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Gamification in Immunization Education: Conception and Development of *Imunodefense* Digital Game

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ABSTRACT: Objective: To report the Development and application of the educational digital game ImunoDefense as a pedagogical tool for teaching immunology, focusing on immunization. Methods: A qualitative study of the experience report typo, developed by students of the Nursing course at the Universidade Estadual do Tocantins. The game was created using Canva and Genially, consisting of a digital board with 20 questions about immunization. For the didactic application, the group of students responsible for creating the game organized themselves internally into subgroups with specific functions: content, technical support, pedagogical mediation, and logistics. Results: The application of the game promoted participant engagement, greater interaction among colleagues, and content covered. The gamified dynamic stimulated prior review of the topics, both by the developers and by the other students. The simulation of clinical situations facilitated the practical contextualization of immunology. Although without formal quantitative evaluation, the reports indicated improved performance in subsequent assessments. Conclusion: ImunoDefense presents itself as an accessible and innovative pedagogical alternative for health Education. Its replication and systematic evaluation in diverse contexts are recommended to measure its educational impact.

KEYWORDS: Educational games, Immunology; Gamification; Active methodologies; Education.

INTRODUCTION

Teaching immunology in nursing Education

Nursing education, as established by the National Curriculum Guidelines (DCN), places the student at the center of their own educational process, promoting a participatory and self-directed approach. Future professionals are expected to acquire not only technical and scientific skills, but also develop ethical and humanistic capacities, adopting a reflective and transformative stance. (Brasil, Ministério da Educação, 2001).

In this context, several innovative pedagogical approaches, aligned with the demands of the digital age and new educational possibilities, are emerging. These strategies seek to transform the teaching-learning process, making it more dynamic and effective. Among the technological resources that have gained prominence in this scenario, digital educational games stand out, as they are interactive tools that provide a unique approach to teaching, combining playful elements with pedagogical content. (Barcelos, Costa & Santos, 2025).

In the basic cycle of health education, the discipline of Immunology occupies a central place, dedicated to the study of the body's defense mechanisms against infectious agents. According to Abbas, Lichtman & Pillai (2023), this area of knowledge investigates the complex biological processes that confer protection to the host against pathogens. In this context, immunization stands out as a fundamental strategy for preventing diseases, being widely used through vaccination.

Immunization through vaccines is one of the greatest achievements of modern medicine, playing a fundamental role in the prevention and eradication of communicable diseases worldwide. Furthermore, vaccination not only protects vaccinated individuals but also promotes herd

immunity, reducing the spread of the pathogen in the community (Junior et al., 2024). The study of immunological principles and vaccine mechanisms is especially urgent in the current scenario, marked by the spread of misinformation and the strengthening of anti-vaccination movements, a phenomenon that gained notoriety during the COVID-19 response campaigns (De Oliveira & Valente, 2024). To overcome these educational challenges, it is essential to adopt innovative methodologies that translate scientific knowledge about vaccination into accessible and engaging formats (De Oliveira & Valente, 2024).

In the current landscape of health education, digital educational games are emerging as strategic tools, as they integrate scientific accuracy with a playful and accessible approach, facilitating the dissemination of knowledge (Dias et al., 2023; De Oliveira & Valente, 2024). These innovative resources transform learning into a hands-on, personalized experience, fostering greater engagement and interaction between educators and students (Ferroni et al., 2024)

Considering the potential of active methodologies in developing practical and cognitive skills essential to professional training, this study aimed to develop the digital educational game, ImunoDefense, which integrates playful and investigative elements. The proposal aims to facilitate the understanding of immunological principles and different immunization mechanisms through an interactive and accessible approach, promoting the active construction of knowledge.

Active Methodologies

Active methodologies represent a contemporary pedagogical approach that redefines the educational process, placing the student as the protagonist of their own learning. Based on the principle of action-reflection-action, these strategies promote active student engagement, encouraging them to mobilize their prior knowledge to solve complex problems in social reality. (Campos, 2025).

These approaches surpass the traditional model of vertical knowledge transmission, favoring the autonomous and collaborative construction of knowledge. Among the various applicable techniques, problem-based learning (PBL), the flipped classroom, and gamification stand out, sharing the common goal of developing cognitive and socio-emotional skills in students (Pereira et al., 2024).

Immunization

Immunization is the process by which an individual becomes protected against a disease; that is, the process by which the individual becomes immune to a specific antigen. These antigens are all agents that are foreign or unknown to the individual's body—such as viruses, bacteria, protozoa, and others—that bind to specific receptors on lymphocytes, triggering an immune response and causing a disorder in the organism (Abbas, Lichtman & Pillai, 2023). Immunology is the science responsible for studying the mechanisms that govern the immunization process in organisms; that is, it is an experimental science that studies the immune system of individuals both in equilibrium and its role in the development of diseases (Sousa, 2020; Vilanova, 2020).

The immune system is responsible for recognizing and fighting off these agents, regardless of the consequences this response may have on the individual, thus conferring immunity (Abbas, Lichtman & Pillai, 2023; De Lima, De Morais & Oliveira, 2022). Thus, the immune system acts in maintaining the body's homeostasis through appropriate immune responses, that is, reactions generated from the recognition of pathogens or defective/altered structures, as well as the manifestation of inflammation and tolerance to agents that are either internal or external to the body (Abbas, Lichtman & Pillai, 2023; Sousa, 2020). This system is composed of complex mechanisms, divided into two defense fronts: the innate immune system and the adaptive or acquired immune system (Abbas, Lichtman & Pillai, 2023; Sousa, 2020).

The innate immune system, also called natural immunity, represents the body's first response to a threat. Present from birth, it responds rapidly and without specificity, relying on monocytes and dendritic cells to detect and eliminate threats. These cells can engulf microbes or present their fragments to adaptive immune cells, triggering a more targeted response (Abbas, Lichtman & Pillai, 2023; Sousa, 2020).

Adaptive immunity, on the other hand, is activated when innate mechanisms are insufficient. It involves T and B lymphocytes, which recognize specific antigens. B lymphocytes produce antibodies and give rise to immunological memory cells, while T lymphocytes are divided into two major classes: CD4+ T cells, which coordinate the immune response through cytokines, and CD8+ T cells, which have cytotoxic action on infected cells (Abbas, Lichtman & Pillai, 2023; Sousa, 2020).

When exposed to an antigen, either by vaccination or naturally, B lymphocytes become sensitized and form plasma cells that produce antibodies, as well as memory B cells; this is the primary immune response. In subsequent exposures to the antigen, the memory cells generated in the primary response rapidly identify the invader; this is called the secondary immune response (Abbas, Lichtman & Pillai, 2023; Chagas et al., 2019; Sousa, 2020). Therefore, in a secondary exposure, the fight against any substance is carried out through the body's defense mechanisms, antibodies (immunoglobulins), which are capable of signaling these specific antigens so that phagocytic cells destroy them or disable the functioning of these molecules foreign to the body, thus conferring immunity (Abbas, Lichtman & Pillai, 2023; Sousa, 2020).

Protective immunity can be provided by exposing the host to microorganisms, which is mediated by the action of immune system cells (T lymphocytes), called active immunization. In this immunization, the individual produces their own antibodies after previous contact with the antigen, thus developing immunological memory through memory T cells. Therefore, by developing memory, it constitutes a more lasting immunization, which may or may not be permanent, but in case of other exposures, a faster response is possible (Abbas, Lichtman & Pillai, 2023; Chagas et al., 2019). Active immunization can occur naturally through exposure or contact, as well as artificially through vaccination, which simulates natural infection and provides protection against diseases (Abbas, Lichtman & Pillai, 2023; Chagas et al., 2019; De Lima, De Morais & Oliveira, 2022).

On the other hand, immunization can also occur passively, when ready-made antibodies are transferred to the body without it needing to activate its own immune response. This method is used, for example, in emergency situations or when immediate protection is desired. It can also occur artificially, such as through the administration of serums containing specific antibodies, used against toxins or poisons (Abbas, Lichtman & Pillai, 2023; Delves, 2018), or naturally, through the transfer of antibodies from mother to fetus via the placenta, or to the newborn during breastfeeding (Abbas, Lichtman & Pillai, 2023; Vojtek et al., 2018). Unlike the active response, this one does not generate immunological memory and, therefore, its protection is temporary.

Vaccination consists of administering an infectious agent or a component of a microorganism in its dead or attenuated form (with its virulence reduced), which does not cause the disease, maintaining its immunogenic characteristics, but promotes an immune response providing protection or resistance against infection by the live pathogenic microorganism (Abbas, Lichtman & Pillai, 2023; Delves, 2018; Vilanova, 2020). It is more efficient when the infectious agent does not regularly undergo antigenic variations and functions as a strategy to prevent infections (Abbas, Lichtman & Pillai, 2023; Delves, 2018). There are different types of vaccines, some of which are shown in Table 1; however, two types prevail: attenuated and inactivated (Chagas et al., 2019). Vaccines are composed of two parts: a specific antigen and excipients, which are usually adjuvants. Adjuvants – such as alum – are characterized as substances that have the ability to intensify/potentiate the T-cell independent immune response and determine different responses (Chagas et al., 2019; Vilanova, 2020).

Attenuated vaccines offer enormous benefits because pathogenic microorganisms induce many innate and adaptive immune responses, making them the ideal way to induce protective immunity. These are produced from modified live microorganisms, meaning the microorganism is alive but with its ability to cause disease diminished (Chagas et al., 2019; Delves, 2018; De Lima, De Morais & Oliveira, 2022). Inactivated vaccines, on the other hand, are usually produced from whole dead viruses or bacteria or parts thereof. Such vaccines may only induce short-term protection – for example, current flu vaccines – and generally require more than one dose to prevent outbreaks of pathogen reproduction and greater consequences for the individual's body (Abbas, Lichtman & Pillai, 2023; Chagas et al., 2019).

Table 1. Vaccination Approaches.

Types of vaccines	**Examples**
Live attenuated or Dead bacteria	Bacilo de Calmett-Guérin, cólera
Live attenuated or killed viroses	Pólio, influenza, raiva
Subunit (antigen) vaccines	Toxoide tetânico, toxoide diftérico
Conjugate vaccines	Haemophilus influenzae, pneumococos
Viral vectors	Clinical trials with the spike protein of SARS-CoV-2 human produced by human and chimpanzee adenoviral vectors
Vaccines of messenger RNA	Aprovadas para a covid-19

Organized by the author, examples of vaccines in use (Abbas, Lichtman & Pillai, 2023).

Vaccination is the most important form of immunization for the prevention of epidemiological diseases, and it can also be used as a therapy (Brazil, Ministry of Health 2025; Vilanova, 2020). In Brazil, the vaccination policy for the Brazilian population is coordinated by the National Immunization Program (PNI) since 1973. The PNI establishes and makes available the National Vaccination Calendar, defining the vaccines indicated for each age period and specific group of individuals, in addition to making them available free of charge through the Unified Health System – SUS (Brazil, Ministry of Health, 2025). Despite this, the growth of anti-vaccine movements in the country contributes to the spread of false information, greater misinformation among the population, and a decrease in the demand for vaccination services in the country, especially regarding vaccination against COVID-19 (De Oliveira & Valente, 2024; Vilanova, 2020).

Given this and considering the complexity of the immunization process and the different biological mechanisms involved, the relevance of using active methodologies, such as games, in the teaching process about immunization is observed, in order to facilitate understanding of the subject (De Oliveira & Valente, 2024).

METHODS

The game was developed as a partial assessment requirement for the Immunology course in the Nursing program at the State University of Tocantins, Augustinópolis campus. It was built in accordance with DCN guidelines for theoretical-practical subjects. The online board game was built with relevant questions about immunization, distributed in squares on the board, causing players to move around the board correctly answering the questions about immunization.

To assemble the game, two main tools were used: Canva and Genially. With these tools, the board design, characters, dynamic responses, feedback, and other graphic details were created in Canva. In Genially, all the visual and structural resources created in Canva were organized to give structure to the game and make it interactive.

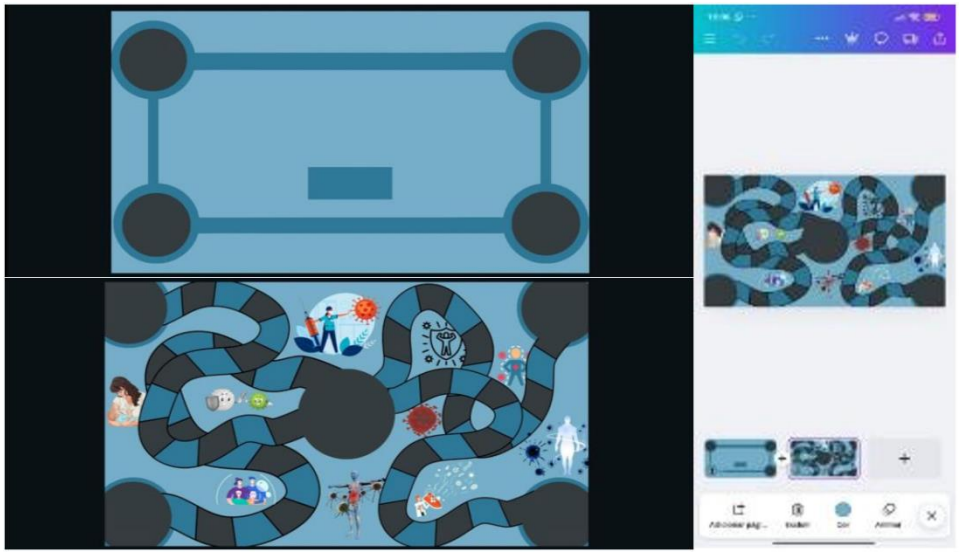

Figure 1. Stage of development of the graphical interface of the ImunoDefense game. The image represents the visual creation process of the game board, developed on the Canva platform. This stage was essential to structure an attractive and functional interface.

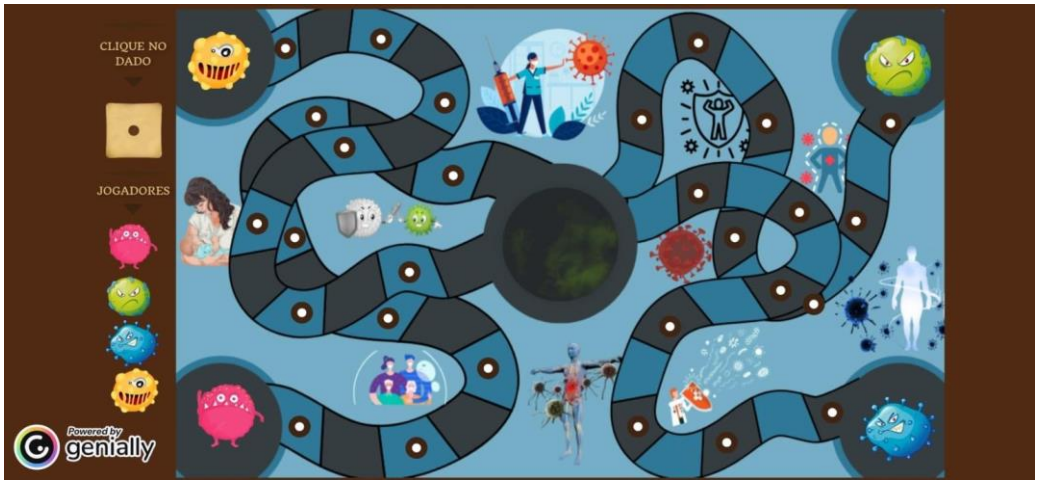

Figure 2. Initial screen of the digital game ImunoDefense. The image shows the interactive layout presented to the player at the beginning of the activity. On this screen, students can choose their personalized avatars and use the virtual die for the game's dynamics.

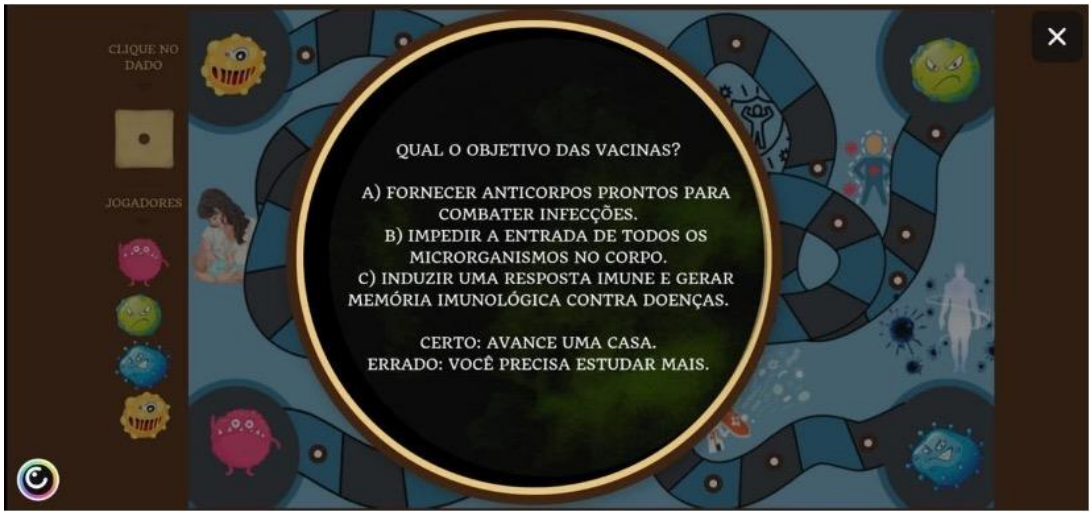

Figure 3. Example of a question presented in the ImunoDefense game. The image shows how the questions are displayed to the player during the activity. The game predominantly uses multiple-choice questions, but also includes some open-ended questions, encouraging reflection and the construction of one's own answers. The content covers fundamentals topics in immunology, such as types of immunity, how vaccines work, and the role of immune system cells.

The game features 4 characters and consists of 20 questions, which are the heart of the game, all with three possible answers (A, B, and C), divided among the green, yellow, blue, and pink players. Below are the questions followed by their correct answers.

Questions from the green character:

1) What is the role of the immune system in the immunization process? A: To identify and destroy infectious agents.

2) Which organs of the human body participate directly in the immune response after vaccination?

A: Lymph nodes, bone marrow, and spleen.

3) Why is it important to continue vaccinating against diseases that are already controlled?

A: To prevent outbreaks and the reintroduction of viruses or bacteria into the population.

4) How does the body "learn" to fight a pathogen after vaccination?

A: Vaccination presents an attenuated version or fragments of the pathogen, teaching the immune system to recognize it.

5) Why is the simultaneous administration of measles and yellow fever vaccines not recommended in children under 2 years of age?

A: Because the immune response may be reduced due to interference between the attenuated viruses of the two vaccines.

Questions from the blue character:

1) What factors can influence the body's response to a vaccine? A: Age, health status, and genetic conditions.

2) Why does active immunization generate a longer-lasting immune response than passive immunization?

A: Because it stimulates the production of memory cells, ensuring a rapid response in future exposures.

3) What differentiates an attenuated vaccine from an inactivated vaccine?

A: The vaccine contains the live, but weakened, pathogen, while the inactivated vaccine contains the dead pathogen.

4) How do vaccines contribute to herd immunity?

A: By immunizing a large part of the population, they reduce the transmission of the disease.

5) Why can some vaccines cause mild side effects, such as fever and pain at the injection site?

A: Because activation of the immune system can generate a temporary and local defense response.

Questions from the yellow character

1) What components can be present in a vaccine? A: Dead or weakened viruses or bacteria, or fragments of them.

2) Why do inactivated vaccines require booster doses?

A: Because immune system cells need multiple stimuli to generate lasting memory.

3) What is the difference between active and passive immunization?

A: Passive immunity provides ready-made antibodies, while active immunity stimulates the body to produce antibodies.

4) What is the function or functions of T lymphocytes?

A: They activate other cells of the immune system, destroy infected cells, and regulate the immune response to prevent exaggerated reactions.

5) How do the adjuvants present in some vaccines help in the immune response?

A: They increase the immune system's response to the vaccine antigen.

Questions from the pink character:

1) Which of the following options represents an example of passive immunization?

A: Transfer of antibodies from mother to baby through breast milk

2) In a previously vaccinated patient, the immune response against a pathogen occurs more quickly and efficiently due to the activation of which cells?

A: Memory B and T cells, which have already been sensitized by the vaccine antigen.

3) What is the purpose of vaccines?

A: To induce an immune response and generate immunological memory against diseases.

4) What is the function or functions of B lymphocytes?

A: To produce antibodies that bind to pathogens, neutralize them or marking them for destruction by other cells of the immune system.

5) According to the National Immunization Program (PNI) vaccination schedule, what is the recommended age for the first dose of the MMR vaccine (measles, mumps, and rubella)?

A: 12 months

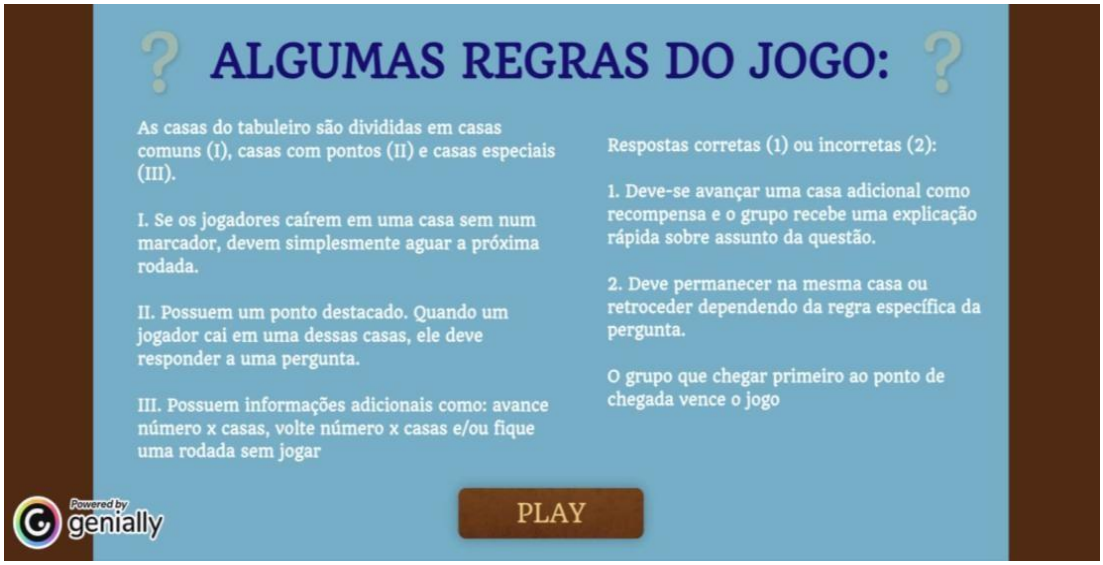

Figure 4. Screenshot of the ImunoDefense game rules. The image shows the set of guidelines that guide the player during the activity. The rules explain the game's dynamics and the criteria for movement on the board.

Rules of the digital educational game ImmunoDefense

The spaces on the board are divided into common spaces (I), spaces with points (II), and special spaces (III).

I. If players land in a space without a marker, they must simply wait for the next round.

II. They have a highlighted point. When a player lands on one of these spaces, they must answer a question.

III. They have additional information such as: advance of spaces, go back x spaces, and/or miss a turn.

Players may land on spaces that do not have questions but rather other information such as: "Study more about the topic," "Congratulations! You have developed immunological memory," "Too bad! Go back two spaces," "You have received all your vaccines. Advance!", "You have spread fake news!"

Correct (1) or incorrect (2) answers:

1. One additional space must be advanced as a reward, and the group receives a quick explanation about the subject of the question.

2. Must remain in the same space or go back depending on the specific rule of the question.

The group that reaches the finish point first wins the game.

Game presentation in the classroom

The didactic demonstration of the game was organized through a strategic division of functions among the academic developers. The team was distributed into four functional groups with specific assignments:

1. Content group: composed of two students responsible for the theoretical exposition on immunization and the conceptual presentation of the game.
2. Technical support group: formed by four students in charge of providing individualized assistance to players, answering questions about the interface and mechanics of the game.
3. Pedagogical mediation group: consisting of four other university students who were responsible for justifying the game's answers, deepening the immunological concepts involved.
4. Logistics group: the remaining participants dedicated themselves to organizing the technological resources and the physical structuring of the environment for the playful activity.

RESULTS

Application of the game in the classroom

The game in question involved the participation of 25 students from the Nursing Course at the State University of Tocantins - Augustinópolis Campus. The students were divided into smaller groups, methodically organized by the student developers of the game (Figure 5).

Figure 5. Records of the game application in the classroom. A. Group of students who developed the game. B-C. Record of the explanation of the game's functionalities by the content group. D. Groups of students who actively participated in the game.

The game application began with a brief explanation of the subject and the game by the content group. The academics asked the participants to divide into groups of approximately 6 students, to improve dynamics, organization, and participation of all the academics present. Then, each group chose one of the characters (pink, yellow, green, or blue) (Figure 5).

The members of the pedagogical mediation and technical support group were responsible for individually assisting each group participating in the game. Subsequently, the activity continued with the game being played (Figure 5). Through the application of the game, it was observed that students need to interact to formulate answers, and the game also provided greater discussion and reflection on the topic studied, contributing significantly to the development of knowledge and the exchange of experiences.

Furthermore, doubts were observed in the students' speech and responses. However, students did not finish the game without resolving them, as they were addressed by the pedagogical mediation group, allowing the students to answer the proposed questions. Therefore, the experience was enriching, with significant learning, both for participating students and for the game developers.

The use of active methodologies in teaching has been widely discussed as a strategy to promote meaningful learning, student autonomy, and the development of critical skills. In this context, the application of the ImunoDefense game in a higher education class in Nursing demonstrated relevant potential as an innovative pedagogical tool for teaching immunology.

Authors highlight that pedagogical strategies based on games favor active learning. In addition, the use of educational games can contribute to reducing traditional barriers in the teaching-learning process (Carvalho et al., 2018; Campbell, 2025; Ferroni et al., 2024). The use of games promotes greater engagement and robust discussions among academics when using the game in the classroom, being more effective for participation and different educational experiences among students (Carvalho et al., 2018; Campbell, 2025)

The proposal also has the potential to be incorporated into university extension activities, allowing adaptation of the language and dynamics for audiences outside the university. Its effectiveness as a health education tool extends its reach, supporting community health by spreading essential information on the immune system and vaccines.

Final Considerations

The implementation of the ImunoDefense Digital Educational Game in the academic environment demonstrated the effectiveness of innovative pedagogical approaches, particularly gamification, in the teaching-learning process about immunology. This playful tool demonstrated the ability to transcend the barriers of the conventional educational paradigm, providing a more interactive, meaningful, and contextualized learning experience.

The gamified resource proved particularly efficient in assimilating complex immunological concepts, such as immune response mechanisms and vaccine classification, by transforming the content into progressive and motivating challenges. During the application sessions, it was possible to observe a significant increase in active participation, improved collaborative interaction among peers, and greater retention of the concepts covered. The simulation of clinical scenarios through the game mechanics allowed for an effective connection between theoretical foundations and practical application, preparing for real-life situations in health education and vaccination campaigns.

During the application of ImunoDefense, it was observed that the game made learning more engaging, meaningful, and motivating. The game's development required prior study and review of theoretical content by the developers, which contributed to the consolidation of knowledge. In addition, the gamified dynamics encouraged the active participation of colleagues, who also needed to review immunological concepts to interact with the other games presented. There was greater interaction among students during the activity, and it was observed that many demonstrated better performance in subsequent assessments of the subject, such as tests and theoretical exercises. Although no formal quantitative assessment instruments were used, the students' perceptions indicate that the proposal favored the understanding of the content covered.

It is therefore suggested that the use of gamified resources be expanded in the health sciences curriculum, as well as the integration of digital technologies to broaden access to these tools. Future studies can evaluate the direct impact of gamification on academic performance and long-term knowledge retention, further consolidating its effectiveness as an active teaching methodology.

Ethical Statements

Funding: No funding was available for the manuscript.

Conflict of interest: The authors indicate that there is no conflict of interest.

Availability of materials: Game information is available upon request to the authors.

Ethical considerations: Approval from an ethics committee was not required, as the study concerns the development of an academic game. All participants provided consent.

Authors contributions

Janayla Alves dos Santos – Refinement of methodology and writing.

Ângela Oliveira Ciqueira – Conceptualization, methodology and writing.

Izadora Maria Barboza de Sousa Lima – Refinement of methodology and writing.

Eduarda Pereira Lima - Refinement of methodology.

Isabela Ferreira Carneiro Locatelli – Conceptualization and methodology.

Lunalva Aurélio Pedroso Sallet – Supervision, guidance, and review.

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