To use virtual gamification through the *wordwall* platform in high school for understanding genetics and its relation to cancer

Uso da gamificação virtual por meio da plataforma *wordwall* no ensino médio para o conhecimento da genética e sua relação com o câncer

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ABSTRACT
Genetics-related topics are complex, and students often struggle to grasp them. Therefore, the use of educational games is recommended, as they incorporate methodologies that connect theoretical knowledge with playful elements. This study aimed to assess the contribution of a game created on the Wordwall platform to high school students' understanding of genetics and its relationship with cancer development. To achieve this, a questionnaire was administered, consisting of questions at basic, intermediate, and advanced levels, to assess students' prior knowledge of the subject matter. Following this, a lecture was delivered, explaining genetic concepts and processes while relating them to various malignant neoplasms. Subsequently, students were provided with a link to access the educational game via WhatsApp, using their smartphones. Those without electronic devices completed the virtual activity using school computer lab computers. After playing the game, an increase in the percentage of correct answers was observed at all three knowledge levels: basic knowledge increased by 43.85%, intermediate by 35.9%, and advanced by 43.3%. Participation in the interactive game facilitated a better understanding of the subject matter for students and encouraged skills such as logical reasoning, creativity, problem-solving, and socialization among peers.

Keywords: knowledge, education, genetics, cancer, games.

RESUMO
As temáticas referentes à Genética são complexas e os educandos têm dificuldade em aprendê-las, logo, a aplicação de games didáticos é recomendável, já consistem em metodologias que associam os conhecimentos teóricos a aspectos lúdicos. Objetivou verificar a contribuição do game criado na plataforma wordwall para os estudantes do ensino médio sobre o conhecimento da genética e sua relação com o desenvolvimento do câncer. Para isso, foi aplicado um questionário dividido em questões de conhecimento básico, intermediário e avançado para avaliar o conhecimento prévio dos estudantes, em relação à temática a ser trabalhada. Posteriormente, realizou-se uma palestra, expondo os conceitos e processos de genética relacionando-os as diversas neoplasias malignas. Em seguida, foi disponibilizado aos estudantes, através do Whatsapp, o link de acesso ao jogo didático, utilizando seus smartphone. Aqueles sem acesso a aparelhos eletrônicos realizaram a atividade virtual utilizando os computadores do laboratório da informática da escola. Após realização do game, identificou-se aumento na porcentagem de acertos nos três níveis de conhecimento. No básico, aumentou 43,85%, no intermediário 35,9% e no avançado, 43,3%. A participação no game interativo propiciou aos alunos uma melhor compreensão sobre a temática e estimulou habilidades como raciocínio lógico, criatividade, resolução de problemas e socialização com os estudantes.

Palavras-chave: conhecimento, ensino, genética, câncer, jogos.
1 INTRODUCTION

The teaching and learning process of Genetics presents obstacles due to the complexity of the subject matter. Traditional teaching practices used in this discipline are often inefficient because they struggle to bridge the gap between molecular phenomena and everyday experiences (SILVA, 2022). However, applications of this field of science are frequently addressed in various contexts in the media (BRITO, 2018), with cancer being a prominent example. Genetic analysis plays a crucial role in identifying gene mutations associated with the disease, and when combined with screening practices promoted in awareness campaigns, it facilitates prevention and early diagnosis (CAETANO; SANTOS; ORSOLIN, 2022).

Nevertheless, despite the potential for contextualizing these approaches with Genetics content, students still find them among the most challenging to grasp (SILVA, 2021). These difficulties are linked to the teaching methodologies applied and the biological processes studied in this field of science. Furthermore, this issue was exacerbated during the COVID-19 pandemic, as the implementation of emergency remote teaching worsened students' educational deficits (GROSSI et al., 2020).

In this context, to overcome these challenges, Filho and Schröter (2018) emphasize the need for educators to make lessons more relevant to students' lives. Therefore, the use of different pedagogical strategies becomes essential to promote contextualized learning, creativity, and student socialization (LOVATO et al., 2018). These strategies correspond to active methodologies, which are alternative teaching methods for approaching content and aim to empower students by encouraging them to be autonomous and critical in the knowledge acquisition process (NOVAES et al., 2021). Examples of such methodologies include problem-based learning, case studies, debates, simulations, and the use of educational games (SANTOS et al., 2021).

According to Carvalho et al. (2021), educational games are important tools for expanding knowledge as they blend educational and playful aspects. In this context, the relevance of gamification is highlighted, which applies typical gaming characteristics in real-world contexts (MURR; FERRARI, 2020). Therefore, as noted by Amaral and
Pigatto (2022), gamification can be a strategy to encourage the learning of challenging content, such as Genetics.

However, integrating gamification into the educational process is viable because this methodology piques students’ interest by making classes more dynamic. Furthermore, it is crucial to contextualize theoretical concepts with situations observed by students in their daily lives to stimulate knowledge acquisition. Regarding genetics, it is possible to associate it with the development of cancer, for instance, given that this theme is prevalent in the media and awareness campaigns. In this context, the present study The objective was to assess the contribution of the game created on the Wordwall platform to high school students' understanding of genetics and its relationship with the development of cancer.

2 METHODOLOGY

This study was conducted in a regular high school within the public education system located in the interior of the state of Minas Gerais, Brazil. In this context, the research was carried out at a peripheral educational institution that primarily serves students from low-income families residing in suburban or rural areas. The project was presented to all students enrolled in the high school classes at the school, and 90 of them agreed to participate in the research. The participants’ profile for this study was determined based on data obtained from school records, indicating that they are between 14, 15, 16, 17 and 18 years of age (Graph 1) and reside in urban areas.

The Wordwall platform was used to create a customized gamified activity (MIRANDA, 2020), which took the form of a virtual maze chase game (Figure 1). This game consisted of ten multiple-choice questions addressing fundamental concepts and processes in genetics, the impact of gene mutations on cancer development, genetic factors that contribute to the prevention and early diagnosis of the disease, as well as awareness campaigns.
To assess the contextualized learning of students regarding the content of genetics and cancer development, two types of questionnaires were employed: pre- and post-quiz: This individual questionnaire consisted of seven multiple-choice questions and was administered both before and after the execution of the quiz. The purpose was to evaluate the students' understanding of genetics and its connection to cancer before and after engaging with the quiz; post-game questionnaire: After completing the game, another questionnaire was administered to assess the influence of the game on learning. This questionnaire included four multiple-choice questions designed to investigate the motivation and interest of the students in the content as a result of the active methodology used. These questionnaires allowed for a comprehensive evaluation of how the game-based learning approach impacted students' comprehension and engagement with the topics of genetics and its relationship with cancer development.

The game was developed on the Wordwall platform, and the chosen game model included a 2-minute countdown timer for the player to navigate their character to the area corresponding to the correct answer while avoiding adversaries within the maze. Additionally, the game featured other interactive elements, such as the number of lives, difficulty levels, final scores, and a leaderboard displaying the top ten results. This
approach aligns with the perspective of Junior et al. (2022), where the application of such strategies in teaching fosters student autonomy in seeking knowledge.

In this context, the procedure unfolded as follows: Pre-Assessment Questionnaire: Initially, a questionnaire was administered to assess the prior knowledge of high school students regarding the topic. Lecture: A lecture was conducted, presenting genetic concepts and processes while linking them to the development of malignant neoplasms. Game Access: Students were provided with a link to access the educational game through WhatsApp. They could open and play the game on their smartphones. Students without access to electronic devices used the computers in the school’s computer lab to complete the virtual activity. Post-Assessment Questionnaire: After the game activity, a post-assessment questionnaire was administered, along with a questionnaire to assess the influence of the game on learning. This allowed for the evaluation of both the acquired knowledge and the students’ perspective on the use of the game.

This structured procedure aimed to gauge the effectiveness of the game-based learning approach in enhancing students' understanding of genetics and its connection to cancer, as well as their motivation and interest in the subject matter.

After data collection, the data were analyzed descriptively using the statistical software SPSS. The project was submitted and approved by the Research Ethics Committee of the State University of Montes Claros. To ensure the safety of research participants, anonymity and confidentiality were maintained.

3 RESULTS AND DISCUSSION

The primary objective of the gamified educational product is to encourage learning through the contextualization of the content covered in textbooks and the information disseminated in the media (AMARAL; PIGATTO, 2022). Therefore, concerning the teaching of Genetics, it is possible to relate its concepts to various everyday approaches to stimulate students' interest and facilitate the assimilation of knowledge.

The students demonstrated a great deal of interest in the topic by asking various questions and relating the subject matter to their family experiences, sharing personal
stories about cancer diagnoses within their families, treatment procedures, and prospects for curing the disease. During the game's execution, the students showed enthusiasm for the challenges presented in the activity, as they had to navigate the character to the correct answers. To do this, they needed to choose the best path and avoid the enemies along the way. Additionally, there was noticeable increased social interaction among them because they wanted to achieve a higher final score, leading to discussions about the content to understand the correct answers.

In relation to errors and successes by levels of knowledge, it was noticed that the game promoted knowledge, since the average of correct answers for the three levels of knowledge increased after application of the game (Table 1).

Table 1: Average of students’ correct answers before and after application of the game for basic, intermediate and advanced levels of knowledge.

<table>
<thead>
<tr>
<th>Level of Knowledge</th>
<th>Average</th>
<th>Variance</th>
<th>After the game</th>
<th>Before the game</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic knowledge</td>
<td></td>
<td></td>
<td>5.20</td>
<td>10.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.20</td>
<td>0.16</td>
</tr>
<tr>
<td>Intermediate knowledge</td>
<td></td>
<td></td>
<td>5.50</td>
<td>9.40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.83</td>
<td>0.30</td>
</tr>
<tr>
<td>Advanced knowledge</td>
<td></td>
<td></td>
<td>4.92</td>
<td>9.37</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.83</td>
<td>0.30</td>
</tr>
</tbody>
</table>

Source: Autor (2023)

Regarding basic knowledge, which includes questions related to the definition of basic genetic concepts and processes, the students initially had a higher percentage of errors before playing the game, which was 51.1%. This decreased to 7.25% after they had access to the game (Graph 1). Consequently, the percentage of correct answers increased from 48.9% to 92.75%, with a 43.85% increase in the average of correctly answered questions.
Graph 1: Percentages of errors and correct answers by students before and after the game application in three levels of genetics knowledge: basic, intermediate, and advanced.

The data above demonstrates the positive impact of the methodology used in the learning process, as it positively influenced the assimilation of knowledge by the students, as also observed in the research conducted by Santos et al. (2021), where they used questionnaires to assess knowledge before and after the application of active teaching methods. They found the effectiveness of these teaching tools due to improved student performance and their motivation to participate in the proposed activities, actively contributing to the construction of knowledge.

Regarding intermediate knowledge, which involves contextualized questions about genetic concepts related to oncogenesis, initially, there were similar percentages of errors and correct answers, namely 49.97% and 50.03%, respectively. However, after the game's application, the percentage of errors decreased to 14.07%, while the percentage of correct answers increased to 85.93%. In this context, there is a study conducted by Carvalho et al. (2021) that demonstrates the contribution of an educational game in
acquiring knowledge of genetics by linking theoretical concepts with practical aspects easily identifiable in students' daily lives. They concluded that participation in the game improved students’ understanding of the presented content, enabling contextualized learning rather than mere memorization. Therefore, this conclusion reaffirms the results obtained in the present study, as there was a 35.9% increase in correct answers to contextualized questions after the implementation of the gamified product.

Regarding advanced knowledge, which encompasses more in-depth questions about cancer incidence, the pre-game survey revealed a high error rate of 56.7%, while the percentage of correct answers was 43.3%. However, after using gamification as a teaching tool, there was a 40% increase in the percentage of correct answers to advanced-level questions. The rate of correctly answered questions rose to 83.3%, and the error rate decreased to 16.4%. According to Barbosa et al. (2020), the use of gamified activities enhances learning and provides interactive teaching by contextualizing game elements with the content being taught. Therefore, the results obtained align with this analysis, as there was a considerable improvement in students' performance due to the methodology used. The percentage of correct answers to questions related to the three levels of genetics knowledge was significantly higher after the quiz's implementation.

However, the evaluation was not limited solely to the acquired learning; the students' perspectives on the game were also considered, as presented in (Table 2). The results obtained from the questionnaire assessing the game's influence on the learning process show that, for 89 students (98.90%), the methodology used facilitated the contextualization of mutations with the development of various types of malignancies. Concerning the association of genetic analyses with early cancer diagnosis, 84 respondents (93.30%) stated that the game enabled this aspect of learning. As for motivation to understand genetic processes and socialization with peers, 85 (94.4%) and 87 (96.6%) of the students, respectively, expressed positive opinions on these aspects.
Table 2: Influence of the interactive quiz on students' knowledge

<table>
<thead>
<tr>
<th>Aspects Evaluated</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contextualize mutations with cancer development</td>
<td>98.90%</td>
<td>1.10%</td>
</tr>
<tr>
<td>Associate genetic analyses with early cancer diagnosis</td>
<td>93.30%</td>
<td>6.70%</td>
</tr>
<tr>
<td>Motivate understanding of genetic processes</td>
<td>94.40%</td>
<td>5.60%</td>
</tr>
<tr>
<td>Facilitate socialization with other peers</td>
<td>96.60%</td>
<td>3.40%</td>
</tr>
</tbody>
</table>

Source: Autor (2023)

The results obtained from the questionnaire assessing the game’s influence on the learning process show that, for 89 students (98.90%), the methodology used favored the contextualization of mutations with the development of various types of malignancies. Regarding the association of genetic analyses with early cancer diagnosis, 84 respondents (93.30%) stated that the game enabled this aspect of learning. As for motivation to understand genetic processes and socialization with peers, 85 (94.4%) and 87 (96.6%) of the students, respectively, expressed positive opinions on these aspects. Silva (2022) asserts that genetics content is considered complex by students as it involves microscopic structures and processes. Therefore, it becomes essential to bridge the theoretical foundation with their consolidated experiences (SANTOS et al., 2020). Building on this, Lovato et al. (2018) propose an educational board game related to genes and emphasize that the use of different teaching resources, combined with contextualized learning, promotes both intellectual and emotional development in students. Therefore, the collected data reinforce this perspective since, for the majority of respondents, the application of the interactive quiz allowed for the contextualization of genetic concepts with everyday approaches related to cancer incidence and promoted group socialization.

The study conducted by Esquivel (2017) reinforces the importance of incorporating gamification in the school environment, given the interest of basic education students in games and the potential of game elements to motivate the pursuit of knowledge. Silva and Sales (2017) also highlight the contributions of this methodological approach regarding student engagement in seeking knowledge, as it introduces challenges during activities, and the teacher acts as a facilitator, encouraging discussions. Therefore, the results obtained by these authors correlate with the percentage...
of participants in the present study who stated that the quiz contributed to motivating them in the learning process.

However, both Silva and Sales (2017) and Carvalho et al. (2021) emphasize that introducing gamification in the classroom can be challenging because conducting these activities requires more planning time, and often, teachers may lack the preparedness to use active methodologies in the teaching process. Therefore, considering the potential of these methods, the best strategy for learning about them is to actually use them in order to diversify lessons and stimulate learning by leveraging the interactive resources present in games, for instance.

Therefore, the use of gamification can assist in students' learning by introducing elements typical of games into the methodology with which they are familiar. This leads to more dynamic lessons that motivate the pursuit of knowledge and can enhance students' performance. Furthermore, it is evident that associating the taught content with everyday applications through contextualized learning is a strategy that contributes to enhancing the teaching and learning process.

4 CONCLUSIONS

In summary, the results of this study highlight the effectiveness of virtual gamification, through the Wordwall platform, as a powerful strategy for enhancing the learning of genetic concepts, especially in a context where students often find this topic complex and challenging. The data shows that the introduction of gaming elements in classes motivated students to seek knowledge in a more engaged manner.

Furthermore, gamification allowed for the contextualization of genetic concepts with real-world situations, such as cancer incidence, making learning more relevant and practical for students. It also promoted socialization among students, encouraging discussions and collaboration during activities.

These results reflect the potential of gamification as a valuable tool in education, especially when it comes to complex topics. However, it's important to acknowledge that implementing gamification can be challenging for educators, requiring more planning and
preparation. Therefore, it's essential that teachers are willing to explore new methodologies to enrich the teaching and learning process.

Ultimately, this study underscores the importance of incorporating innovative approaches like gamification into education to create more dynamic and motivating classes that inspire students to actively and engagingly seek knowledge. Further research is expected to deepen our understanding of the effective use of games in education, exploring various educational perspectives and possibilities.
REFERENCES


