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LUDO GAME IN PLANT ECOLOGY: EDUCATIONAL PROPOSAL IN THE SCHOOL ENVIRONMENT

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Lívia Chagas Santana Ribeiro[1], Arabután Maracaipe da Silva Neto[2], Daniel Lopes Costa[3], Nailthon Neponucena Van Silva[4], João Henrique da Silva e Silva[5] and Niara Porto de Carvalho[6].

ABSTRACT

Plant ecology has transdisciplinarity within the sciences, and can be taught through different active methodologies, as is the case of games in teaching. The objective of this work was to develop a board game for the explanation of contents related to plant ecology. The design of the ludo game was developed in Adobe Photoshop CC software, based on the original illustration of ludo. Gamification provides the construction of a collaborative and competitive atmosphere in the classroom, boosting and motivating the retention of knowledge and the development of essential skills in the student, transmuting from traditional to progressive teaching. Thus, the readapted ludo game in plant ecology represents an innovative and effective approach to the teaching and learning process.

Keywords: Gamification. Teaching Botany. Apprenticeship. Education.

[1] Undergraduate student in Biological Sciences, State University of the Tocantina Region of Maranhão - UEMASUL
Email: pablolivia2319@gmail.com
ORCID: 0009-0004-0060-942X
[2] Undergraduate student in Biological Sciences, State University of the Tocantina Region of Maranhão - UEMASUL
E-mail: arabutanmaracaipe@gmail.com
ORCID: 0000-0002-8238-5412
[3] Undergraduate student in Biological Sciences, State University of the Tocantina Region of Maranhão - UEMASUL
Email: danielcosta.20200002165@uemasul.edu.br
ORCID: 0000-0002-2406-5576
[4] Undergraduate student in Biological Sciences, State University of the Tocantina Region of Maranhão - UEMASUL
Email: n4ilth0nneponu@gmail.com
ORCID: 0009-0005-7110-2631
[5] Undergraduate student in Biological Sciences, State University of the Tocantina Region of Maranhão - UEMASUL
E-mail: joaosilva2174@outlook.pt
ORCID: 0009-0000-6799-4060
[6] Adjunct Professor III, Biological Sciences Course, Center for Exact, Natural and Technological Sciences – CCENT, State University of the Tocantina Region of Maranhão – UEMASUL
E-mail: niaraporto@uemasul.edu.br
ORCID: 0000-0003-3704-7294

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INTRODUCTION

The term ecology gained evidence at the end of the nineteenth century, however, much was already known regarding this area of study in Darwin's writings (the origin of species) even before the creation of the word ecology (Begon, 2023). In the current century, this science has been improved and diversified, being not only a sub-area of the biological sciences, but now a vast field of research, officially an undergraduate course, thus seeking to study and understand the abundance and distribution of living beings in a given environment, and the relationships between these individuals and the environment in which they live (Ricklefs, 1996).

Darwin's voyage of the Beagle contributed significantly to current knowledge of the flora, through the cataloguing of specimens, observations, and rich notes (Parmentier, 2023). In this bias, one of the concepts built throughout scientific research by ecologists and various scholars was the term plant ecology. This has a prehistoric origin, when the health, and respectively, the survival of human beings depended exclusively on mastering techniques of observing, handling and extracting substances from plants for their subsistence (Gurevitch *et al*., 2009).

In this sense, plant ecology has captivated researchers, gaining a space in the scientific community, becoming essential in the understanding of diverse biological processes, relating all biotic and abiotic organisms, as well as the importance of them constantly acting together (Brum *et al*., 2022). Therefore, in educational environments, plant ecology is seen in a transversal way, because it goes beyond the understanding of botany, it permeates several subareas of teaching, becoming a fundamental piece in the acuity of the functioning of our planet.

In addition, due to transdisciplinarity within the sciences, plant ecology can be taught through different methodologies, such as: playful games, films, videos, parodies, dramatization, didactic-pedagogical activities already done (exercises, expository classes and seminars, etc.), case studies, and conversation circles (Batista, 2021). However, what happens is the lack of training in the methodologies mentioned by the teacher, or even the negligence in teaching the content, by whatever the methodological tool (Candido *et al*., 2018). Therefore, the present work aimed to develop a board game for the explanation of contents related to Plant Ecology.

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HISTORY OF GAMIFICATION AS A TEACHING TOOL

The term "gamification" emanates from the English gamification and has gained visibility in different sectors, including: economic, medical, marketing, and, above all, educational (Cieslak *et al*., 2020). In this sense, the word gamification was created by British researcher Nick Pelling at the beginning of the twenty-first century, being a priori designated for the improvement of business activities, such as: employee training, increased profitability through sales, in addition to television development, based on the premise of profit and consequently the accumulation of capital (Rodrigues, 2023).

In the Brazilian scenario, the use of games, that is, gamification, has a milestone with the arrival of the Atari 2600 in the 1980s, allowing players of this generation space for entertainment and pleasure (Fadel *et al*., 2014). Nowadays, there is an exponential growth of gamers due to the immersion of the technological era, leading this universe to be seen from different perspectives, as well as education, communication, psychology, computing, design, among others (Martin, 2018). In this logic, gamification goes from marketing to the educational training process, leading to being recognized by the Ministries of Culture and Education, as an audiovisual, playful and inclusive product, which reflects on a significant educational model, which is based on the foundation for problem solving (Aguiar, 2023).

In this bias, gamification is a tool that proposed the use of game elements and mechanics, in order to engage, motivate, and influence the behavior of individuals in society (Martins, 2023). In this way, it promotes the construction of an attractive environment, thus stimulating active participation and the achievement of goals through characteristic elements of games, such as points, rewards, competition and challenges, transmuting tasks that would normally be considered monotonous or challenging, more interesting.

LEARNING THEORIES RELATED TO GAMIFICATION

Flow theory aims to understand why people focus on specific activities, neglecting basic needs such as food and rest, by exploring the psychological mechanisms that direct goal-seeking behavior (Machado *et al.*, 2015). The term *flow* reflects a psychological state driven by intrinsic motivation, leading to the achievement of desired goals. It arises when people engaged in a specific task feel satisfaction in achieving the established goals (Khan; Pearce, 2015).

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The principles of Self-Determination Theory highlight that individual motivations are shaped by contexts that meet diverse psychological needs. This makes students' motivation for learning a complex phenomenon, influenced by observations of behavior in real situations of performance or self-report of students (Leal *et al*., 2013). In this bias, gamification integrates into teaching and learning elements of games, content and concepts of the theory of self-determination to motivate students' daily activities, including more complex subjects that often lack attractiveness or intrinsic interest, and can make the student reach their state of flow.

In constructivist theory, the construction of knowledge occurs through provocative and challenging practices, recognizing individuals as active agents in the incorporation of new information (Vasconcelos; Manzi, 2017). Experiential learning theory, influenced by Lewin, Dewey, and Piaget, integrates experience, perception, cognition, and behavior (Kolb, 2014). Thus, gamification in the educational context aligns with these theories, providing interactive environments and challenges for the active construction of knowledge, making activities more engaging by introducing playful elements. This reflects the emphasis on practical experience and reflection present in the theories mentioned.

CHALLENGES AND LIMITATIONS OF GAMIFICATION

Gamification can be a great ally in education by promoting engagement and motivation in students, however, good planning is necessary to achieve the desired goals (Toda *et al*., 2017). For Barros and Cavalvanti (2023), one of the main obstacles identified is the need to incorporate aspects of substantial relevance into the proposed game for deep learning, not only focused on gameplay and *design*, as the reductionism of content makes learning superficial, deviating from the methodological proposal.

Kapp et al. (2013) defend gamification as a valuable tool in teaching, emphasizing that its application must be careful and based on "right reasons". For them, the right reasons include creating interactivity, promoting teaching through discovery, increasing student engagement, providing opportunities for reflection and deep thinking, and bringing about positive changes in behavior. On the other hand, the "wrong reasons" involve merely recreational activities, the belief that all teachers use gamification, the idea that learning occurs effortlessly, and the assumption that all students love to play.

Araújo (2016) highlights the importance of teachers analyzing the students' context, understanding their interests and motivations, and performing a self-analysis before

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applying a new methodology, considering limitations such as unavailable spaces or tools. In consonance, Martins et al. (2022) emphasize the challenge in the teacher training course, advocating the systematic approach of methodologies such as gamification, especially in initial or continuing training. He highlights the need for reading, knowledge of current methodologies and the creation of games by teachers in training to effectively establish the connection between teaching and gamification.

Gamification in inclusive education, as highlighted by Coelho et al. (2022), plays a crucial role in promoting the teaching, learning, and social inclusion of students with disabilities. However, Cheiran (2013) argues that inclusive games often focus on specific groups, resulting in segregation. On the contrary, Peixoto et al. (2021) demonstrate that gamification can be an effective inclusive alternative for diverse groups of disabled and non-disabled people, evidenced by experimental behaviours and arguments that validate learning.

BOARD GAME AS AN EFFECTIVE ALTERNATIVE IN GAMIFICATION

Among the different unconventional teaching methodologies provided and enhanced by current technologies, there is the Modern Board. This can present different configurations, ways of playing and applications in education. The trail game, the most popular, is characterized by having only one path, where the player who reaches the last square is the winner. The Ludo game determines the winner who reaches the center first, while chess stimulates competition and reasoning (Prado, 2018).

Figueres (2016) highlights the effectiveness of the use of board games in the teaching of technology in high school and in engineering, respectively. These pedagogical applications, according to Huzinga (2000), contribute significantly to the development of individual skills. In addition, Huzinga argues that in games that involve knowledge, skill and competition, the communication of tension is more effective, strengthening healthy competitiveness among participants and enriching the teacher's participation in the classroom (Pereira, 2013; Medina *et al*., 2019).

The next topic reports the process of elaboration of the board game developed from a plant ecology theme proposed as a protocol of the discipline of Curricular Practice for the Teaching of Botany, offered by the State University of the Tocantina Region of Maranhão (UEMASUL), for students enrolled in the 8th period of the Full Degree course in Biological

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Sciences, with the objective of working on active methodologies in the New High School (NEM) of the Public Network in the municipality of Imperatriz, Maranhão.

METHODOLOGY

The rereading of the game aimed to understand the basic concepts of ecology, emphasizing the basic structure of the food chain, demonstrating the relationships of food interdependence between living beings and their importance for the maintenance of the biosphere. During the course, *brainstorm* meetings were held with the students involved to discuss ideas and later, organize strategies and develop the game.

The choice of the board in *Ludo King*'s profile made it possible to create a game of small proportions, being ideal for application in public schools that usually have overcrowded classes. Its high popularity among young people also facilitates the understanding of the rules of execution, thus reducing the period of previous explanations, helping the teacher in the management of the time of practical application. The final design was developed in *Adobe Photoshop CC software*, based on the original illustration of the game, with differentiations to facilitate applicability in the classroom, making it shorter and more compact.

RESULTS AND DISCUSSION

The main focus of the game was to address plant ecology in the 1st year classes of high school, based on the sequence of the contents of the textbook, in which the curricular component adhered to by the state of Maranhão is inserted. However, the game can also be applied to other high school classes as long as they address the theme of ecology, with emphasis on the plant part. In addition, the ecology theme can be worked on in High School in a transdisciplinary way, involving disciplines such as life project, electives, among other subjects of the curricular matrix.

According to Camargo (2019), ecology is a subarea of the biological sciences with a high level of complexity, not dealing with the difficulty itself, but with the fact that it requires special attention, since it includes diversified subjects, such as: mathematical (graphs, formulas, variables, among others), biological (intraspecific and interspecific ecological relationships), biogeographic (environment, relief, climate, topography, soil and etc.) physicochemical (pH, temperature, chemical reactions, biogeochemical cycles) among others.

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Through the above, the importance of the theme developed is evidenced, in view of its contributions in the different biological spheres. Furthermore, ecology has ramifications that contribute significantly to the understanding of organisms existing in the biosphere. In this context, plants go through all trophic levels, considering that they are photosynthesizing beings that occupy the first trophic level, where light energy is converted into chemical energy, and can be transferred from then on to the other levels of organization.

The implementation of games in teaching is an active methodology of great value for the teaching and learning process, being a playful way of teaching, helping in the following aspects: motivational, reasoning, engagement, interaction and effectiveness (Mendes; Gomides, 2020; Fernandes *et al.*, 2023). In this bias, the thought ludo game directly affects the characteristics mentioned above, thus, the reinterpretation of the ludo game was idealized by modifying rules and the original physical aspects, adapting them to the teaching of plant ecology.

In this sense, the game was elaborated from the theoretical framework (Gotelli, 2007; Begon, 2023), facilitating and making the language more accessible to students. The practice addressed in this article also respects the specific competence of the National Common Curricular Base (BNCC), in which the analysis and interpretation of the dynamics of life is recommended, making it possible to predict the functioning and evolution of living beings, and of the universe, following the ability EM13CNT202 (Brasil, 2017).

The basic illustration of the tray was given on a sheet of paper in A4 format. To differentiate the players inserted, four colors were selected, namely: blue, red, lilac and green, each in a square, representing the four competitors. Three of the images used to compose the game's aesthetics were taken from the *rawpixel.com*/*Freepik* website (Figure 01), with a *free* license and free use. The remaining image, present in the blue house, is the only one authored by the writers, made using *Adobe Photoshop CC software*. Changes have been made to the images using the Remove.bg website to remove the background, in order to facilitate their visualization.

The cards are composed of the questions, alternatives and their respective answers, the last one being in lowercase in the lower right corner of the player. The questions used were developed by the authors. The design was created through the *Canva* website, using the *Open Sans* font of size 12 for both the questions and the alternatives, while size 10

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was used in the template. The art used on the back was developed by Artificial Intelligence (AI) present on the same website.

The design of the board has a dimension of 22x21 cm, being smaller than an A4 sheet, having 33 squares (Figure 01), and 50 questions about plant ecology, of which all are objective, containing four assertions, of which only one corresponds to the true answer, such data are inserted in cards with proportions of 10x11cm (Figure 02).

Figure 01: Game board adapted for the teaching of plant ecology.

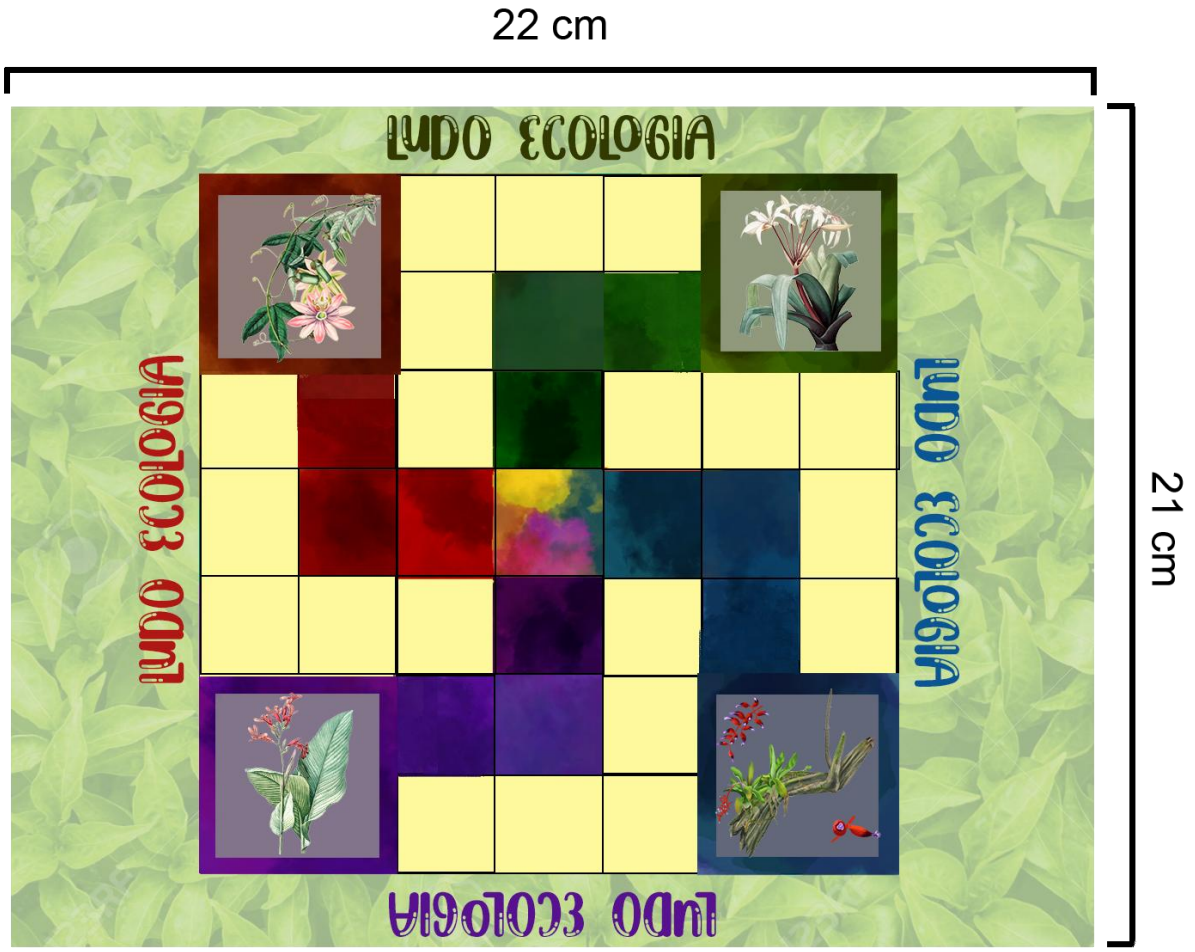

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Figure 02: The cards in the game total 51 units, and the last figure represents the back of the other cards in front.

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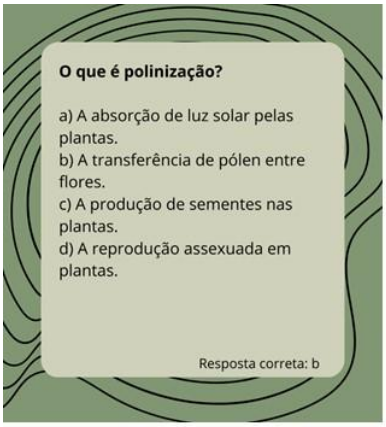

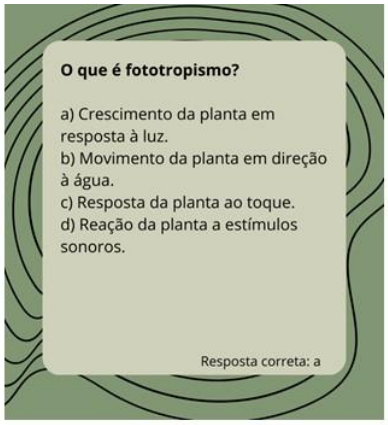

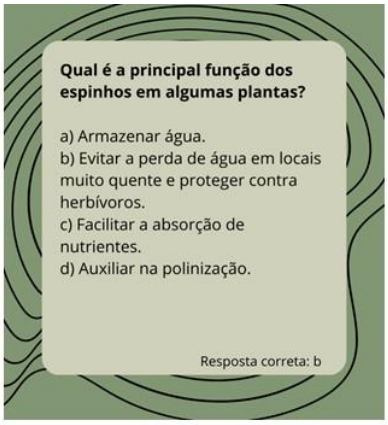

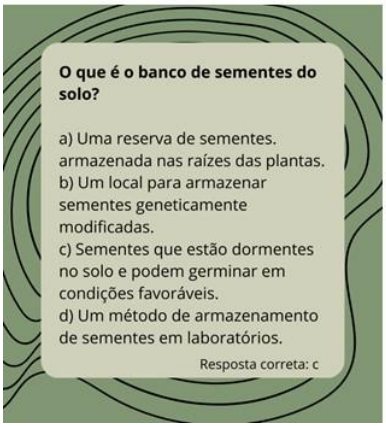

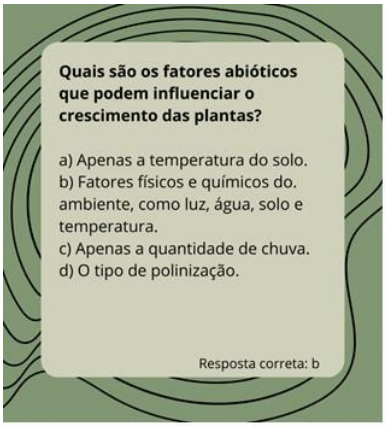

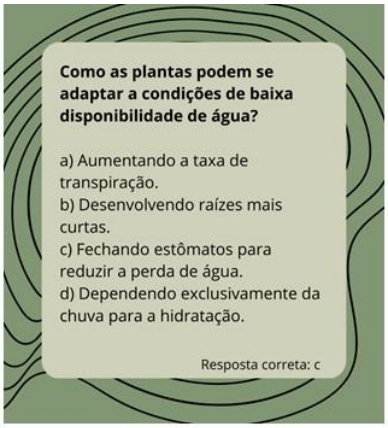

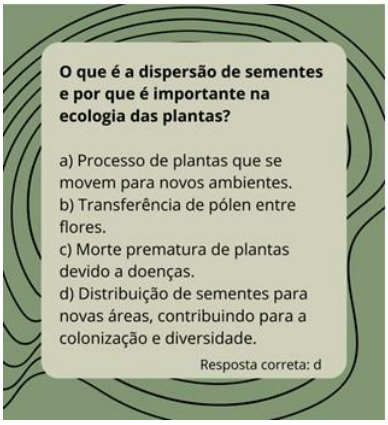

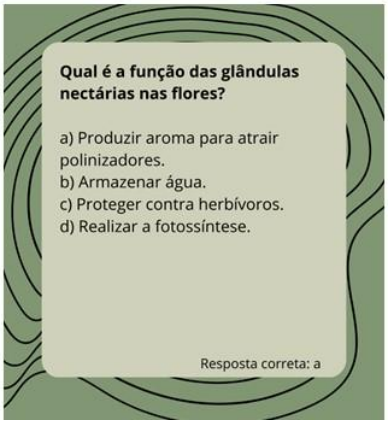

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O que são plantas halófitas?

a) Plantas adaptadas a climas frios.
b) Espécies que crescem em ambientes com altos níveis de salinidade.
c) Plantas que requerem sombra intensa.
d) Plantas que se desenvolvem apenas em regiões montanhosas.

Resposta correta: b

O que é a polinização cruzada?

a) Transferência de pólen da flor masculina para a feminina na mesma planta.
b) Transferência de pólen entre flores de plantas diferentes da mesma espécie.
c) Processo de formação de sementes nas plantas.
d) Interação entre flores e polinizadores.

Resposta correta: b

O que é mimetismo floral?

a) Imitação de cheiros por flores para atrair polinizadores.
b) Imitação de formas e cores por flores para atrair polinizadores.
c) Processo de formação de frutos.
d) Estratégia de defesa contra herbívoros.

Resposta correta: b

O que é um bioma?

a) Um tipo específico de planta.
b) Uma área geográfica com características climáticas e ecológicas distintas.
c) Uma espécie de fungo.
d) Um método de reprodução assexuada em plantas.

Resposta correta: b

O que é a micorriza?

a) Uma estrutura de suporte em plantas.
b) Um tipo de clorofila.
c) Uma associação simbiótica entre raízes de plantas e fungos.
d) Um método de reprodução assexuada em plantas.

Resposta correta: c

Como as plantas carnívoras obtêm nutrientes essenciais para o crescimento?

a) Se alimentam de outras plantas.
b) Obtêm nutrientes apenas do solo.
c) Consomem insetos e outros pequenos organismos para suprir deficiências nutricionais.
d) Dependem exclusivamente de micorrizas para a nutrição.

Resposta correta: c

Qual é a importância da biodiversidade na estabilidade dos ecossistemas?

a) Quanto menor a biodiversidade, mais estável é o ecossistema.
b) A biodiversidade não influencia a estabilidade do ecossistema.
c) Maior biodiversidade está sempre associada a ecossistemas mais estáveis.
d) Biodiversidade e estabilidade não têm relação.

Resposta correta: c

O que é a teoria da sucessão ecológica?

a) Teoria que explica a relação entre diferentes níveis tróficos em um ecossistema.
b) Processo de formação de solos.
c) Mudanças graduais na composição de comunidades ao longo do tempo em uma área recém-impactada.
d) Estudo das interações entre plantas e animais.

Resposta correta: c

Qual é a principal função das raízes das plantas?

a) Fotossíntese.
b) Absorção de água e nutrientes.
c) Reprodução.
d) Armazenamento de energia.

Resposta correta: b

Qual é a importância das folhas para as plantas?

a) Produção de sementes.
b) Absorção de água.
c) Realização da fotossíntese.
d) Fixação do carbono na atmosfera.

Resposta correta: c

Qual é a principal função das sementes nas plantas?

a) Armazenamento de energia.
b) Reprodução.
c) Fotossíntese.
d) Absorção de água.

Resposta correta: b

O que é a transpiração nas plantas?

a) Processo de produção de oxigênio.
b) Processo de liberação de água pelas folhas.
c) Processo de absorção de nutrientes pelas raízes.
d) Processo de fotossíntese.

Resposta correta: b

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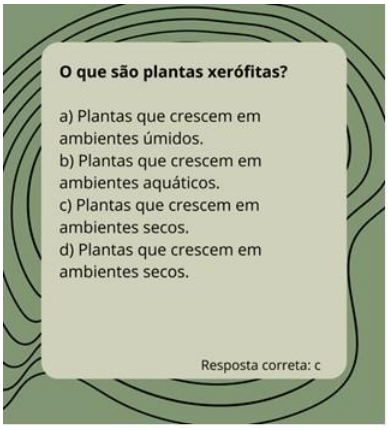

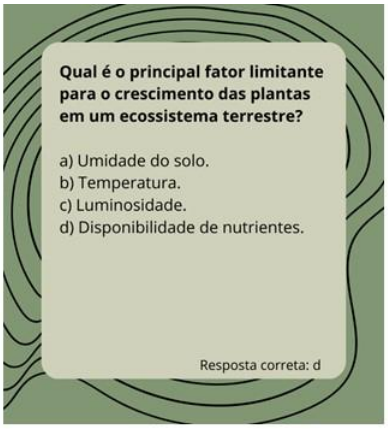

The set can be printed on A4 format sheet, with a grammage starting at 75g/m², a widely used sheet. It is preferable to use higher weights or canvas for printing in cases of prolonged use, the letters can be printed on cardboard paper, with weights above 100g/m². The teacher must also provide caps for *pet bottles* already used, corresponding to the number of teams included in the competition.

The game can vary in terms of the number of participants inserted, and can hold a minimum of two players and a maximum of 4 members, ideally each group containing 5 participants, to facilitate administration by the teacher applying the practice. Each player will be responsible for moving only one pin, which will represent him in the move, unlike the Ludo game in which there are four pins for each competitor. This characteristic was adopted in order to minimize the execution time, aiming to fit precisely into the reduced schedule of the NEM discipline.

The match begins with the choice of the group that will start, such selection can be made through the teacher. This group will start with the roll of the dice, which will indicate the number of squares to be jumped, followed by the other groups. In the second round, after the roll of the dice, the team in activity must answer a question contained in the cards made available, in case of success, the number of squares delimited on the die skips, in case of error, the value indicated on the die will be the number of squares returned by the member.

Competitors must go around the board following the yellow squares clockwise, after the turn, when passing through the squares of their respective colors they must follow the squares towards the center, the first to reach the center will win the competition.

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GAME RULES

- The competitor is not allowed to jump more squares than the amount presented on the die.
- Each player or team may roll the dice only once per round.
- In case of error in the answers, the team needs to return to the number of squares delimited in the data.
- In case any member of any of the teams sees the question contained in the cards ahead of time, the group loses its turn.
- Each group will only have 1 minute to answer the question, in case they do not answer the question, they move on to the next group, which in case of correct skips or error returns to the number of squares indicated on the dice, and in case they are unable to answer the answer passes to the next group.
- If none of the groups can answer, none scores, and it is an indication for the teacher to review the theme.

FINAL CONSIDERATIONS

In summary, gamification is a tool that has gained space in the school environment, whether physically or digitally. Its incorporation has shown many contributions in different areas and strands, due to its potential to make a theme more attractive. In this way, gamification provides the construction of a collaborative and competitive atmosphere in the classroom, boosting and motivating the retention of knowledge and the development of essential skills in the student, transmuting from traditional to progressive education.

In addition, gamification raises the inclusion of diversity present in educational spaces, tangential to the adaptation of evaluative models that seek to meet individual but also collective needs, including all neurodiverse individuals, especially neuroatypical ones. In addition, games in teaching are effective alternatives for the promotion of individuals with learning disorders, being a facilitating instrument, as it presents a simplicity compared to traditional methodologies.

Thus, gamification in plant ecology goes back to transversal teachings, permeating the various areas of knowledge, such as geography, chemistry, physics, biology, among others. Such particularities are of paramount importance for the student to contextualize his knowledge in order to position himself as a spectator of his role in the biosphere, both at the individual and collective levels. Therefore, such action of the student leads him to

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explore the principles of emergent properties in an unconscious way, starting from the basal to the highest level of understanding of the environment.

In view of the above, the action of games in teaching is favorable in the fixation of knowledge, providing students with the ability to learn autonomously, even outside the school environment, through reflection and the acquisition of thinking and action skills that enable them to continue learning throughout life. Thus, the introduction of gamification, with emphasis on the readapted ludo game in plant ecology, represents an innovative and effective approach to the teaching and learning process.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest related to the publication of this manuscript.

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