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THE STUDY OF GREEN CHEMISTRY APPLIED IN A BOARD GAME

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ABSTRACT

At present, the depletion of natural resources is projected to increase the challenges of humanity with the scarcity of fresh water and the loss of biodiversity. Green Chemistry (GQ) can be defined as the management of chemical products and processes that are intended to reduce or eliminate the use of hazardous substances in the environment. Basic education students must be educated on the concept of sustainable chemistry. To achieve a better understanding, students must create a critical and participatory sense of the complexity of social challenges, such as the environmental impact caused by anthropic action. Didactic games are a tool for the inclusion of students, immersing them in everyday situations and their reflexions.The present work aims to develop a question board game on the subject under study, and in this way, it will be possible to discuss attitudes and sensitise students in reducing environmental impacts. The board is a quiz game and contains 41 spaces filled with questions related to the following themes: sustainability, sustainable development, conscious consumption, and biodiversity. With the application of the game, it is expected that students will develop a better understanding of the environmental impacts caused by attitudes due to anthropic action due to lack of knowledge about sustainability.

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INTRODUCTION

With the increase in the rate of the biodiversity reduction, the call for global conservation solutions becomes more urgent. In particular, it is necessary to break the stigma of chemistry as a threat to environment, but rather to acknowledge its potential for providing sustainable and environment-friendly solutions. (Bull *et al.,* 2013). Although sustainable practises exist, humanity is under the threat of food and water shortages as a result of the decrease in biodiversity. (Tupala, Huttunen, Halme, 2022; Cortés-Capano *et al.,* 2022). Conservation of biodiversity is correlated with numerous objectives of entrepreneurs, conservationists, and local populations. However, the debate regarding the support of sustainable uses of natural resources remains open (Mountford & Keppler, 1999). Sustainability is related to addressing the needs of present and future generations through a conscious effort, based on three main pillars: environmental, economic, and social (Constanza & Patten, 1995). In the light of the high environmental damage that Chemistry is commonly associated with, the term Green Chemistry (GC) has been proposed to direct public awareness towards chemical products and processes designed to reduce and/or eliminate the use of hazardous substances to the environment (Gomes *et al.,* 2018). In recent years, especially in the 1990s, GC has gained strength due to how chemical industries perform, and as such, the programme "Alternative Synthetic Routes for Pollution Prevention" was created with the objective of rewarding industries that reduce the production of waste. Educational proposals play a fundamental role and do not reach the ideas that surround or conceive sustainability, however, for it to be possible, it is necessary to reorganise them, promoting interdisciplinarity (Sousa, Silva, Costa, 2019). The concepts of sustainability and biodiversity are entangled, and both are related to the conscious utilisation of natural resources, thus resulting in a healthy exercise of citizenship based on three main pillars: economic, social, and environmental (Pitanga, 2016). As an awareness of sustainability and sustainable development, it becomes easier to teach about sustainable awareness, or rather, the concept needs to be intrinsically a teaching body (Mello *et al.,* 2021). It can be argued that the learning process can be improved by raising the level of critical thinking of the students, as they face the challenge of understanding and reversing the environmental impact caused by anthropic actions. The didactic games serve as a tool to engage the students, immersing themselves in daily situations and their reflections (Despeisse, 2018). Learning, from the viewpoint of the students, is perceived as a method of repetition Under this perspective, the first part of the process to be attributed to a student's failure to learn a subject is the work of the teacher. Therefore, in such an environment, no space exists for tools that stimulate and engage the students, such as didactic games (Da Cunha, 2012). An

educational game aims at linking the playful with the fun and educational part, leading to the construction of knowledge. To promote integral and dynamic development, the introduction of games in the school environment requires a teacher to maintain the balance between playing and learning. (Kishimoto, 2003). To become part of the didactic toolkit of a teacher, a game must fulfil the following list of criteria: present the programmatic content, observe relevant aspects, evaluate previous successful content, review important concepts, highlight relevant issues related to the chemistry content, integrate multidisciplinary points, and contextualise facts. (Da Cunha, 2012). A game can be part of the teacher's planning if the following criteria are observed: present the programmatic content, identify relevant aspects, evaluate content that has already been worked on, review important concepts, highlight relevant issues to the chemistry content, and integrate issues. The present work aims to develop a question board game on the subject under study (Biodiversity, Sustainability and Green Chemistry) and in this way enables the discussion of attitudes and further sensitise students on environment-related issues.

MATERIALS AND METHODS

The board (Figure 1) represents a game of questions with 41 spaces divided into simple squares (blue planet) and squares with a call to action: lamp (questions), yellow planet (throw the dice again), grey planet (come back two spaces), stop (stay around without playing), bridge (shortcut) and volumetric balloon (Curiosities). The questions are related to the following subjects: sustainability, sustainable development, conscious consumption, and biodiversity; some taken from entrance exams and the National High School Examination (ENEM) have three alternatives to facilitate the dynamics of the game, with 35 question cards. Curiosity is related to the content of the questions, but there is a benefit or punishment to be applied. The question cards are 7x9 cm in size, and the trivia cards are 4x6cm. They will be laminated for better handling during the activity. The board will be the size of an A2 sheet (42x59.4cm).

Game rules: The class is divided into teams of four or five participants, with each team choosing a pin of the desired colour representing their team on the board. To start the game, one member of each team rolls the dice once with the highest number drawn defining the first team to play. After rolling the dice, each team moves its pin according to the number of spaces determined by the face. If the pin stops on the lamp, it must pick a question. The opposing team is then supposed to read the question and alternatives. If the answer is correct, the team remains in the same place, otherwise, the team moves one square backwards. If the pin lands on the grey planet, it must move back two squares. Accordingly, if the pin lands on the golden planet, the team must roll the dice again. Falling on the stop square penalises the team with one round out of the game. Falling into the volumetric balloon house requires the team to pick a curiosity card , and if the planet is connected to the bridge, the team can take a shortcut. The team that reaches the end of the board first (Home) wins.

RESULTS AND DISCUSSION

Games are an excellent learning method, and their use in the classroom has provided an alternative educational method for students by enabling a more interactive learning journey, which turns out to be more engaging than the traditional class (Russel, 1999). Brazil's territory includes the largest part of the Amazon rainforest, which is also a home of rich biodiversity and poses a challenge for its sustainability and environmental conservation. However, in the classroom, the difficulty of approaching these issues may pose a challenge for school teachers.

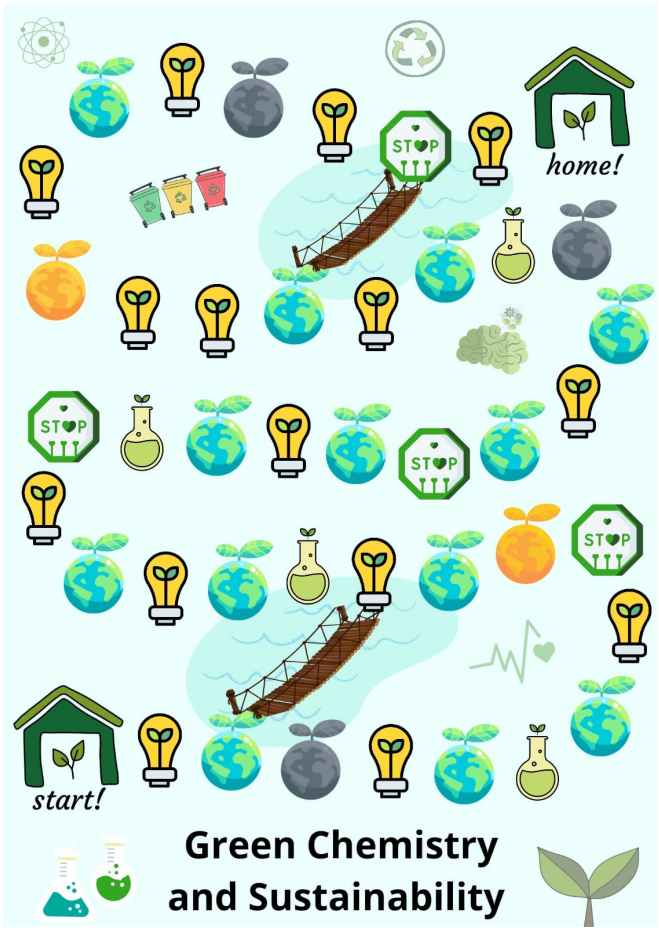

Figure 1. Image of the game board

The goal of the game is to ask questions about the recurring global issues in the life of a student, i.e., the greenhouse effect, eutrophication, el Niño and la Niña effects, and global warming. Here are some example questions:

Question 01. Some actions of modern society contribute to the planet suffering changes in its temperatures. The greenhouse effect keeps some of the heat radiated by the sun around the earth, warming it up. Among the human activities carried out below, indicate which one directly contributes to the increase in the greenhouse effect.

a) Use of automobiles as the only or main means of locomotion and transportation
b) Daily use (relatively long time) of Internet resources.
c) Exaggerated consumption of soft drinks instead of other healthier drinks.

The answer in bold is correct.

Or issues related to tragedies at the regional, state, or municipal level as an example below of a question:

Question 02. "In the episode that occurred in Brumadinho, approximately 125 hectares of forests were lost, the equivalent of more than a million square metres or 125 soccer fields, leaving people dead and missing."

Check the alternative that does not have the environmental and social impacts that the collapse of the dam caused,

a) It affected water supply in some municipalities.
b) Leaving contaminated water that will be used for irrigation.
c) Decreased availability of oxygen in water.

The answer in bold is correct.

The teacher can also pose conceptual issues such as sustainability and green chemistry, as described below.

***Question**:* Green chemistry is a branch of chemistry that seeks to reduce or eliminate the use of substances that promote pollution as well as to recover the quality of the environment. It was first defined in 1991 by John Warner and Paul Anastas, members of the North American Environmental Agency (EPA). According to Green Chemistry, it is incorrect:

a) Improve natural synthesis processes.
b) Develop conditions for chemical reactions to have higher yields and produce fewer impurities.
c) Use of nonrenewable reagents and reduction of the loss of materials.

The answer in bold is correct.

Regarding the curiosities, the teacher can put alerts about garbage and disposal as an example below:

Batteries are not allowed to be put in common trash because they are made of heavy metals that are toxic and harm the body. Undue discard, go back 3 squares.

With this, students can acquire concepts about sustainability, green chemistry at the time of the game, but they will only advance in it if they know the thematic areas addressed by the teacher. Leadership disputes can be a motivator for students, and this board game can be used as a tool and aid in their studies.

Conclusions

The proposed project was to develop a board game for teachers and students that assists in reviewing content on sustainability, green chemistry, and biodiversity. In this context, the game was applied as a tool to assist teachers in building a dynamic and versatile class through the formulation of questions about these topics in a playful way.

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