Dungeons and Diabetes: co-design of an educational game to promote diabetes awareness

Airton Filho[1,2], **Fabrizio Honda**[1,2], **Jeniffer Macena**[1,2], **Márcia Lima**[1], **Marcela Pessoa**[1], **Fernanda Pires**[1]

[1]Higher School of Technology – Amazonas State University (EST-UEA)
ThinkTEd Lab - Research, Development and Innovation in Emerging Technologies

[2]Institute of Computing – Federal University of Amazonas (IComp-UFAM)

{msllima,fpires,msppessoa}@uea.edu.br

{airton.filho,fabrizio.honda,jeniffer.souza}@icomp.ufam.edu.br

Abstract. *Given the challenges related to a lack of knowledge about diabetes and low adherence to self-care practices, this work presents the initial proposal for the educational game Dungeons and Diabetes. Its development followed an educational game design process involving reviewing existing research and identifying learning gaps. We created the game in co-design with a student in computer science who has diabetes, and it aims to raise awareness through playful challenges that encourage reflection on daily care routines. The proposal incorporates principles from Multimedia Learning and Narrative Learning theories, resulting in a 2D proof of concept with mechanics and elements aligned with educational goals in the health context.*

1. Introduction

Diabetes mellitus is a multifactorial metabolic syndrome characterized by changes in the secretion or action of insulin in the body, resulting in high blood glucose levels [Candido et al. 2024]. It has two forms of classification: type 1, in which the immune system destroys the pancreatic cells responsible for producing insulin, and type 2, in which the body develops insulin resistance or presents dysfunction of the pancreatic cells that produce this hormone [Egan and Dinneen 2022]. Diabetes is a relevant public health problem, mainly due to the lack of access to information about care, prevention, and adequate management, which contributes to neglect in controlling the condition.

The World Health Organization (WHO) estimates that by 2050, the number of people living with the condition will reach 852.5 million worldwide. In Brazil, about 16.6 million adults lived with diabetes in 2024, and projections indicate that this number will increase to 24.7 million in 2025 [Federation 2025]. This scenario raises concern because diabetes requires daily attention to self-monitoring of blood glucose, lifestyle, and diet, in addition to medication administration [Egan and Dinneen 2022]. In this way, diabetes education is fundamental, helping patients perform the necessary self-management activities [Ling et al. 2022].

One alternative to help raise awareness about diabetes is Serious Games. They are applications that combine experience, entertainment, and multimedia to promote the development of specific skills, such as problem-solving through educational content and playful interaction, unlike entertainment games, whose primary focus is leisure

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[Gurbuz and Celik 2022, Cheng et al. 2015]. Serious Games has expanded to different domains, such as education (Educational Serious Games or educational games) and health [Wang et al. 2022, Thangavelu et al. 2022]. Combining these two areas, we can observe the creation of educational games aimed at understanding and raising awareness about diabetes [Ling et al. 2022].

Regarding educational games, it is necessary to incorporate learning theories to place the student at the center of the learning process and ensure rigor in game design [Gurbuz and Celik 2022, Gui et al. 2023]. Two important theories are Narrative Learning, which explains how a well-structured narrative can facilitate cognitive development by aligning with the learning path [Clark and Rossiter 2008], and the Cognitive Theory of Multimedia Learning (CTML), which establishes principles for organizing words and images to promote understanding and prevent cognitive overload [Mayer 2005].

Thus, considering the importance of raising awareness about diabetes, developing serious games, and incorporating learning theories, this work presents the educational game "Dungeons and Diabetes". We created it through a co-design process, drawing on narrative learning and multimedia learning theories.

2. Foundations and related work

Patients with diabetes often face barriers to managing the condition, such as a lack of knowledge, low adherence to self-care, limited understanding of medication, or emotional denial that delays acceptance of the diagnosis [CDC 2024, Jimmy and Jose 2011, WHO 2003, NIDDK 2023]. These challenges highlight the need for approaches that make self-management more accessible and engaging. Serious games are one promising strategy, fostering cooperation between families and health professionals and engaging users through narratives and challenges [Novák 2015]. Educational Serious Games, in particular, support learning processes, and incorporating learning theories can strengthen their efficiency by placing students at the center of the learning process [Cheng et al. 2015, Plass et al. 2015, Pires 2021].

One of the learning theories is Narrative Learning [Bruner 1990], which considers the principle that "being human is telling stories". This theory focuses on building a meaningful narrative context that supports the student in the learning process [Clark 2010, Fisher 1984, Nascimento et al. 2023, Clark and Rossiter 2008]. A well-structured narrative aligned with the game's progression can engage the player and facilitate cognitive development. Another fundamental theory is the Cognitive Theory of Multimedia Learning (CTML) [Mayer 2002], which proposes that students learn better when words and images are combined meaningfully. This theory explains learning as a sequence in which sensory memory first receives visual and auditory information, working memory organizes it, and long-term memory stores it.

In this sense, by combining learning theories with the process of developing educational games, it is possible to identify strategies that integrate playful elements with biological mechanisms and real health contexts [Pires et al. 2020]. In the literature, some studies have sought to apply these approaches to promote awareness of chronic conditions, emphasizing diabetes and using digital games to support the prevention and management of the condition. We described these works below.

Bujanda and Bujanda [2022] introduce "Diabescape", an educational game de-

signed as a diabetes-themed escape room for vocational health students in Navarra, Spain. The study involved 302 participants, divided into a control group with a traditional session and an intervention group that played the game. Both groups completed pre- and post-tests as well as satisfaction surveys. Students who played Diabescape achieved higher post-test scores and reported greater satisfaction, significantly improving most evaluated items. The results show that games like "Diabescape" enhance knowledge acquisition and increase motivation, offering a more engaging alternative to conventional approaches.

Shadan et al. [2025] present "Diabe-teach", a board game designed for medical students to explore key aspects of diabetes. In a randomized controlled trial with 56 preclinical students, one group played the game while another engaged in structured self-study with the same material. Both groups improved post-test performance, but the Diabe-teach group reached higher scores, showed greater awareness of knowledge gaps, and expressed more substantial confidence and preference for the game. The study demonstrates that "Diabe-teach" supports knowledge retention, critical reflection, and collaborative learning as an engaging alternative to traditional approaches.

Jullien [2013] created "Candy Castle", a serious game for people with diabetes, primarily aimed at children but adaptable to other age groups. The game applies Game-Based Learning principles to motivate players to perform light physical activity, monitor glucose levels regularly, and communicate with doctors through remote supervision. Players build and protect a virtual castle by entering their glucose data, which the system synchronizes with a server accessible to healthcare professionals. "Candy Castle" shows how playful mechanics actively engage patients in self-care while supporting continuous clinical follow-up.

Table 1 presents the characteristics distinguishing the related games – "Diabescape", "Diabe-teach", and "Candy Castle" – from the proposed "Dungeons and Diabetes". All three are serious games addressing diabetes; however, only Candy Castle targets mobile devices. None of these works incorporates learning theories or adopts a co-design approach. This research advances the field by (i) applying Narrative Learning and the Cognitive Theory of Multimedia Learning (CTML); (ii) engaging in a co-design process with people living with diabetes, so that the game reflects their real experiences; and (iii) targeting mobile devices to enhance accessibility and usability.

Table 1. Diabetes-related projects: type, theory, and co-design

Serious Game	Diabetes	Theories	Co-design	Mobile
Diabescape [Bujanda and Bujanda 2022]	X	-	-	-
Diabe-teach [Shadan et al. 2025]	X	-	-	-
Candy Castle [Jullien 2013]	X	-	-	X
Dungeons and Diabetes (this work)	X	X	X	X

3. Methods

In this work, we adopted the educational game design methodology proposed by Pires et al. [2021], an iterative and incremental process in which each stage produces a deliverable artifact (e.g., documentation, requirements, prototypes). At the end of each stage, the process advances to the next one, possibly returning to earlier steps when adjustments are needed. Figure 1 illustrates the methodology, which we detail in the following subsections. An undergraduate student in Computing at the Federal University of Amazonas

(UFAM) developed the game, and the co-design process involved two people living with type 1 diabetes: a Master's student in Computer Science at the same university and a teacher at the State University of Amazonas (UEA), both of whom actively contributed to the proposal.

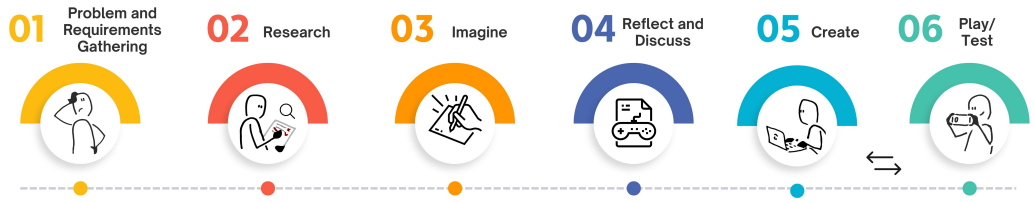


Figure 1. Educational game methodology by Pires et al. [2021] adapted.

3.1. Problems and Requirements Gathering

The first step involves identifying a learning problem through literature searches and/or fieldwork. In this study, we searched the literature and found challenges related to understanding and managing diabetes, such as neglect of the condition due to lack of knowledge, denial, or lack of motivation [CDC 2024, Jimmy and Jose 2011]; low adherence to medical recommendations [WHO 2003]; difficulty recognizing the importance of medication, especially when symptoms do not appear [NIDDK 2023]; and emotional denial, which hinders acceptance of the diagnosis and delays necessary care [Jimmy and Jose 2011]. The Master's student reinforced these points by reporting that he did not understand the condition until he received the diagnosis. He did not know about the different types of diabetes, the use of insulin, or other related aspects, and he also felt unmotivated at the beginning of management.

Given this, we define the first requirements of the game as follows: (i) theme – diabetes mellitus; (ii) content – raising awareness about diabetes; and (iii) target audience – people with type 1 or type 2 diabetes, as well as pre-diabetics.

3.2. Research and Imagine

In the "Research" step, we identify existing media related to the problem. Media is not limited to scientific articles and may include games, books, series, and other formats. In this study, we carried out three types of research: (i) diabetes concepts, to gain a better understanding of the condition; (ii) serious games, to analyze how these tools incorporate diabetes concepts; and (iii) scientific articles, to locate references in the field and examine how they present those concepts. We created a benchmark spreadsheet for each game we identified – either through articles or directly from the media – to store relevant information, including game name, release date, country, target audience, platform, and availability. The spreadsheet also mapped game mechanics related to diabetes.

Next, in the "Imagine" stage, we defined the first ideas for the solution. After discussions among the students, we chose to create an educational game to raise awareness about diabetes. This decision considered (i) the learning problems we identified; (ii) the condition of the Master's student, who has diabetes; (iii) the undergraduate student's interest in building games; (iv) the Master's student's expertise in educational games, with 8 years of experience in the field; and (v) the existence of other serious games with the

same purpose. We also defined the game design as including the exploration of dungeons by a protagonist with diabetes. Finally, we named the game "Dungeons and Diabetes", a parody inspired by the iconic "Dungeons and Dragons"[1], which we used exclusively for educational purposes and without any official association with the brand.

3.3. Reflect and Discuss

The proposal planning begins at this stage, involving creating game elements and their association with learning aspects. We describe them in the Educational Game Design Document (EGDD) [Pires 2021], which includes narrative, gameplay, learning mechanics, and learning theory, which are detailed below.

Narrative: In a distant kingdom, the villagers are at war with monsters. The protagonist has type 1 diabetes and sets out on a journey to explore the dungeons where the monsters live, aiming to recover the food and insulin pens that the monsters took. His mission is essential, as other villagers with diabetes need the medicine and food to control their blood sugar levels. Throughout his journey, the character must face monsters, explore environments, collect items, manage resources, and care for his health.

Gameplay: The player must advance through scenarios full of traps and enemies that use powers capable of altering the protagonist's glucose levels. To deal with these situations, storing items, such as food and insulin pens, and using them through an inventory to increase or reduce glucose as necessary will be possible. Blood glucose levels will represent the character's life bar, and very high or very low values may result at the end of the game, with the player starting the match with balanced glycemic levels. In addition, the character will have a running ability, which may be affected by glycemic conditions, reducing the speed or time of the action.

Learning mechanics: The game's learning process will be developed through food and medicine consumption decision-making. The player must reflect on the consumption of their resources throughout the gameplay; for example, if glucose levels are high, it will be necessary to reconsider the consumption of foods with a high glycemic index. The game also seeks to address the effects of different glycemic levels: when glucose is low, the character will present symptoms of hypoglycemia, a condition that can cause weakness, dizziness, blurred vision, and, in severe cases, fainting; and when glucose is high, the character will suffer the effects of hyperglycemia, which can include fatigue, excessive thirst and, if not controlled, more severe health risks. In addition, game mechanics are correlated with diabetes education, described in detail in Section 4.

Learning theories: The game incorporates narrative learning, linking the narrative to a learning flow about diabetes. As players advance in the game, they also advance in the narrative and build knowledge about the condition. To avoid cognitive overload, we applied CTML principles from the initial version of the game. This theory, focused on learning design, guides the use of images and text in three ways: (i) reducing irrelevant stimuli; (ii) managing the complexity of essential information; and (iii) promoting active engagement [Mayer 2005]. We applied these principles in the interface as follows: the subtitle with the speech appears close to the character's image (spatial contiguity); the character's speech combines audio and image (modality); the dialogue uses informal,

[1]https://www.dndbeyond.com/

player-directed language (personalization); the screen remains clean and free of irrelevant elements (coherence); and the speech bubble directs attention to the character (signaling).

3.4. Create and Play/Test

In "Create" stage, we build preliminary software versions called "prototypes" to validate ideas, mechanics, and interfaces. The low-fidelity version (paper prototype) is under construction, while we are also developing the POC (Proof of Concept) and partially implementing it in a game engine. These artifacts appear in Section 4. This stage cycles with the next one, refining the game based on feedback and identified inconsistencies.

In "Play/Test", experts validate the prototypes to analyze whether the scope aligns with the learning objectives, and/or computer science students test them to identify inconsistencies and provide feedback. This validation enables the team to adjust the game, detect bugs in advance, and ensure application quality. Since the objective is not yet to evaluate the target audience's learning, testing the prototypes does not necessarily require their presence. The co-design participants (student and teacher) are currently validating both versions – the paper prototype and the POC.

4. Preliminary results

This study involved co-designing a diabetes awareness game called "Dungeons and Diabetes". The game is still in development and undergoing adjustments and validation. The preliminary results include: (i) the definition of game mechanics related to diabetes, which we based on the mapping of serious games and scientific articles; (ii) earlier versions of the game – a low-fidelity paper prototype and a POC implemented in the Godot game engine[2], both used for initial validation; and (iii) the lessons learned by an undergraduate student while developing an educational game on diabetes awareness.

The first result appears in Table 2, which presents the initial mechanics defined for "Dungeons and Diabetes". All of them relate to diabetes and were partly inspired by mechanics from other games, then adapted to the context of this project to let players practice the content while having fun – such as controlling blood sugar levels, understanding the impact of food and insulin pens, and recognizing the importance of physical exercise, among others. In addition, the game's narrative aligns with the learning flow: as players progress and acquire new knowledge, they also advance in the story, which promotes greater cognitive development.

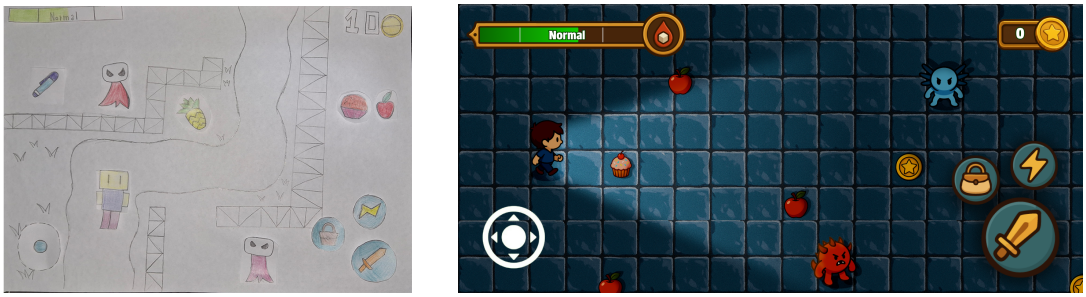
Regarding game development, we created a low-fidelity paper prototype to validate the initial ideas and, in parallel, started building a POC to test the proposed mechanics and explore possibilities for level design. Since the game involves controlling and collecting multiple items and displaying several indicators, the POC also incorporates CTML principles to organize the interface and prevent cognitive overload. Figure 2 shows both versions, including a joystick for character movement, a glucose level bar, acquired coins, attack, run, inventory buttons, enemies, food, and the playable character. Although the figure presents a male character, future versions will include a functionality allowing players to customize their character. While the POC uses Pixel Art, later versions will adopt 2D vector sprites and scenes to clarify information. We adopted Godot

[2]https://godotengine.org/

Table 2. Mechanics related to diabetes with high feasibility

No.	Mechanic Name	Description	Relation to Diabetes
1	Blood Sugar Level	A visual indicator displays the character's blood sugar levels	Monitoring blood glucose, essential for diabetes management
2	Debuffs from Unregulated Glucose	The character suffers different effects depending on glycemic level (low or high)	Demonstrates the physiological effects of hypo- and hyperglycemia
3	Stamina Bar	An energy bar limits the character's running	Shows the influence of physical effort on glycemic conditions
4	Running	A button lets the player move faster, consuming stamina and lowering glucose	Simulates the impact of physical exercise on blood sugar control
5	Food	Foods appear across the map and change the character's glucose levels when consumed	Represents the impact of diet on blood glucose levels
6	Insulin Pens	The character uses this item to keep glucose levels stable	Represents various-acting medications used for glycemic control
7	Inventory System	The character stores items for later use	Relates to planning and condition management

as the POC engine for practicality; however, we will develop future versions in Unity[3] to integrate the GLBoard package [Silva et al. 2022] for collecting and analyzing Game Learning Analytics (GLA) data.



(a) Low fidelity (paper). (b) POC (Godot game engine).

Figure 2. Low fidelity prototypes and POC of the game, respectively.

Finally, the initial results of this work include the lessons learned by the undergraduate student during the research and development of the diabetes awareness game:

- **Understanding diabetes:** he was unfamiliar with the types of diabetes (1 and 2), but his research helped him understand how each type affects the body and daily routine. This knowledge supported the design of mechanics consistent with each type; for example, the protagonist with type 1 diabetes needs to use insulin pens.
- **Recognizing risks of hypo/hyperglycemia:** although he knew the dangers of hyperglycemia, he did not understand the risks of hypoglycemia. In the game, this insight supported the creation of conditions that alert the player when reaching glycemic peaks.

[3]https://unity.com/pt

- **Understanding insulin types:** although he knew how to use insulin pens, he was unaware of their variations and action times. This gap motivated us to add a store system where players can buy different pens according to their needs.
- **Perspective on food:** he initially thought that people with diabetes should eliminate sugar rather than manage blood glucose levels. This misconception influenced the inclusion of collectible foods in the game to help manage hypoglycemia.

5. Conclusions

Diabetes mellitus is a condition that requires daily self-monitoring, as well as attention to lifestyle and diet. However, challenges to its management remain, such as negligence, non-adherence, and a lack of understanding of the condition. Education about diabetes is essential, as it supports patients in self-management activities. Serious games emerge as an alternative, fostering engagement and motivation through narratives and challenges. They combine education and health, assisting in the practice of curricular content and the development of skills. Incorporating learning theories into these games is fundamental to facilitating cognitive development, such as narrative learning and multimedia learning.

This study aimed to create an educational game to raise awareness about diabetes through co-design, guided by narrative learning and multimedia learning theories. We adopted an iterative-incremental educational game design methodology, in which each stage produced an artefact. The game features a character with type 1 diabetes who explores dungeons and faces monsters to recover stolen food and insulin pens. Players progress by managing collected resources, directly reflecting diabetes self-management. We integrated theories through a dynamic narrative linked to the learning process and applied CTML principles to the interface design to prevent cognitive overload.

The preliminary results include a table of game mechanics related to diabetes education, such as blood glucose monitoring (sugar bar), glucose debuffs (physiological effects of hypo- and hyperglycemia), and running (effects of physical exercise on blood glucose), among others. For initial validation, we developed a low-fidelity paper prototype and a POC in the Godot game engine, which features elements such as collectible foods, glucose bars, enemies, and coins. The study also reports the lessons learned by the undergraduate student during the research and early development of the game, including understanding diabetes, recognizing the risks of blood glucose spikes, distinguishing types of insulin, and rethinking nutrition.

The game is currently under development, and the next step involves validating the low-fidelity prototype with three computer science teachers, one of whom has diabetes. In this regard, future work includes (i) validating the prototype with the teachers; (ii) correcting issues and starting the medium-fidelity version using visual tools such as Figma; (iii) testing the mechanics in the POC to decide whether to include them in the game; (iv) applying the medium-fidelity prototype with computer science students to identify inconsistencies and collect suggestions for improvement; (v) studying the addition of new features such as character customization, additional characters with type 2 and other forms of diabetes, and more insulin pens; (vi) conducting future evaluations with the target audience (people with diabetes) and (vii) sharing the completed game with the community.

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