

Designing and validating ‘Health Unit in Focus’: a serious game for enhancing undergraduate education on older adults health

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Designing and validating 'Health Unit in Focus': a serious game for enhancing undergraduate education on older adults health

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Abstract

Background: Population aging underlines the critical need for improving health professional training to adequately care for older adults (over 60 years old).

Objective: Develop and validate a serious game on older adult health for undergraduate nursing students.

Methods: This quantitative and descriptive methodological study, conducted between February and December 2023 at a public university in the Federal District, involved the active participation of 27 8th-year undergraduate nursing students. The game, 'Unidade de Saúde em Foco' ('Health Unit in Focus'), was developed and validated with their input. It features 75 clinical cases distributed across three themes: pharmacology, metabolic syndrome, and semiology. The application was validated using the SUS, and the students' feedback.

Results: Of the 40 students initially enrolled, 27 completed the study. The game received an average SUS score of 85.75 (median: 86.57), classified as excellent—all evaluated items scored above 75. Participants considered the game easy to use, accessible, practical, and rich in well-founded, useful content. This high usability score, coupled with the overwhelmingly positive feedback from the students who found the game easy to use, accessible, practical, and rich in well-founded, useful content, instills confidence in the game's effectiveness. Furthermore, 100% of students agreed that learning through games is effective and expressed interest in incorporating more interactive games into their training.

Conclusions: The Serious Game 'Unidade de Saúde em Foco' ('Health Unit in Focus') is not just a valid and reliable tool for training nursing students, but also an engaging and interactive approach to learning. Its ability to captivate and involve students in the learning process is a testament to its potential to revolutionize nursing education.

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Original Manuscript

Original Paper

Designing and validating 'Health Unit in Focus': a serious game for enhancing undergraduate education on older adults' health

Abstract

Background: Population aging underlines the critical need for improving health professional training to adequately care for adults over 60. Developing educational resources to support academics and professionals presents a valuable opportunity to enhance understanding of health conditions and improve clinical management. Serious games are designed to develop teaching, training, and learning skills. Their use in the educational setting is warranted, as they integrate digital aspects and gamification to create a playful content acquisition experience. Deepening this theme in nursing education will improve assistance to the older adult population, promoting more qualified care based on gerontological practices and comprehensive health care for older adults. **Objective:** Develop and validate a serious game on older adult health for undergraduate nursing students. **Methods:** This quantitative and descriptive methodological study, conducted between February and December 2023 at a public university in the Federal District, involved the active participation of 27, 8th to 10th semester undergraduate nursing students. The game, 'Health Unit in Focus', was developed and validated with their input. It features 75 clinical cases distributed across three themes: pharmacology, metabolic syndrome, and semiology. Of the 40 students initially enrolled, 27 completed the study. The application was validated using the System Usability Scale (SUS), the students' feedback, and reported according to the recommendations of the Game-Based Intervention Reporting Guidelines. **Results:** The participants had a mean age of 22.67 years (SD 1.44), were mostly female (74.1%) and were in their 8th semester (96.3%). The game received an average SUS score of 85.75 (median: 86.57), classified as excellent—all evaluated items scored above 75. Participants considered the game easy to use, accessible, practical, and rich in well-founded, useful content. This high usability score, coupled with the overwhelmingly positive feedback from the students, instills confidence in the game's effectiveness. Furthermore, 100% of students agreed that learning through games is effective and expressed interest in incorporating more interactive games into their training. The 'Health Unit in Focus' serious game showed good usability, as the overall score was 'excellent' with its highest score in the odd-numbered items that deal with the positive aspects found in the analysis. **Conclusions:** The Serious Game 'Health Unit in Focus' is not just a valid and reliable tool for training nursing students, but also an engaging and interactive approach to learning. Its ability to captivate and involve students in the learning process is a testament to its potential to revolutionize nursing education. It is essential that the development of new methodological resources, such as *Serious Games*, be based on scientific evidence in order to guarantee greater reliability and success in their established objectives.

Keywords: Serious Games; Nursing Education; Aged; Games, Experimental.

Introduction

On the world stage, the health concerns of older adults (over 60 years old) have gained notoriety driven by population aging and the epidemiological transition. This transition reflects a shift in the pattern of mortality and disease, with a growing prevalence of chronic non-communicable diseases in older age groups [1]. United Nations data shows a threefold increase in older adults between 1980 and 2022. By 2023, this demographic should number 994 million, accounting for 12% of the global population. Over the next three decades, the older adult population worldwide is projected to more than double, reaching over 1.5 billion people by mid-century [2].

Under these circumstances, health practices should prioritize promoting active aging by enhancing quality of life, supporting health maintenance, and preventing disease [3]. In the 2000s, the World Health Organization (WHO) introduced 'active aging' policies that addressed various determinants, including health, social, and economic factors, while also emphasizing the need for adequately trained professionals to support and assist this population [4].

In this sense, developing educational resources to support academics and professionals presents a valuable opportunity to enhance understanding of health conditions and improve clinical management. These resources can take various forms—such as guides, brochures, applications, and games—providing information that can effectively optimize the teaching-learning process in health [5].

Serious games are designed to develop teaching, training, and learning skills, with the first records dating back to the 1970s [6]. These days, they are most typically employed in digital games, although they can also be utilized in physical games. Their use in the educational setting is warranted since they integrate digital aspects and gamification to create a playful content acquisition experience [7]. In recent years, they have been widely applied in health education [8,9].

One study compared the effects of traditional lectures with a serious game on nursing students' knowledge and skills in assessing burn patients, finding a significant improvement in educational outcomes for those engaged with the game [10]. Similarly, another study explored the effects of using a serious game in a home environment, reporting an enhancement in theoretical knowledge related to the game's central theme [11].

This study introduces a novel approach to teaching issues related to older adult health conditions commonly encountered in primary healthcare. The serious game, designed for any mobile device, offers content tailored to the target population and is adaptable to students' daily lives. At the time of this research, our game was the only application identified that integrated these specific characteristics, making it a unique and potentially impactful tool in nursing education.

Deepening this theme in nursing education will improve assistance to the older adult population, promoting more qualified care based on gerontological practices and comprehensive health care for older adults.

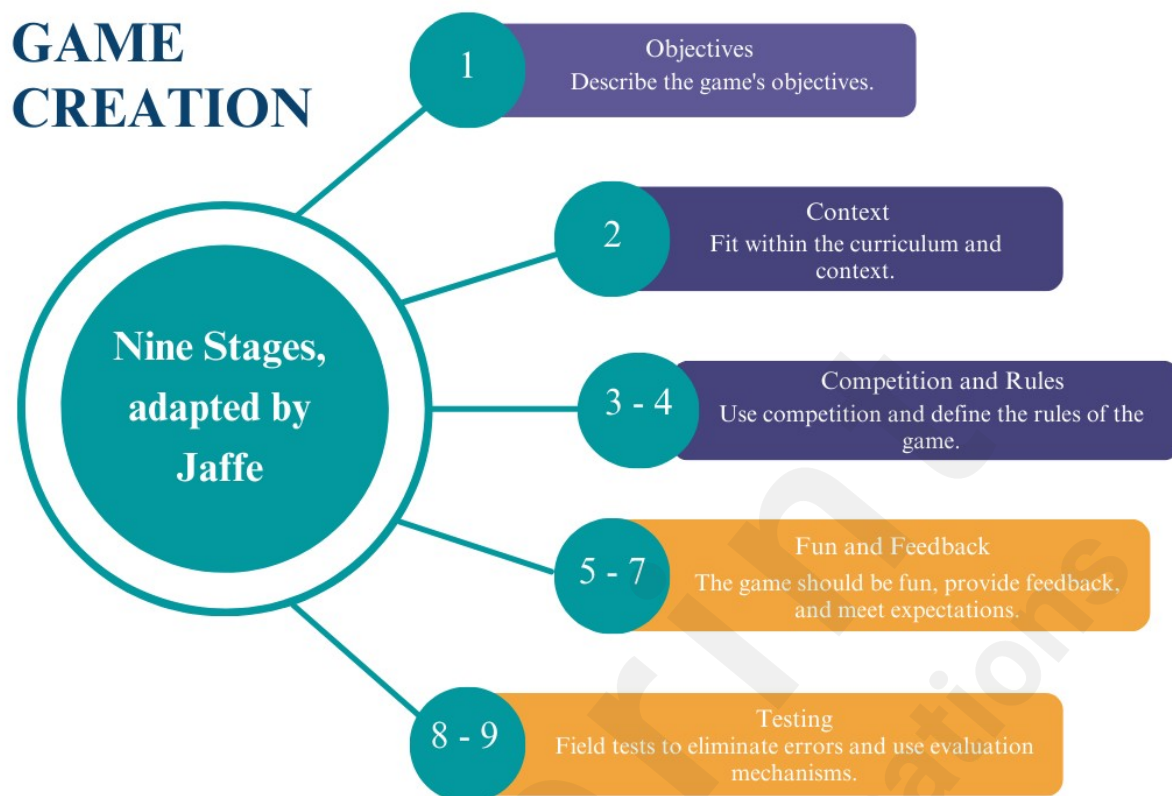
Once developed and validated, a serious learning game focused on the health of older adults with chronic non-communicable diseases could be a strategic tool for promoting independent learning among students. Building on this potential for self-directed learning, the present study, rooted in methodological development research, aims to create and validate a Serious Game on older adults' health for undergraduate nursing students.

Methods

Study development and population

This methodological development study, with a quantitative and descriptive approach, was designed at a public university in the Federal District between February and December 2023 and reported according to the recommendations of the Game-Based Intervention Reporting Guidelines (GAMING) [12]. The stages proposed by Jaffe [13] were used for construction, describing the stages of construction, testing, and validation of the game, as shown in Figure 1.

Figure 1- Stages of game construction.



In stage 1, the game's objectives, educational aims, content, and problematizations were established. For stage 2, the context in which students would use the theme was surveyed. In stage 3, the competitive aspects were adjusted to the application's proposal, as it is a single-player game. For the rules, stage 4, a 'help' tab was set up with all the rules and guidelines. Step 5 was aimed at integrating the gamification aspects. Step 6, immediate feedback, was included immediately after the participants' responses.

In stage 7, the researchers of this study analyzed and carefully studied such variables, especially because they were inserted within the academic context of the population. For evaluation, in step 8, the study followed a pilot test with 13 undergraduate students with the minimum knowledge requirements for game use. All participants were enrolled in a discipline that dealt with aging in health. In the last step, the support team adjusted the notes from the previous step evaluation.

The themes included in the Serious Game were developed based on the needs of nursing undergraduates, focusing on areas of older adults' health where students faced the greatest difficulty or expressed the most interest in deepening their knowledge. This step of assessing students' needs had already been conducted previously. The game incorporates 75 clinical cases, with 25 cases for each theme: pharmacology, metabolic syndrome, and semiology as applied to older adults' health, Multimedia Appendix 1. All clinical cases were submitted for validation by expert judges in previous works.

The cases were built and validated by experts on older adult health topics. All cases have a contextualization and true-or-false affirmative on the subject, which was defined from more prevalent themes in the clinical context of each older adult health topic.

Sample

After the Serious Game application was fully developed, its usability was evaluated by 8th-semester undergraduate nursing students at a public university. The initial sample consisted of 40

enrolled students, of which 13 were excluded (10 for not attending, 2 for withdrawing from the course during collection and 1 for dropping out during the validation process), resulting in 27 final participants. It is assumed at a 95% confidence level that at least 70% of the experts will classify the item as appropriate. The calculation would be $n = 1.96^2 * 0.85 * 0.15 / 0.15^2 = 22$ students [14]. To detect effect sizes of 0.85 with an α level of .05 and a power of 95%, a sample size of 22 participants was required. Considering the likelihood of participant dropout or ineligibility, we increased our target sample size to 27 participants. Although sample size calculations ensured adequate statistical power, future multi-center studies are recommended to strengthen external validity and account for institutional and regional educational variations.

Data Collections Tools

Prior to the moment of validation, students responded to the characterization questionnaire with information such as age, sex, semester, education, year of entry into the current degree, whether they participate or have participated in scientific initiation, already have experience with educational technologies, like games, think it is possible to learn through games and frequency of using games on mobile. The scale used for this validation was the System Usability Scale (SUS) [15]. The SUS and Educational Games Evaluation Scale were selected for their demonstrated reliability, ease of interpretation, and extensive validation within educational technology research contexts.

This scale assesses the user's degree of agreement using a Likert scale, ranging from 'totally agree' to 'totally disagree.' The final score is calculated by summing the individual contributions of each item. For even-numbered items, subtract the user's response from five (5 - user's response); for odd-numbered items, subtract one from the user's response (user's response - 1). The resulting values are then added and multiplied by 2.5, yielding a 'user satisfaction index' ranging from 0 to 100. The score is classified as follows: worst imaginable (0-20.5), poor (21-38.5), average (39-52.5), good (53-73.5), excellent (74-85.5), and best imaginable (86-100). The system can be further classified based on the following categories: ease of memorization (item 2), ease of comprehension (items 3, 4, 7, and 10), system efficiency (items 5, 6, and 8), user satisfaction (items 1, 4, and 9), and identification of inconsistencies (item 6) [16,17]. This instrument was printed and delivered to participants.

To evaluate the Serious Game, the 'Educational Games Evaluation Scale' scale was used to evaluate the game quality proposed by Savi [18]. It has evaluation in three main components: motivation (10 questions), user experience (16 questions), and learning (3 questions), totaling 29 items. The answering scale is a 5-point Likert-like response scale.

Statistical Analysis

Data from the answers database were processed and analyzed using the Statistical Package for the Social Science (SPSS), version 20.0. Statistical tests were conducted as necessary, with p-values <0.05 considered statistically significant. The Shapiro-Wilk test was applied to analyze normality, after evaluation it was considered within normality. Content validity was evaluated based on the questions' relevance, purpose, and clarity of the information. Reliability was calculated by Cronbach's alpha index, which estimates the questionnaire items' internal consistency [19].

The Likert-type scales have the following configurations: judgments with responses 1 and 2 characterize total disagreement and disagreement with the statement, respectively. Judgment with response 3 in the answers characterizes indecision; the student neither agrees nor disagrees with the statement. Meanwhile, judgments with responses 4 and 5 characterize agreement with and total agreement with the statement, respectively.

Ethical considerations

This study was rigorously designed and implemented following the ethical guidelines established by the Declaration of Helsinki, with ethical approval granted by the Research Ethics Committee of the Faculty of Ceilândia at the University of Brasília (UnB/FCe), under protocol number 5.237.938. Participants engaged actively by downloading their match data and submitting it securely through the university's educational e-platform. This platform provided a protected digital storage area exclusively accessible to the research team, ensuring participant confidentiality.

Prior to enrollment, all potential participants received clear, detailed explanations concerning the study's purpose, methods, and procedures, as well as the specific types of data to be collected. Voluntary informed consent was systematically obtained in written form from each participant, emphasizing their autonomy and freedom to withdraw from the research at any point without any repercussions or adverse outcomes.

To protect the participants' right to privacy, personal identifiers were safeguarded in secure, password-protected digital files. During data analysis and the reporting of results, only anonymized or pseudonymized information was used. Specifically, each nursing student participant was assigned a unique numeric identifier according to the sequential order of their questionnaire submissions, ensuring complete anonymity throughout the research process.

Participants received no financial incentives for their involvement, aligning with ethical standards promoting voluntary, unbiased participation. Additionally, considerable care was taken to prevent any potential identification through the publication or supplementary materials associated with this study. In instances where the use of potentially identifiable images was unavoidable, explicit written consent was obtained from the concerned individuals. However, no identifiable images were ultimately included in the present paper or its supplementary documentation, thereby reinforcing the commitment to participants' confidentiality and ethical research conduct.

Results

Serious Game – 'Health Unit in Focus'

This study's final product is a Serious Game application called 'Health Unit in Focus' (HUF) for mobile devices. HUF is a single-player question-and-answer game composed of clinical cases with online and offline functionality. On its home screen are fields for login and password if the user is already registered and a field for creating a new account.

Also, on its home screen, the player can access the game's established area: pharmacy for pharmacology cases; laboratory for metabolic syndrome; and consulting room for semiology. The player can also consult solved cases and other players' achievements in the archive and secretary areas. Furthermore, a help tab provides information on game areas, how to play, emergencies, content review, achievements, and profiles.

Upon entering the game area, participants must respond to a clinical case on their chosen topic. These cases are categorized as easy, medium, or difficult, and participants must complete the initial levels to advance to more challenging ones. Immediate feedback is provided after each response, explaining the correct answer. Emergency scenarios will also appear during gameplay, requiring the participant to respond within 60 seconds. Figure 2 presents some of the tabs from the HUF application.

Figure 2- Tabs of the 'Health Unit in Focus' application.



Stages in the construction of the Serious Game

The game's scenarios focus on older adults' health issues within the Primary Health Care (PHC) context, combining technological resources with gamification and innovation to create an engaging and effective learning experience [20].

Stage 1—Developing and describing the game's specific objectives. According to Jaffe [13], developing an educational game requires determining the content, problematizing it, and setting clear objectives to achieve that align with the context. That said, the objectives of the app focus on consulting specific knowledge related to the health of older adults in clinical contexts within PHC by solving problematizing content related to pharmacology, chronic non-communicable diseases (metabolic syndrome), and semiology.

The game development explicitly integrated pedagogical theories such as experiential learning and self-directed learning to ensure that clinical cases and interactive elements facilitated deeper cognitive engagement and autonomous knowledge construction.

Stage 2—The context is inserted (Contextual Integration). This Serious Game model is intended for use by undergraduate nursing students in their final graduation periods. Stage 3—Competitive space. As a single-player game, HUF includes a feature that allows users to compare their achievements, introducing an element of competition. Stage 4—Defining the game rules. The game includes detailed rules descriptions, gameplay mechanics, game areas, content review, and how to earn new achievements. Immediate feedback and emergency scenarios were purposefully designed to replicate clinical decision-making urgency and foster real-time critical thinking skills directly related to clinical practice.

Stage 5—Fun. Gamification aspects commonly seen in games and applications were incorporated to enhance engagement [21]. Stage 6—Immediate feedback. Upon evaluating a clinical case and selecting a response, the user receives immediate feedback on the success or failure of their choice. Stage 7—Meeting the needs of the participants. The themes in HUF are designed to address the target audience's needs, considering factors such as age, gender, culture, and academic level. Stages 8 and 9—Testing and evaluation mechanisms. This research involves testing the application prototype and assessing its usability with undergraduate nursing students.

During Stage 8 and 9 performances, 13 undergraduate nursing students, with an average age of 22 and predominantly female (69.2%), participated in the study. Their profile closely matched the final target audience. At the time, students assessed the game's quality using a Savi [18] developed scale divided into three categories: motivation, user experience, and learning. The results indicate that most statements received a satisfactory average in student evaluations, suggesting that the game can be effectively used as an educational tool based on the evaluated points, Multimedia appendix 2 [Responses to the educational games evaluation model].

Four items positively highlighted the motivation and user experience categories, with average ratings of 4.6 and 4.8, respectively. These items pertain to the game's relevance, recommendation to friends, interest in playing again, and ease of learning. The learning domain also stood out, with high averages in two of its three items. These statements focus on the game's contribution to knowledge and its efficiency in learning.

Usability validation (sample)

The sample that validated the game's usability closely matches the desired profile of the Serious Game's end users. It comprised 27 undergraduate nursing students, primarily women, with an average age of 22.66, all in the eighth semester of their undergraduate degree. The average age was 22.66 years (SD = 1.44), with values varying between 21 and 27 years (min and max).

The need for digital literacy was not a concern for these researchers, since the students already had previous experience of using digital platforms in previous subjects, such as Mentimeter and Kahoot, among others. This academic profile demonstrates previous familiarity with educational technologies, which makes it easier to adapt to and interact with new digital tools in the teaching-learning context.

Although participants generally possessed adequate digital literacy from prior educational experiences, variability in digital proficiency levels could influence engagement and game effectiveness, which should be considered when generalizing results.

The participants unanimously agreed on the value of incorporating games into academic training and recognized the potential for learning through games (Table 1). The students employed the application before they were in contact with their practice scenarios (supervised internship).

Students could download the application through a QR Code, which optimized its access. The game takes approximately 35 minutes, so the researchers timed the students for 40 minutes to complete the task.

Table 1 - User characteristics of the usability test participants (n=27).

		n	%
Biological sex	Female	20	74.1
	Male	7	25.9
Semester	8 th	26	96.3
	10 th	1	3.7
Other experiences with ET ^a	Yes	16	59.3
	No	11	40.7
Do you like games?	Yes, I like it a lot	18	66.7
	Yes, I like it a little	9	33.3
	I don't like it	0	0.0
Do you think it is possible to	Yes	27	100.0

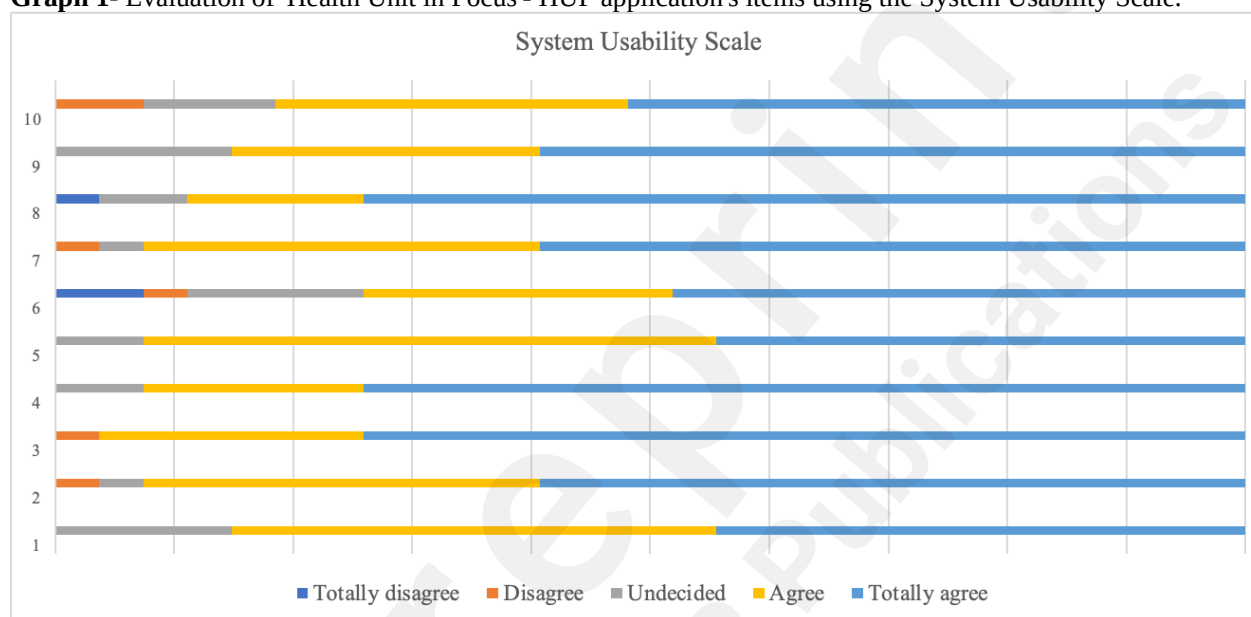
learn through games?	No	0	0.0
Would you like to include interactive games during your undergraduate course?	Yes	27	100.0
	No	0	0.0

^aET: Educational Technology.

Validation

Based on the degree of agreement with the items evaluated using the SUS, which focused on assessing the suitability of the Serious Game as an educational tool on issues related to older adults' health, the participants found the game easy to use, accessible, practical with well-founded content and Useful. The final score was 85.75, considered excellent, with a median of 86.57. All the other items scored above 75, with a Cronbach's alpha of 0.755 (Graph 1).

Graph 1- Evaluation of 'Health Unit in Focus'- HUF application's items using the System Usability Scale.



The items evaluated by SUS have specific usability characteristics with relevant meanings. Their scores have value intervals between 0 and 100 points to help quantify and qualify them, thus demonstrating software quality (Table 2). The score is classified as follows: worst imaginable (0-20.5), poor (21-38.5), average (39-52.5), good (53-73.5), excellent (74-85.5), and best imaginable (86-100).

Table 2 - Characterization of the usability of the 'Health Unit in Focus'- HUF application evaluated by SUS (n=27).

Usability characteristic	Median	Meaning
Ease of learning	89.34	Easy-to-understand
Efficiency	84.25	Agility in executing proposed tasks
Inconstancy	75.92	Absence or low number of errors
Ease of memorization	87.03	Easy-to-use system even after a period of inactivity
Satisfaction	86.11	Pleasant design
Total	84.53	Excellent

Based on individual participant responses, the Serious Game's average usability value most frequently fell within the 86–100 range on a scale from worst imaginable to best imaginable (Table 3).

Table 3 - System Usability Scale (SUS)'s categorization and classification of 'Health Unit in Focus' - HUF application usability (n=27).

Categorization Scale	Frequency		SUS classification
	n	%	
0 - 20.5	0	0.0	Worst imaginable
21 - 38.5	0	0.0	Poor
39 - 52.5	1	3.7	Average
53 - 73.5	2	7.4	Good
74 - 85.5	9	33.3	Excellent
86 - 100	15	55.6	Best imaginable

Discussion

Principal Results

Noting the satisfactory performance of educational technologies in the teaching-learning process is a reality of modern times, especially in the health educational scenario. This performance can be substantiated by its scope, which is focused on personal, technical, and theoretical development supported by a playful and fun process. In addition to this, these technologies optimize time, work, and even healthcare. During the training process, they can be used to prepare students for the field since clinical practice already uses several mobile technologies [22].

The development of the 'Health Unit in Focus'- HUF serious game intends to facilitate access to everyday content on older adults' health playfully and interactively, and the target population validated it. The conditions added to this application describe possible clinical cases that appear daily in a nursing professional's routine and are sometimes not covered in traditional classes. In this way, students may be more aware of how to approach these cases.

While results indicate strong usability and satisfaction within this specific academic setting, replication in diverse educational contexts, particularly those with varying degrees of technological infrastructure and student digital literacy, is essential for broader applicability.

It is essential that the development of new methodological resources, such as serious games, be based on scientific evidence to ensure greater reliability and success in their established objectives [23]. Studies show that educational games tend to achieve good results using standardized methods to meet educational demands [24,25]. Therefore, this study sought references previously used in the literature to construct and validate the HUF application [13,15].

Technological resources such as Serious Games must arouse students' interest, be compatible with their needs, and suit (adapt to) their cognitive style. In this way, this technology can foster knowledge formation [26]. The HUF was developed based on feedback from nursing students, giving prominence to their most challenging subjects. We therefore sought to meet the needs of this audience.

Technologies should be engaging and enjoyable in addition to meeting user expectations.

Combining leisure with involvement in the clinical context and acquiring new knowledge are key gamification aspects and have been recognized as essential elements of a fun experience [27]. The proposed Serious Game incorporates these aspects, offering features like totems, trophies, and opportunities for advancement and new achievements.

This approach demonstrates how technological resources facilitate the integration of theoretical aspects, practical daily-life routines, and student accessibility [9].

Usability evaluation guarantees a system's ease, suitability, and rapid learning in handling while seeking to minimize operational errors. Therefore, usability evaluation seeks greater efficiency and safety (security) in implementing such systems, making the user experience more pleasant [28].

According to Brooke's [29] findings, the aspects evaluated in the SUS are considered a reliable and robust evaluation tool with a high degree of validity. They are essential for a good software result, covering a range of system aspects such as complexity, need for support, interface, and others.

Regarding these aspects, the HUF serious game demonstrated good usability, as the overall score was considered excellent. HUF's highest score was in the odd-numbered items that deal with positive aspects found in the analysis. Other findings present a variation in usability between 78.8 and 88.2 among young students [30–32].

There is a constant growth in the use of serious games as a learning tool in the health sector. These digital games, developed for educational purposes as well as entertainment, have been widely used to improve the theoretical and practical knowledge of students and health professionals. Several studies have shown that serious games can improve knowledge retention, the development of clinical skills and decision-making, making them a promising pedagogical resource for training more prepared and qualified professionals [33,34].

The System Usability Scale (SUS) is a widely adopted tool for measuring the usability of various software and hardware products. However, its original conception was not specifically aimed at evaluating mobile applications. However, studies have shown its effective use with promising results [35,36].

A study carried out in Brazil evaluated the usability of a digital tool using SUS. The authors presented usability results measuring 75 [37]. Another study carried out in Germany validated a virtual reality serious game for patients. The SUS results showed a final score of 86.9 [38]. These studies are in line with the findings described in this manuscript.

The scale used also allows for assessing user satisfaction, which is considered a key component of usability [29]. The HUF reflects high user satisfaction with a score above 86 on items 1, 4, and 9, which permits this assessment. Studies show that using serious games produces results associated with high satisfaction rates [39–41].

The modern scenario involves technologies in the daily lives of the entire population, especially young people and adults. This involvement has brought new needs and challenges to producing relevant and acceptable educational products. In this sense, the researcher must be able to transform knowledge into attractive, coherent, and intriguing products for the user [42]. According to the participants' evaluation, HUF proved to be a pleasant and easy-to-use system with low errors.

Integrating innovative tools and strategies into education and training is not novel. However, combining new dynamic and interactive approaches is critical for enhancing learning [43]. In addition to the educational/training process, technological advancements have resulted in higher-quality nursing care in a variety of contexts [44–46].

Games, especially Serious Games, are advantageous for undergraduate health courses, positively impacting student motivation and satisfaction. As educators, teachers should be attentive to complementing learning methods with resources such as games as long as they are reliable and validated [47]. Notably, the HUF serious game has reliable internal consistency and is appropriately validated.

Limitations

This study has several limitations. The application usage time was approximately 40 minutes, which could limit its depth if not integrated into the participants' regular academic routine. Immediate access also depended on a stable internet connection or prior download. The small sample size and the fact that it was conducted with students in a single centre can be given as limitations. The study did not include pre- or post-testing or comparisons with other instructional formats. Since no other studies have addressed this topic to date, the potential influence of the novelty effect on the results remains unexplored. Lastly, functional technical limitations, such as the lack of communication between synchronous players, may have influenced the outcomes.

Future studies should incorporate longitudinal designs, multi-center participation, and comparative evaluations against traditional and alternative digital education formats to better evaluate long-term effectiveness and transferability of learned skills

Conclusions

In the current scenario, characterized by rapid technological advancements and easy access to information, the challenge of enhancing the educational process, particularly in the health sector, is significant. Creating new technological tools aligned with the target audience's needs can contribute to a better learning process. HUF serious game was validated with undergraduate students, with promising results for its use and replication in similar contexts. Furthermore, HUF features easy access to information, a user-approved interface, and content relevant to older adults' health, making it a valuable educational resource.

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Conflicts of Interest

None declared.

Abbreviations

ET: Educational Technology
FCe: Faculty of Ceilândia
GAMING: Game-Based Intervention Reporting Guidelines
JMIR: Journal of Medical Internet Research
SPSS: Software Package for the Social Sciences
SUS: System Usability Scale
PHC: Primary Health Care
HUF: Health Unit in Focus
UnB: University of Brasília
WHO: World Health Organization

Multimedia Appendix

Multimedia Appendix 1

Questions	
1	Mr. Carlos, 64 years old, has long-term metabolic syndrome and insulin resistance. He makes daily and continuous use of insulin, which can cause adverse effects such as insulin lipodystrophy. This condition is characterized by fibrous and little vascularized lesions in subcutaneous adipose tissue. This case is RIGHT or WRONG.
2	Estela has diabetes and uses insulin continuously and regularly at home. When necessary, the concomitant administration of the two types of insulin was oriented so that it would first be aspirated to NPH insulin and then regular. This case is RIGHT or WRONG.
3	David, 58, has diabetes and continuously uses insulin. As usual, he went to the Basic Health Unit (UBS) to seek his continuous medications. Upon checking the medical record, the team verified the prescription of 12 regular human insulin units (applied between 30 and 45 minutes before meals start) subcutaneously twice daily. The unit has insulin 100 IU/ml in 5 ml vials. David will receive two vials to use at home for a thirty-day treatment. This case is RIGHT or WRONG.
4	Betina, 67, recently lost her mother due to complications from type 2 diabetes. Following this incident, she resolved to take care of herself, requesting routine tests and consulting with health professionals. One of her worries was the occurrence of diabetes and other chronic nontransmittable diseases due to inheritance. During the consultation, it was stated that the factors contributing to these syndromes' pathogenesis are exclusively acquired; that is, they are only related to the person's lifestyle. This case is RIGHT or WRONG.
5	Mariana, a 58-year-old obese woman, was diagnosed with metabolic syndrome (7 years ago) and diabetes (2 years ago). The accumulation of these clinical health conditions impacts her social, physiological, and endocrine context. Nevertheless, her inflammatory parameter, as measured by PCR examination (0.3 - 1), remains unchanged. Thus, activation of the inflammatory process is unrelated to the clinical conditions of metabolic syndrome, obesity, and diabetes. This case is RIGHT or WRONG.
6	Gabriela, 68, is a widow who has been hypertensive for more than a decade. She underwent an elective surgical procedure and, during preoperative hospitalization, found that she possessed the correct number of components required for metabolic syndrome diagnosis. The Surgical Center's multi-professional team clarified the existing risks of metabolic syndrome and systemic arterial hypertension, which could happen during the procedure. Therefore, the risk of mortality due to hypertension is independent, even though it is one of the components of metabolic syndrome. This case is RIGHT or WRONG.
7	Valter, 68, has had high blood pressure for a long time and is being monitored at the Basic Health Unit near his home. Upon arriving at the unit, he was told that his vital signs would be checked. When measuring blood pressure, the patient's positioning and behavior are essential to avoid interfering with the result. The health professional must verify the following information: the patient's bladder is not full; the patient has not consumed coffee, alcoholic beverages, or food before the measurement; the patient has not exercised in the last 60 minutes and has not smoked in the last 30 minutes. Regarding the information checked, this case is RIGHT or WRONG.
8	Flávia, a 72-year-old black woman with grade II obesity and a history of systemic arterial hypertension, was admitted to the hospital emergency department with epigastric pain and dyspnea on mild exertion. As part of the initial care, an electrocardiogram was requested. To perform this exam, the healthcare professional must have prior knowledge of the cardiac foci, which are aortic, pulmonary, tricuspid, valvular, and mitral foci. Regarding the cardiac foci, this case is RIGHT or WRONG.
9	Insulin resistance is one component of Metabolic Syndrome. It is known that isolated factors do not accurately diagnose the syndrome; rather, a combination of these factors is necessary. Insulin resistance predisposes individuals to the onset of hypertension, which develops from the impairment of the venous network and its vasodilatory and vasoconstrictive action. This case is RIGHT or WRONG.
10	Rafaela, a 69-year-old woman with a family history of chronic diseases, lost her parents to complications from Systemic Arterial Hypertension. Aware of her risk factors, she decided to change her routine and lifestyle habits. Her transformation included monitoring by a health professional who could guide her eating habits. Measures such as low intake of saturated fats, trans fats, cholesterol, sodium, and sugars are part of essential basic guidelines to help exclusively with hypertension. This case is RIGHT or WRONG.

Multimedia Appendix 2

Responses to the educational games evaluation model. Brasília, 2023.

	Mean	SD	P25	Median	P75
Motivation					
1. The game design is appealing	4.4	0.2	4.0	5.0	5.0
2. Something was interesting at the beginning of the game that caught my attention	4.5	0.1	4.0	5.0	5.0
3. The variation (form, content, or activities) helped me stay focused on the game	4.5	0.2	4.0	5.0	5.0
4. The game content is relevant to my interests	4.8	0.1	5.0	5.0	5.0
5. The way this game works is suited to my learning style	4.2	0.3	4.0	4.0	5.0
6. The game content is connected to other knowledge I already had	4.5	0.1	4.0	5.0	5.0
7. It was easy to understand the game and start using it as study material	4.5	0.2	4.0	5.0	5.0
8. As I went through the stages of the game, I felt confident that I was learning	4.5	0.1	4.0	4.0	5.0
9. I am satisfied because I know that I will have opportunities to put into practice things I learned from the game	4.5	0.2	4.0	5.0	5.0
10. It is because of my personal effort that I am able to advance in the game	4.0	0.2	4.0	4.0	4.0
User Experience					
11. I temporarily forgot my daily worries; I was totally focused on the game	3.8	0.3	3.0	4.0	5.0
12. I didn't notice time passing while playing when I saw the game was over	3.5	0.3	2.0	4.0	4.0
13. I felt more in the game environment than in the real world, forgetting what was around me	3.2	0.3	2.0	3.0	4.0
14. I was able to interact with other people during the game	3.3	0.3	2.0	4.0	4.0
15. I had fun together with other people	3.1	0.2	2.0	3.0	4.0
16. The game promotes moments of cooperation and/or competition between the people who participate	3.4	0.4	2.0	3.0	5.0
17. This game is adequately challenging for me; the tasks are neither too easy nor too difficult	3.9	0.3	4.0	4.0	5.0
18. The game evolves at an adequate pace and does not become monotonous - it offers new obstacles, situations, or variations of activities	3.6	0.4	2.0	4.0	5.0
19. I had fun with the game	4.3	0.2	4.0	4.0	5.0
20. When interrupted, I was disappointed that the game was over	2.8	0.3	2.0	3.0	3.0
21. I would recommend this game to my colleagues	4.8	0.1	5.0	5.0	5.0

22. I would like to use this game again	4.6	0.2	4.0	5.0	5.0
23. I was able to achieve the objectives of the game through my skills	4.3	0.1	4.0	4.0	5.0
24. I had positive feelings of efficiency in the course of the game	4.4	0.1	4.0	4.0	5.0
25. The controls for performing actions in the game responded well	4.0	0.3	4.0	4.0	5.0
26. It is easy to learn how to use the game's interface and controls	4.8	0.1	5.0	5.0	5.0
Learning					
27. The game contributed to my learning about NCDs and older adult health	4.8	0.1	5.0	5.0	5.0
28. The game was efficient for my learning compared to other activities I have had on NCDs and older adult health	4.6	0.2	4.0	5.0	5.0
29. The experience with the game will contribute to my performance in my professional life	4.5	0.2	4.0	5.0	5.0

Abreviaturas: DP, Desvio Padrão; P25, Percentil 25; P75, Percentil 75.

Abbreviations: SD, Standard Deviation; P25, 25th Percentile; P75, 75th Percentile; NCDs, Noncommunicable chronic diseases

Fonte: Dados da Pesquisa

Source: Survey Data

References

1. Sousa M da C, Barroso ILD, Viana JA, et al. The aging population: aspects of brazil and the world, under the look of literature. *Brazilian Journal of Development*. 2020;6(8):61871-61877. doi:10.34117/BJDV6N8-564
2. United Nations. World Population Prospects 2022: Summary of Results. Population Division. USA, New York: United Nations.
3. Oliveira NGN, Tavares DMDS. Active ageing among elderly community members: structural equation modeling analysis. *Rev Bras Enferm*. 2020;73:e20200110. doi:10.1590/0034-7167-2020-0110
4. da Silva Sousa NF, Lima MG, Cesar CLG, de Azevedo Barros MB. Active aging: Prevalence and gender and age differences in a population-based study. *Cad Saude Publica*. 2018;34(11). doi:10.1590/0102-311X00173317
5. Gonzaga AR, Jesus LMV de, Duque AM. Proposal for an educational guide on active aging and cognitive stimulation for the elderly. *Revisbrato*. 2022;6(4):1308-1327. doi:10.47222/2526-3544.RBTO53872
6. Abt CC. *Serious Games*. Viking Press; 1970.
7. Tsekleves E, Cosmas J, Aggoun A. Benefits, barriers and guideline recommendations for the implementation of serious games in education for stakeholders and policymakers. *British Journal of Educational Technology*. 2016;47(1):164-183. doi:10.1111/bjet.12223
8. Fernandes CSNDN, Couto G, Afonso A. An aging simulation game's impact on the attitudes of nursing students. *Nursing Practice Today*. 2019;6(3):142-151. doi:10.18502/NPT.V6I3.1257
9. Fernandes CS, Angelo M, Martins MM. Giving Voice to Caregivers: A game for family caregivers of dependent individuals. *Revista da Escola de Enfermagem*. 2018;52. doi:10.1590/S1980-220X2017013903309
10. Nasirzade A, Deldar K, Froutan R, Shakeri MT. Comparison of the effects of burn assessment

- mission game with feedback lecture on nursing students' knowledge and skills in the burn patients' assessment: a randomized clinical trial. *BMC Med Inform Decis Mak.* 2024;24(1). doi:10.1186/S12911-024-02558-4
11. Fijačko N, Creber RM, Metličar Š, et al. Effects of a Serious Smartphone Game on Nursing Students' Theoretical Knowledge and Practical Skills in Adult Basic Life Support: Randomized Wait List–Controlled Trial. *JMIR Serious Games.* 2024;12. doi:10.2196/56037
 12. Warsinsky S, Schmidt-Kraepelin M, Rank S, Thiebes S, Sunyaev A. Conceptual Ambiguity Surrounding Gamification and Serious Games in Health Care: Literature Review and Development of Game-Based Intervention Reporting Guidelines (GAMING). *J Med Internet Res.* 2021;23(9):e30390. doi:10.2196/30390
 13. Jaffe L. Games are Multidimensional in Educational situations. In: *Bradshaw M., Lowenstein A, Editores. Innovative Teaching Strategies in Nursing and Related Health Professions.* 5°. Jones and Bartlett Publishers; 2011:175-187.
 14. Venícios M, Lopes O, Martins Da Silva V, Leite De Araujo T. *Methods for Establishing the Accuracy of Clinical Indicators in Predicting Nursing Diagnoses* Jnk_1213 1..9.; 2012.
 15. Lourenço DF, Carmona EV, de Moraes Lopes MHB. Translation and cross-cultural adaptation of the System Usability Scale to Brazilian Portuguese. *Aquichan.* 2022;22(2). doi:10.5294/aqui.2022.22.2.8
 16. Padrini-Andrade L, De Cássia Xavier Balda R, Areco KCN, et al. Evaluation of usability of a neonatal health information system according to the user's perception. *Revista Paulista de Pediatria.* 2019;37(1):90-96. doi:10.1590/1984-0462/2019;37;1;00019
 17. Bangor A, Kortum P, Miller J. *Determining What Individual SUS Scores Mean: Adding an Adjective Rating Scale.* Vol 4.; 2009.
 18. Savi R, Wangenheim CG Von, Ulbricht V, Vanzin T. Proposta de um Modelo de Avaliação de Jogos Educacionais. *Revistas Novas Tecnologias na Educação.* 2010;8(3).
 19. Gliem JA, Gliem RR. Calculating, Interpreting, and Reporting Cronbach's Alpha Reliability Coefficient for Likert-Type Scales. In: *Midwest Research to Practice Conference in Adult, Continuing, and Community Education;* 2003:82-88.
 20. Deguirmendjian SC, Maria De Miranda F, Zem-Mascarenhas SH. Serious Game desenvolvidos na Saúde: Revisão Integrativa da Literatura. *J Health Inform.* 2016;8(3):110-126. www.jhi-sbis.saude.ws
 21. Visch V, Van Der Kooij K, Hoogendoorn E, Spijkerman R. Validation of Serious Games Evert Hoogendoorn Ijsfontein interactieve media Validation of Games for Behavioral Change: Connecting the Playful and Serious. *International Journal of Serious Games.* 2015;2(3). doi:10.17083/ijsg.v2i3.75
 22. Silva AM de A, Mascarenhas VHA, Araújo SNM, Machado R da S, Santos AMR Dos, Andrade EMLR. Mobile technologies in the Nursing area. *Rev Bras Enferm.* 2018;71(5):2570-2578. doi:10.1590/0034-7167-2017-0513
 23. Fernandes KT, Lucena MJNR, Arana EH da S. Uma Experiência na Criação de Game Design de Jogos Digitais Educativos a partir do Design Thinking. *RENOTE.* 2018;16(1). doi:DOI: 10.22456/1679-1916.85928
 24. Jewell D. Design Thinking in Education and Bayong. Higher Education, Prek-12 Education .
 25. Chandler HM. *Manual de Produção de Jogos Digitais* . 2°. Bookman; 2012.
 26. Pereira ALM, Leon CGRMP, Ribeiro LM, et al. Web-Based Virtual Learning Environment for Medicine Administration in Pediatrics and Neonatology: Content Evaluation. *JMIR Serious Games.* 2020;8(4):e18258. doi:10.2196/18258
 27. Viana LS, Oliveira EN, Vasconcelos MIO, Fernandes CAR, Dutra MCX, Almeida PC de. Development and validation of an educational game about drug abuse and the risk of suicide. *SMAD, Revista Eletrônica Saúde Mental Álcool e Drogas (Edição em Português).* 2023;19(2):16-25. doi:10.11606/ISSN.1806-6976.SMAD.2023.188483
 28. Melo LS de, Santana FM, Ramos JVM, et al. Parameterization and usability of the Nursing Process

- System. *Research, Society and Development*. 2022;11(3):e1811326088-e1811326088. doi:10.33448/RSD-V11I3.26088
29. Brooke J. SUS: A “Quick and Dirty” Usability Scale. *Usability Evaluation In Industry*. Published online June 11, 1996:207-212. doi:10.1201/9781498710411-35
 30. da Silva Lima Roque G, Roque de Souza R, Araújo do Nascimento JW, de Campos Filho AS, de Melo Queiroz SR, Ramos Vieira Santos IC. Content validation and usability of a chatbot of guidelines for wound dressing. *Int J Med Inform*. 2021;151:104473. doi:10.1016/J.IJMEDINF.2021.104473
 31. Hägglund M, Hankins J, Joseph Strouse J, et al. Toward a Conversational Agent to Support the Self-Management of Adults and Young Adults With Sickle Cell Disease: Usability and Usefulness Study. *Front Digit Health*. 2021;3:600333. doi:10.3389/FDGTH.2021.600333
 32. Griffin AC, Khairat S, Bailey SC, Chung AE. A chatbot for hypertension self-management support: user-centered design, development, and usability testing. *JAMIA Open*. 2023;6(3). doi:10.1093/JAMIAOPEN/OOAO073
 33. Fang H, Fang C, Che Y, Peng X, Zhang X, Lin D. Reward Feedback Mechanism in Virtual Reality Serious Games in Interventions for Children With Attention Deficits: Pre- and Posttest Experimental Control Group Study. *JMIR Serious Games*. 2025;13(1):e67338. doi:10.2196/67338
 34. Palee P, Wongta N, Khwanngern K, Jitmun W, Choosri N. Serious Game for Teaching Undergraduate Medical Students in Cleft lip and Palate Treatment Protocol. *Int J Med Inform*. 2020;141:104166. doi:10.1016/J.IJMEDINF.2020.104166
 35. Amorim AAL, de Freitas Alvarenga K, Jacob LCB, Araújo ES. Usability evaluation of the Agente Escuta application: translational research. *Codas*. 2023;35(4):e20220149-e20220149. doi:10.1590/2317-1782/20232022149PT
 36. Hyzy M, Bond R, Mulvenna M, et al. System Usability Scale Benchmarking for Digital Health Apps: Meta-analysis. *JMIR Mhealth Uhealth*. 2022;10(8):e37290. doi:10.2196/37290
 37. Flato UAP, Beffa Dos Santos EJ, Bispo Diaz T Martins I, et al. Interactive Serious Game to Teach Basic Life Support Among Schoolchildren in Brazil: Design and Rationale. *JMIR Serious Games*. 2024;12(1):e55333. doi:10.2196/55333
 38. Bressler M, Merk J, Gohlke T, et al. A Virtual Reality Serious Game for the Rehabilitation of Hand and Finger Function: Iterative Development and Suitability Study. *JMIR Serious Games*. 2024;12(1):e54193. doi:10.2196/54193
 39. Rickenbacher-Frey S, Adam S, Exadaktylos AK, Müller M, Sauter TC, Birrenbach T. Development and evaluation of a virtual reality training for emergency treatment of shortness of breath based on frameworks for serious games. *GMS J Med Educ*. 2023;40(2). doi:10.3205/ZMA001598
 40. de Oliveira Cavalcanti HG, Bushatsky M, Barros MBSC, da Silva Melo CMC, Filho AJFD. Evaluation of the usability of a mobile application in early detection of pediatric cancer. *Rev Gaucha Enferm*. 2021;42. doi:10.1590/1983-1447.2021.20190384
 41. Costa RR de O, Medeiros SM de, Coutinho VRD, Mazzo A, Araújo MS de. Satisfaction and self-confidence in the learning of nursing students: Randomized clinical trial. *Escola Anna Nery*. 2020;24(1). doi:10.1590/2177-9465-EAN-2019-0094
 42. de Moraes VC, Ferraz L. Educational technology on expressing breast milk: development and validation of a Serious Game. *Revista Brasileira de Saúde Materno Infantil*. 2021;21(3):845-855. doi:10.1590/1806-93042021000300007
 43. Galvão ECF, Püschel VAA. Multimedia application in mobile platform for teaching the measurement of central venous pressure. *Revista da Escola de Enfermagem da USP*. 2012;46:107-115. www.scielo.br/reeusp
 44. de Oliveira RM, Duarte AF, Alves D, Furegato ARF. Development of the tabacoquest app for computerization of data collection on smoking in psychiatric nursing. *Rev Lat Am Enfermagem*. 2016;24. doi:10.1590/1518-8345.0661.2726
 45. Araujo JP, Gallo AM, de Lima Parada CMG, et al. Mobile applications as a strategy to support

- parents in the care of newborns: a scoping review. *Revista da Escola de Enfermagem*. 2023;57. doi:10.1590/1980-220X-REEUSP-2022-0470EN
46. Pineros N, Tenaillon K, Marin J, et al. Using gamification to improve engagement and learning outcomes in medical microbiology: the case study of 'BacteriaGame.' *FEMS Microbiol Lett*. 2023;370:1-6. doi:10.1093/FEMSLE/FNAD034
47. Arruzza E, Chau M. A scoping review of randomised controlled trials to assess the value of gamification in the higher education of health science students. *J Med Imaging Radiat Sci*. 2021;52(1):137-146. doi:10.1016/J.JMIR.2020.10.003

Supplementary Files

revised version with tracked changes (highlighted sections of text where changes were made).

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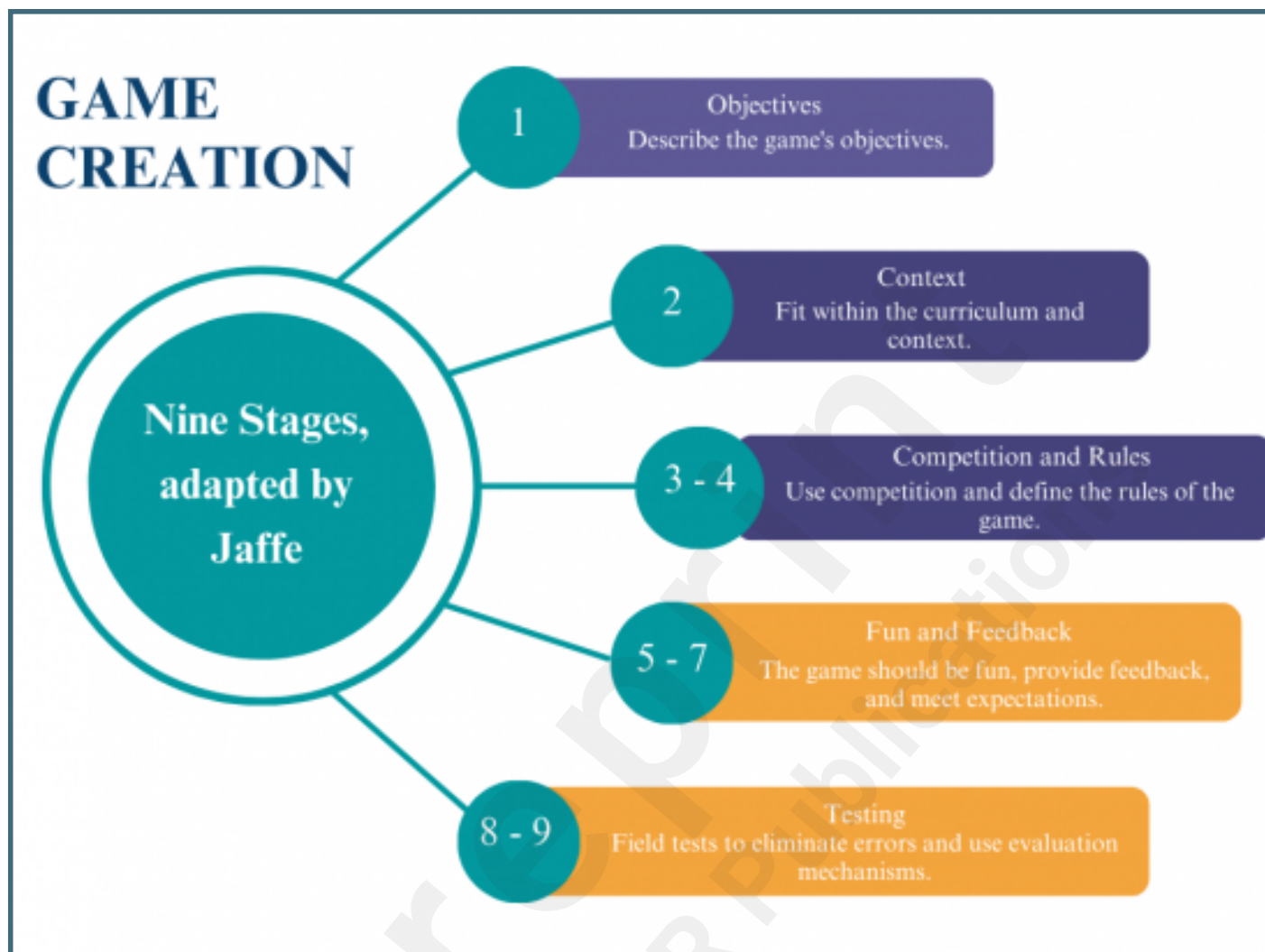
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Figures

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Multimedia Appendixes

Examples of clinical cases.

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Responses to the educational games evaluation model. Brasília, 2025.

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