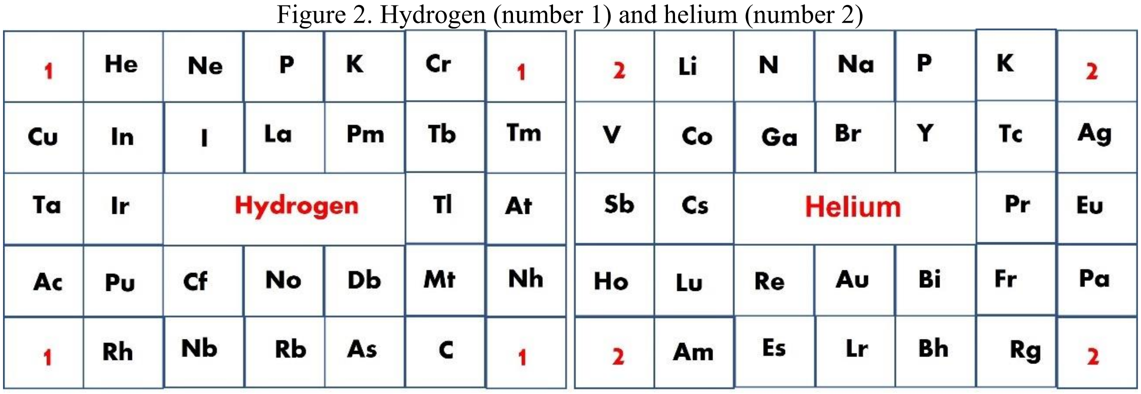
Figure 1. Sizing a game card



Source: The authors (2023).

In four caselas of 3 cm by 3 cm, the four present in the four corners of the cartouche, the atomic number Z of the element whose name is in the central carela (the one of 3 cm by 9 cm) is presented, and this cartouche is called by this name, hence there are 118 cartouches, as there are currently 118 known chemical elements, between natural and artificial. The other 32 caselas in the card are filled with a symbol of other chemical elements. This filling is not random. The first symbol to be written must be the chemical symbol of the chemical element immediately after the element in the cartouche, and the others must be taken every four from this element, so that an equivalent distribution of the 118 elements in the 118 cartouches is obtained. There is no element with much more occurrence in cards than other elements. Figure 2 illustrates the hydrogen (pack 1) and helium (pack 2) packs.

Figure 2. Hydrogen (number 1) and helium (number 2)

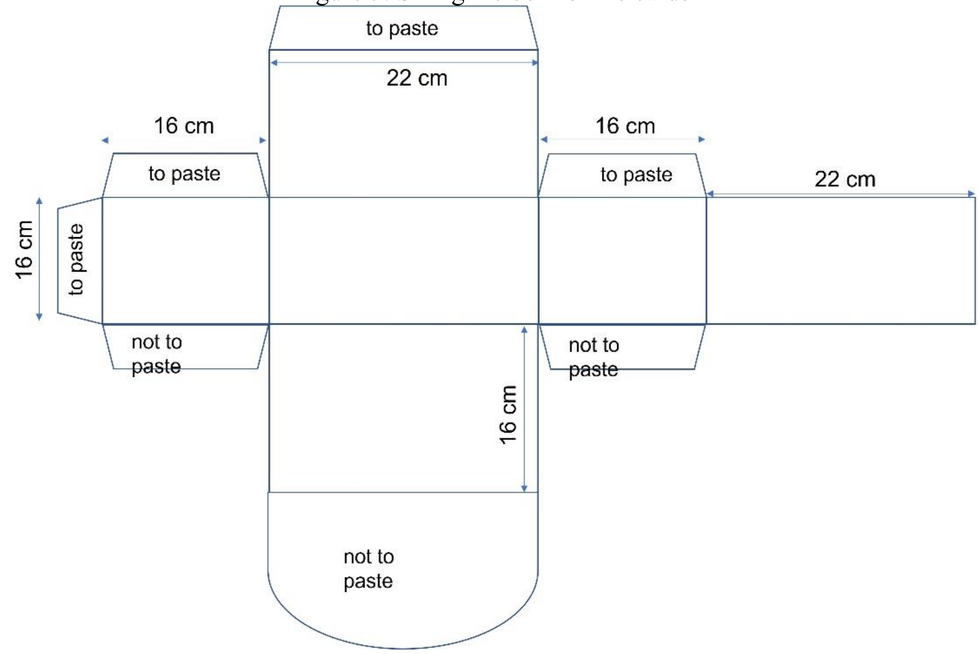


Source: The authors (2023).

As hydrogen is the chemical element with an atomic number (Z) equal to one, in the four corners of the hydrogen card the number 1 was written, and as helium is the next chemical element in the periodic table, the second casela has its symbol, and the others are placed in fours. This is repeated in the helium cartouche, where lithium (Li) appears in the second casela because it is the third element in the periodic table.

To store and facilitate the transport of the cards, a box was made with cardboard and paper glue, and using pencils, rulers and scissors. The dimensions of such a box are described in Figure 3.

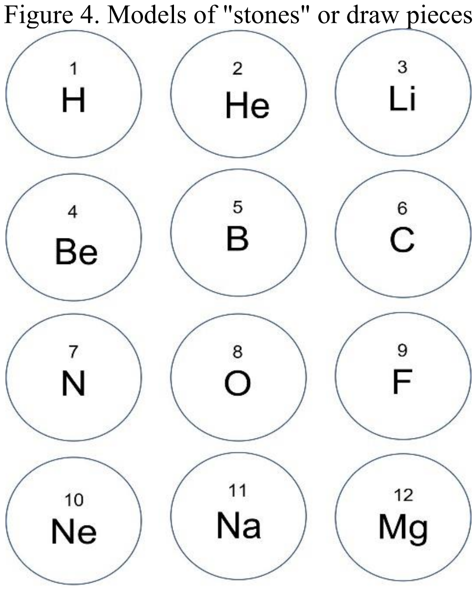
Figure 3. Sizing the box for the cards



Source: The authors (2023).

The draw pieces or "stones" were made with white cardboard paper and colored pens, as well as pencils and rulers for their tracings and scissors for cutting. They were elaborated in circular pieces with a radius of 2 cm, in a number of 118, one for each chemical element (Figure 4).

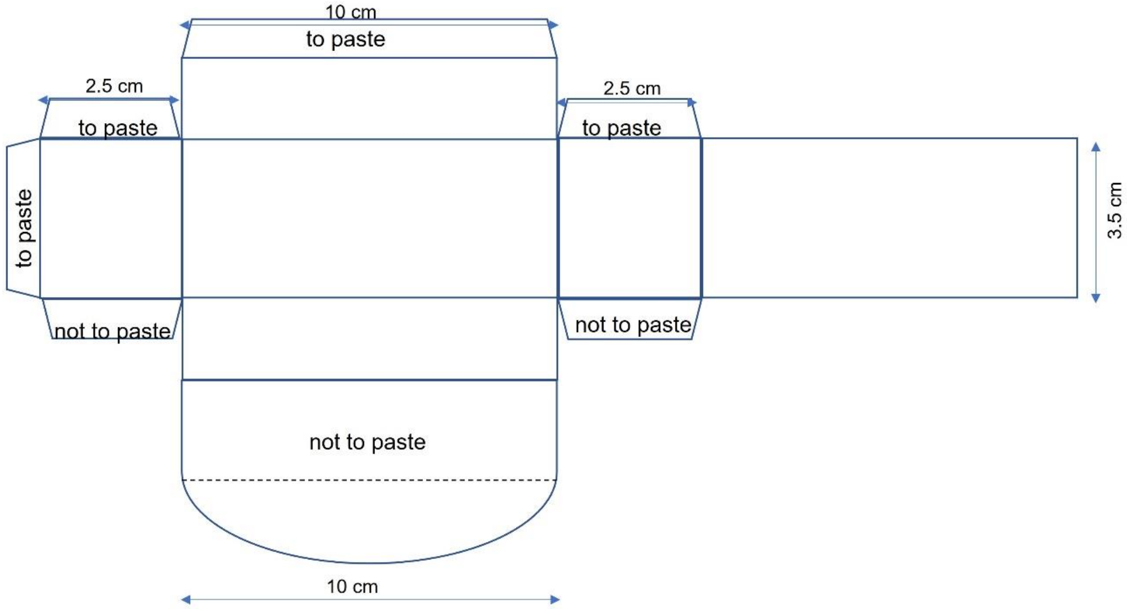
Figure 4. Models of "stones" or draw pieces



Source: The authors (2023).

To store and facilitate the transport of the "stones" of the game, a box was made with cardboard paper and paper glue, and using pencils, rulers and scissors. The dimensions of such a box are described in Figure 5.

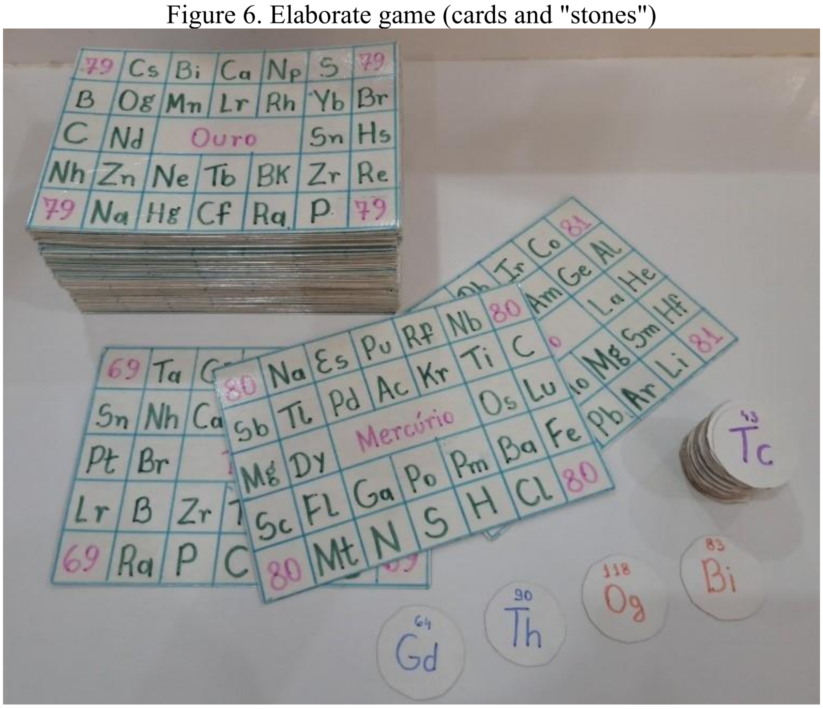
Figure 5. Box model for the "stones" of the game



Source: The authors (2023).

Figure 6 presents a photograph of the ready-made game, with its 118 cards and "stones".

Figure 6. Elaborate game (cards and "stones")



Source: The authors (2023).

GAME RULES

The rules of elaborate bingo are similar to those of traditional bingo, with minor adaptations, the following rules:

1- Each student must choose only a single card, by lottery;

2- After all the students have their cards, the teacher or a student chosen by him, proceeds to draw one of the stones of the game, placed beforehand in a dark bag;

3- The teacher (or the chosen student) reads the name of the chemical element drawn, and not the chemical symbol present in the stone. For example: if the stone says K, the teacher should say potassium;

4- Each student checks if he has this element on his card (the symbol). If you do, mark the symbol drawn with a grain of corn or other small object;

5- The teacher draws a next stone and the students again check if they have this name element on their card;

6- The drawing of stones proceeds until a student completes their entire card or, alternatively, a horizontal or vertical column of the card. This issue should be agreed upon with the class at the beginning of the game;

7- The student who fills out his card first must go to the teacher to confirm that he has marked correctly, at which time he must say the names of the elements drawn.

8- A round of the game ends when a student fills in the card and correctly says the names of the symbols drawn, and there may be other rounds, which is defined at the beginning of the game.

GAME TEST

After having its pieces and rules elaborated by the team of students (monitors), the game was tested with a small group of students (five, in total, being the two monitors and three other students invited by them), in order to perceive the applicability of its rules and collect possible modifications favorable to the good progress of the game and acquisition of knowledge, and following the recommendations given by Lobo *et al*. (2024), who point to the prior testing of the game as being the first care for the use of the didactic resource, with the intention of avoiding unpleasant surprises at the time of its execution in class.

APPLICATION OF THE GAME

The game was applied to a Basic Chemistry class of the Pharmacy course at the Federal University of Pará (UFPA), in the 1st semester of 2023, more precisely in the discipline "Bases of Chemistry and Physics Applied to Pharmacy" which is a component of the 2nd semester of that course. This class had 42 students, however, on the day of the application of the game only 37 students were present.

The reading of the "stones" (names of the chemical symbols) was done by the teacher of the discipline and the students had to mark the "stones" on their cards. When they completed the card, they should come to the teacher's desk and check if they had correctly associated the symbols of the cards with the names read (according to the rules already described).

At the end of the activity, each of the 37 students received an evaluative questionnaire (Figure 7) about the activity performed.

Figure 7. Applied appraisal form

UFPA – ICS – FACULDADE DE FARMÁCIA – BQF

ALUNO (A) : ____ Data: __/05/23

FICHA DE AVALIAÇÃO DA ATIVIDADE

1- Você daria que nota para a atividade lúdica desenvolvida, entre zero e dez? Nota: ___________

2- Você gostaria de ter mais atividade como esta ao longo da disciplina? (   ) Sim   (   ) Não

3- Você acha que aprendeu mais sobre o tema através da atividade desenvolvida? (   ) Sim   (   ) Não

4- Qual a sua opinião sobre a atividade desenvolvida?

Resposta:
____
____
____
____
____

5- Você teria alguma sugestão a dar sobre a atividade?

Resposta:
____
____
____
____
____

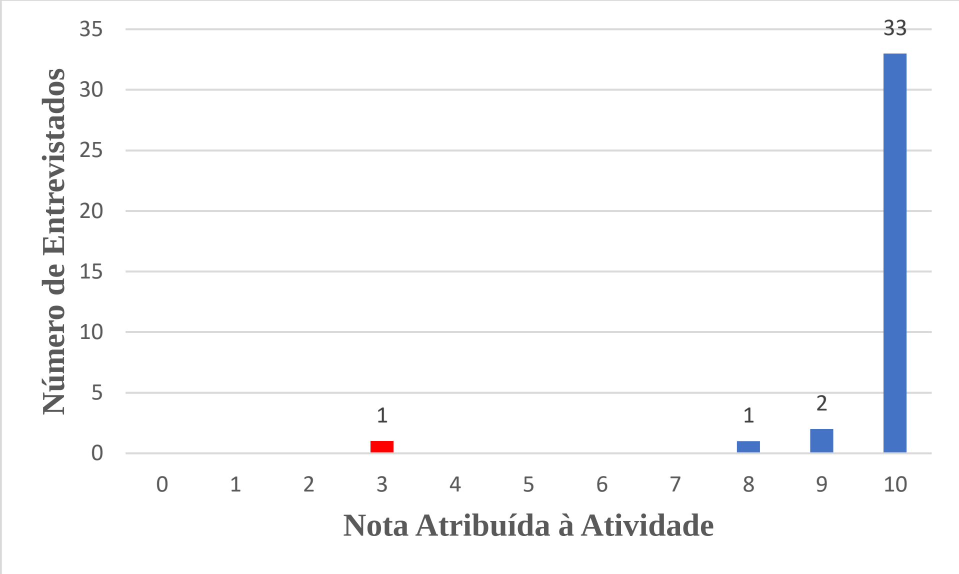
Source: The authors (2023).

The students' answers were spreadsheets in the Excel 2010 program and the data were analyzed in terms of descriptive statistics, in addition to the construction of an appropriate graph.

RESULTS AND DISCUSSIONS

Figure 8 shows the distribution of grades attributed by the students to the first question (would you give what grade for the playful activity developed, between zero and ten?), with an average of 9.7 being obtained, and only one student (2.70%) attributes a low grade (3) to the development of the activity, which demonstrates good acceptance of the activity by the students.

Figure 8. Distribution of grades attributed to the playful activity developed



Source: The authors (2023).

For the second and third questions, 100% of the students chose the alternative "yes", proving their acceptance and interest in playful methodologies, also highlighting that they affirmed greater learning with the applied methodology.

For the 4th question, the following comments stand out:

Student A: "It's much easier and more fun to decorate the elements this way, it doesn't get so boring";

Student B: "It's good because it's not worth a point, then the concern is much less";

Student C: "a lot of fun."

Through these three statements, it is again clear the acceptance of the activity and the recognition that through the applied activity there was a more pleasurable and meaningful learning.

These statements agree with what Barros *et al*. affirm. (2016), who consider games as innovative tools that enhance the teaching-learning process by leading students to spontaneous participation, which do not make them worry about mistakes, thus contributing to the quality of learning. Zanon *et al*. (2008), who applied the game "Ludo Química" in the teaching of organic chemistry, evaluated the performance of the methodology, and verified the favoring of the acquisition of knowledge. Souza and Silva (2012), obtained good acceptance of the methodology by using a game called "Organic Data".

When asked to give suggestions (question 5), the students suggested the application of more didactic games such as dice, cards, races, among others, and that also addressed other subjects of Basic Chemistry, such as chemical bonds; inorganic functions (acids, bases, salts and oxides); chemical reactions; laboratory glassware; chemical calculations; among other topics.

The acceptance of the game in the Chemistry class finds support in Vigotsky (2007), who says that such a resource can stimulate the student's curiosity; to get him to take initiatives; become self-confident; improve the development of language and concentration skills, provide better interaction between them and contribute to teamwork.

FINAL CONSIDERATIONS

The game was designed to work as an auxiliary and facilitating tool for the teaching and learning process of Basic Chemistry, subject chemical elements, within the scope of an introductory course of a higher education course in the health area (pharmacy). But it can be perfectly applied in similar disciplines of other courses in the health area (nutrition, nursing, etc.) or even in other areas such as engineering and exact and natural sciences.

The game pieces were made quickly, practically and at low cost, a fact that further boosts its use. But they can also be made with other materials, as discussed before. Therefore, the result of this work is configured as a tool of multidisciplinary applicability and easy access.

The playful activity developed in a Basic Chemistry class of the Pharmacy course was well accepted by the students of this class, who considered its use as a learning strategy as positive.

By adopting playful approaches, such as educational games and practical activities, the work suggests that it is possible to transform the learning environment, making it more engaging and accessible to students.

The use of the proposed game aims not only to illustrate the concepts of the periodic table, but also to promote the active participation of students and other participants (teachers and monitors).

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