



Go Extinct! The Educational Game for Learning about Invertebrates

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Abstract

Educational games offer a multitude of advantages in the teaching process, including enhancing motivation, active learning, fostering collaboration, skill development, immediate feedback, practical application of knowledge, adaptability, stress reduction, promotion of creativity, memory improvement, and retention. These attributes render games as effective tools for engaging students, facilitating understanding and learning, as well as promoting both social and cognitive skills. Nevertheless, their effectiveness hinges on their seamless integration into the curriculum, along with a careful consideration of students' needs and age [1] [2]. In this study, we present an educational game entitled "Go Extinct!" designed to teach students about invertebrates. The game comprises a deck of 16 cards, each featuring illustrations of invertebrates from various taxonomic groups. At the outset, four cards are randomly distributed to each player. In each round, players discard one of their cards and pass it to the player on their right. The objective of the game is to extinguish an entire invertebrate group by collecting four cards from the same taxonomic category. The first player to achieve this and announce the invertebrate group's name wins the game. We implemented this game with 42 eighth-grade students (aged 11-12) who were studying biology in a high school in Spain as part of their invertebrate module. After the game, the students completed a [8] in which they assessed the activity and its impact on their learning. In terms of evaluating their learning, students rated their initial knowledge at 4.69 out of 10, which increased to 7.98 after the activity, indicating an improvement of 3.29 points. The game received high ratings, with 70% finding it very easy, 77% deeming it very useful, 67% describing it as highly attractive, and 81% considering it very interesting. Overall, the students rated the game at 9.1 out of 10. The results from this study seem to suggest that the educational game "Go Extinct!" effectively promotes the understanding of invertebrate groups among Spanish eighth-grade biology students. Additionally, it has positively influenced motivation, generated interest, and increased student participation. Building on these promising findings, our future plans include digitizing the game and subjecting it to evaluation using e-rubrics.

Keywords: Game-Based Learning, Invertebrates, Science Education

1. Introduction

Gaming-based learning, an educational paradigm leveraging games for learning facilitation, has garnered attention for its effectiveness in developing diverse skills, notably computational thinking [1]. Educational games confer numerous advantages to the teaching process, encompassing enhanced motivation, active learning, collaborative skills, proficiency development, immediate feedback, practical knowledge application, adaptability, stress reduction, creativity promotion, memory enhancement, and improved retention [2]. The efficacy of games as educational tools depends on their seamless integration into the curriculum and a careful consideration of students' needs and age [1] [2].

Recent reports, systematic reviews, and literature reviews have delved into motivation, engagement, and learning in games, providing valuable insights into their multifaceted impact [2] [3] [4] [5]. Gaming-based learning, rooted in the fusion of entertainment and learning, not only introduces novel entertainment experiences [4] but also utilizes a delivery mode often integrated with other pedagogical approaches [7]. Playing techniques, as demonstrated by Frank [6], inject realism and experiential learning into the classroom, facilitating critical evaluation of complex issues that demand moral and judgmental competencies. Moreover, game-based learning has been identified as a catalyst for intrinsic motivation, enjoyment, and emotional involvement, as emphasized by Gee [8].

The utilization of games for teaching sciences [9] [10], particularly biology [12] [13], holds significant importance and offers a plethora of benefits. Some examples include the board game presented by



Spiegel [11], which is based on learning by problem-solving, and educational card games designed to reinforce biological concepts compared to traditional teaching methods [14]. Games provide an immersive and interactive environment that not only captures students' attention but also fosters a deep understanding of complex biological concepts [1]. The dynamic nature of biological systems can be effectively simulated through games, allowing students to explore, experiment, and observe virtual ecosystems. This experiential learning enhances retention and application of biological knowledge, as students engage in problem-solving scenarios and make real-time decisions, mirroring the challenges faced by scientists in the field. Additionally, the gamified approach introduces an element of fun and excitement, contributing to increased motivation and enthusiasm for learning.

The combination of games and fictional characters can enhance learning outcomes. So, various authors have investigated the benefits of using fiction resources such as films, TV programmes, series, stories or novels to teach science [15]. These resources may help to create mental images that can be correlated with an underlying scientific theory, may help to understand abstract concepts, are very visual, fun, improve the applicability of the content learned or enhance the interest in learning science, amongst other advantages [16]. Thus, the bibliography shows some examples of how physics can be taught by posing interesting problem situations based on sequences from series or films, addressing the study of kinematics with *Game of Thrones* [15], dynamics with *Prison Break* [17] or optics with *Peppa Pig* [18]. In the field of chemistry, Torres and García [19] proposed workshops based on the films *Shutter Island* or *A Todo Gas*, or series such as *Bones*, to introduce chemistry concepts or show the importance of chemistry in our lives. Also in this subject, it has been proposed to explain the chemistry of special effects in film and television [20]. Using games containing cartoon characters familiar to students can help with this issue.

In the context of this study, we introduce an educational game titled "*Go Extinct!*" designed to impart knowledge about invertebrates, showcasing the potential of game-based learning in specific educational contexts.

2. Methodology

2.1. Participants

This study was conducted with 42 eighth-grade students (42.86% were girls, while 57.14% were boys, aged 11-12) who were studying biology in a high school in Spain as part of their invertebrate module.

The students had recently completed a module on invertebrates. This involved studying the taxonomic groups of invertebrates, their classification, and characteristics. They worked with various individuals in the laboratory and carried out identification activities as part of the learning process. This activity was presented as an application activity, so that students could apply their learning from the invertebrate module.

2.2. Game Description and Educational Goals

"*Go Extinct!*" is an educational card game depicting the different invertebrates. The game is played with 16 cards. Although four players is recommended, the game may be played by three or five players.

The educational aims for the students are:

- Identify invertebrate animals.
- Recognize different invertebrate individuals within the same taxonomic group.
- Reinforce knowledge about the various taxonomic groups of invertebrates.
- Identify to which taxonomic group different invertebrates belong.

A typical game takes 15–20 min.



Each card featuring illustrations of invertebrates from various taxonomic groups (Table 1). You may note that cartoons from the television series *SpongeBob SquarePants* were included to make certain taxonomic groups more relatable and engaging for the students.

Table 1. Cards, invertebrate and taxonomic groups

Card	Invertebrate	Taxonomic groups
Number 1	Squidward Tentacles (squid)	Mollusks
Number 2	Octopus	
Number 3	Clam	
Number 4	Gary (Snail)	
Number 5	Leech	Annelids
Number 6	Earthworm	
Number 7	Polychaete Worm	
Number 8	Tubifex Worm	Arthropods
Number 9	Mr. Krabs (Crab)	
Number 10	Spider	
Number 11	Ant	
Number 12	Millipede	Sponges
Number 13	SpongeBob (Sponge)	
Number 14	Bath Sponge (<i>Spongia sfficinals</i>)	
Number 15	Venus' Flower Basket (<i>Euplectella aspergillum</i>)	
Number 16	Freshwater sponge (<i>Spongilla lacustris</i>)	

*The groups can be extended with other cartoons such as Patrick Star (echinoderm).

2.3. Rules of the game

At the outset, four cards are randomly distributed to each player (Figure 1). In each round, players discard one of their cards and pass it to the player on their right. The objective of the game is to extinguish an entire invertebrate group by collecting four cards from the same taxonomic category. The first player to achieve this and announce the invertebrate group's name wins the game.



Figure 1. Student's card

Let's imagine a round of this game. At the outset, Player 1 is dealt cards featuring a starfish, a crab, an octopus, and a jellyfish. In the first round, Player 1 decides to discard the crab card and passes it to Player 2. In the next round, Player 1 receives a squid card and chooses to discard the jellyfish card, passing it to Player 3. Meanwhile, Player 2 receives the crab card and decides to discard the octopus card. The game progresses with players strategically exchanging cards, each aiming to collect four cards from the same taxonomic group. The first player to achieve this and announces the name of the invertebrate group becomes the winner of the game.

The teacher played a test game with the students in order. Afterwards, the students were able to play freely. The teacher acted as a guide, answering any questions that arose during the game.

2.4. Assessment of the educational value

After the game, the students completed a questionnaire [9] in which they assessed the activity and its impact on their learning. Survey assessing their learning and the activity. Students were asked to score the activity from 0 to 10 points, what they had learned from the game (With the game, I have learned...), perception of their knowledge a score of between 0 and 10 before and after the activity, and four qualities of the activity (simplicity, attractiveness, usefulness and interest) on a Likert scale (nothing, little, quiet, a lot).

For the qualitative data analysis, content analysis was performed to identify themes and recurrent patterns in students' open-ended responses regarding what they had learned from the game. For the quantitative data analysis, responses were tallied, and their mean was calculated.



3. Results

The students rated the Go Extint! with an average of 9.1 points out of 10. In addition, they rated their knowledge before the activity with 4.69 points on average, and after the activity, they considered that it improved their learning by 3.29 points out of 10.

The game received high ratings, with 70% finding it very easy, 77% deeming it very useful, 67% describing it as highly attractive, and 81% considering it very interesting. Overall, the students rated the game at 9.1 out of 10 (Figure 2).

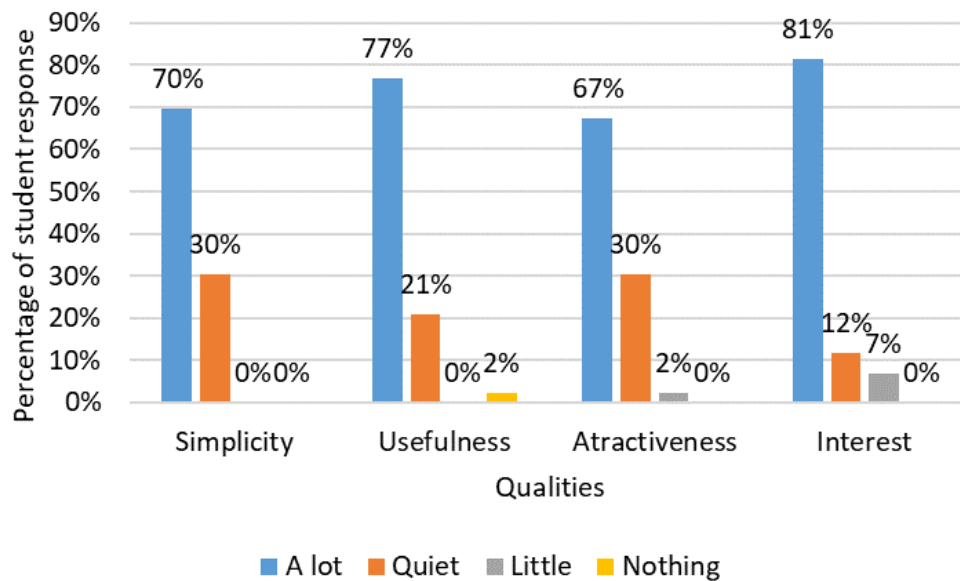


Figure 2. Students' assessment of the qualities of the activity.

The responses to "With the game, I have learned..." were categorized into three groups: Learning and Knowledge; Strategy and Competition; and Fun and Motivation.

The Learning and Knowledge category was the majority, comprising 47.62% of the responses (20 answers). Here, students express how the game has allowed them to acquire new knowledge about the classification and identification of invertebrates. Some examples include: "This game helped me better understand the classification of invertebrates." "I learned to identify different groups of invertebrates more quickly."

In the Fun and Motivation category, with 33.33% (14 responses), comments revolve around the enjoyable and motivational experience of the game. Students share how fun and intrinsic motivation have become catalysts for learning. Examples include: "It was amazing how the game reinforced my knowledge without me realizing it." "I learned that fun can be an excellent way to learn about biology."

Lastly, in the Strategy and Competition category, with 19.05% of the responses (8 answers), students highlight the importance of strategy and competition in the game. Examples include: "I discovered the importance of strategy in discarding and passing cards." "It was exciting to discover how strategies can change the course of the game."



4. Conclusions

The results from this study seem to suggest that the educational game “Go Extinct!” effectively promotes the understanding of invertebrate groups among Spanish eighth-grade biology students.

In conclusion, the outcomes of the student evaluations provide compelling evidence supporting the efficacy of the biology learning game. The high levels of satisfaction expressed by students, as evidenced by the impressive overall rating of 9.1 out of 10 for both the game, underscore the positive impact of incorporating gamified approaches into biology education. The substantial increase in perceived knowledge post-activity, along with favorable ratings for the game's ease of use, utility, attractiveness, and interest, highlights the potential of such educational initiatives to enhance both engagement and learning outcomes. These conclusions suggest that well-designed educational games have the capacity not only to capture students' interest but also to foster meaningful and effective learning experiences in the realm of biology education [4] [5].

The results of this study will be used for the digitisation of educational resources and the creation of mobile applications for the ecological transition.

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