Bachelor Project



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F3

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Design of story line for serious educational game

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Declaration

I hereby declare that I have written this bachelor thesis independently and quoted all the sources of information in accordance with Methodical instructions about ethical principles for writing academic theses.

In Prague, 26. May 2023

Abstract

This thesis explores the design of a story line for a serious educational game targeted at children with diabetes. The game takes inspiration from popular mobile games such as Tamagotchi and Talking Tom and is developed using the Unity game engine and C# programming language. The objective of the game is to help children with diabetes become accustomed to using insulin and managing their condition effectively. This thesis investigates the significance of storytelling in serious educational games and proposes a compelling narrative that engages and educates the target audience. The design process involves extensive research on diabetes management and the application of game design principles to create an immersive and educational gaming experience. The resulting story line integrates educational content with interactive gameplay, aiming to empower children with diabetes and facilitate their understanding of insulin usage.

Keywords: MyDiabetic, Android, iOS, Diabetes mellitus, Unity, serious game

Supervisor: doc. Ing. Daniel Novák, Ph.D.

Abstrakt

Tato práce zkoumá návrh dějové linie vážné vzdělávací hry zaměřené na děti s diabetem. Hra čerpá inspiraci z populárních mobilních her, jako jsou Tamagotchi a Talking Tom, a je vyvíjena pomocí herního enginu Unity a programovacího jazyka C#. Cílem hry je pomoci dětem s diabetem se seznámit s užíváním inzulinu a efektivním řízením svého stavu. Tato práce zkoumá význam vyprávění příběhu ve vážných vzdělávacích hrách a navrhuje poutavý příběh, který zapojuje a vzdělává cílovou skupinu. Návrhový proces zahrnuje rozsáhlý výzkum správy diabetu a aplikaci principů herního designu pro vytvoření poutavého a vzdělávacího herního zážitku. Výsledná dějová linie integruje vzdělávací obsah s interaktivním hraním, s cílem posílit schopnosti dětí s diabetem a usnadnit jim porozumění užívání inzulinu.

Klíčová slova: MyDiabetic, Android, iOS, Diabetes mellitus, Unity, seriózní hra

Překlad názvu: Vytvoření příběhového modulu pro seriózní hru

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Chapter 1 Introduction

1.1 Background and Rationale

Serious educational games have gained significant attention in recent years due to their potential to engage and educate players in various domains. These games combine the elements of entertainment and learning to create interactive experiences that can effectively convey educational content [2]. As a result, serious educational games have been utilized in diverse fields such as health education, environmental awareness, and cultural heritage preservation [3].

One area where serious educational games hold great promise is in the management of chronic health conditions among children. Chronic diseases, such as diabetes, pose significant challenges to children's well-being and require them to learn complex self-management skills. Diabetes, in particular, necessitates continuous monitoring of blood glucose levels, insulin administration, and adherence to dietary and lifestyle changes [4].

Mobile games have become increasingly popular among children, offering a convenient and engaging platform for delivering educational content. Games like Tamagotchi and Talking Tom have demonstrated the potential to captivate and entertain young audiences [5]. By leveraging the success of these games, there is an opportunity to develop a serious educational game that can help children with diabetes become familiar with insulin usage and empower them to manage their condition effectively.

1.2 Research Objectives

The primary objective of this research is to design a compelling story line for a serious educational game aimed at children with diabetes. The specific research objectives are as follows:

- 1. To investigate the role of storytelling in serious educational games and its impact on player engagement and learning outcomes.
- 2. To explore the potential of mobile game platforms, such as Unity and C#, for creating an immersive and interactive gaming experience.

1. Introduction

- 3. To understand the challenges and barriers faced by children with diabetes in managing their condition, particularly regarding insulin usage.
- 4. To design a game narrative that integrates educational content related to diabetes management and insulin usage.
- 5. To implement the game mechanics, user interface, and insulin management systems within the Unity game engine using C#.
- 6. To evaluate the effectiveness of the game in achieving its learning objectives and engaging the target audience through user testing and feedback collection.

1.3 Thesis Structure

This thesis is structured into several chapters to provide a comprehensive exploration of the design of a story line for a serious educational game targeting children with diabetes. The subsequent chapters include:

- Chapter 2: Understanding Diabetes: This chapter provides an overview of diabetes, different types of diabetes, the importance of insulin, and the challenges and barriers faced by children with diabetes in insulin usage.
- Chapter 3: Literature Review: This chapter presents a review of relevant literature on serious educational games, the role of story-telling in games, mobile games and child health education, and design considerations for games targeted at children with diabetes.
- Chapter 4: Game Development Tools and Technologies: This chapter discusses the game development tools and technologies, specifically focusing on the Unity game engine and C# programming language.
- Chapter 5: Designing the Game Story Line: This chapter outlines the process of designing the game story line, including defining the target audience, identifying learning objectives, incorporating game mechanics and interactivity, and integrating diabetes education within the narrative.
- Chapter 6: Implementation in Unity and C#: This chapter describes the implementation of the game mechanics, user interface design, and development of interactive insulin management systems using Unity and C#.
- Chapter 7: Evaluation and Conclusion: This chapter analyzes the results, discusses the contributions and limitations of the research, and provides suggestions for future directions.

Chapter 2

Understanding Diabetes

This chapter provides an overview of diabetes, a chronic metabolic disorder that affects millions of people worldwide. Understanding the basics of diabetes is essential for developing a serious educational game targeted at children with diabetes. This chapter aims to explain the key aspects of diabetes, its types, causes, symptoms, complications, and management strategies, drawing on relevant research and expert opinions.

2.1 Diabetes Mellitus

Diabetes mellitus is a chronic illness that affects the lives of many people, including children. Not only in the Czech Republic but in the whole world, diabetes mellitus is one of the most common illnesses that children are diagnosed with, and the number is only rising. Proper treatment and management of diabetes is key to improving the quality of life of patients, especially for children who are dealing with this disease.

Number of People
813 871
792 338
782 967
$760 \ 372$
$744 \ 454$
$728 \ 413$
706 149

Table 2.1: Number of people with diabetes under treatment in Czechia from2015 to 2021.

2.2 Types of Diabetes

Diabetes is characterized by the body's inability to regulate blood glucose levels effectively. There are several types of diabetes, including:

- 1. Type 1 Diabetes: Also known as insulin-dependent diabetes, type 1 diabetes is an autoimmune disease where the body's immune system mistakenly attacks and destroys the insulin-producing cells in the pancreas. As a result, individuals with type 1 diabetes require insulin injections or the use of an insulin pump to manage their blood glucose levels **6**.
- 2. Type 2 Diabetes: Type 2 diabetes is a metabolic disorder characterized by insulin resistance, where the body's cells become resistant to the effects of insulin. It is often associated with lifestyle factors such as obesity, physical inactivity, and poor dietary choices. Type 2 diabetes can be managed through lifestyle modifications, oral medications, or insulin therapy if necessary [6].
- 3. Gestational Diabetes: Gestational diabetes occurs during pregnancy and usually resolves after childbirth. It is characterized by high blood glucose levels that develop due to hormonal changes during pregnancy. Women with gestational diabetes have an increased risk of developing type 2 diabetes later in life 6.

2.3 Causes and Risk Factors

The exact causes of diabetes vary depending on the type, but there are common factors that contribute to its development. For type 1 diabetes, genetic predisposition and autoimmune factors play a significant role. Type 2 diabetes, on the other hand, is influenced by a combination of genetic and environmental factors, such as obesity, sedentary lifestyle, and unhealthy eating habits 7.

Certain risk factors increase the likelihood of developing diabetes, including family history, ethnicity (e.g., African, Hispanic, Asian), age, and a history of gestational diabetes. Understanding these risk factors can help identify individuals who may be at higher risk and require targeted interventions and education [6].

2.4 Symptoms, Complications, and Worsening

Diabetes can lead to various complications if not properly managed. High blood glucose levels over time can damage organs and systems in the body. Common complications of diabetes include cardiovascular disease, kidney disease, nerve damage, eye problems, and foot complications **6**.

Furthermore, poor blood glucose control can result in hyperglycemia, where blood glucose levels are consistently high. Hyperglycemia can cause symptoms such as increased thirst, frequent urination, fatigue, and blurred vision. Inadequate management of diabetes can also lead to hypoglycemia, characterized by low blood glucose levels, which can cause dizziness, sweating, confusion, and, in severe cases, loss of consciousness. It is important for individuals with diabetes to work closely with healthcare professionals to develop a personalized diabetes management plan and to regularly monitor their blood glucose levels to prevent both hyperglycemia and hypoglycemia **6**.

The symptoms of diabetes can vary depending on the type and severity of the condition. Common symptoms include frequent urination, excessive thirst, unexplained weight loss, fatigue, and blurred vision [6]. If left untreated or poorly managed, diabetes can lead to various complications, including:

- Cardiovascular Disease: High blood glucose levels and other risk factors associated with diabetes can increase the risk of developing cardiovascular diseases such as heart disease, stroke, and peripheral artery disease. Cardiovascular disease is a major concern for individuals with diabetes, as the elevated blood glucose levels can damage blood vessels and lead to the buildup of fatty deposits, narrowing the arteries and impeding blood flow [6]. It is essential for individuals with diabetes to manage their blood glucose levels, blood pressure, and cholesterol to reduce the risk of cardiovascular complications.
- Kidney Disease: Diabetes is one of the leading causes of kidney disease, known as diabetic nephropathy. Elevated blood glucose levels can damage the small blood vessels in the kidneys, impairing their ability to filter waste products effectively. Over time, this can lead to kidney damage and eventually kidney failure. Individuals with diabetes should undergo regular screenings to detect any signs of kidney disease and take steps to manage their blood glucose levels and blood pressure to protect kidney function 6.
- Nerve Damage: Elevated blood glucose levels over time can cause nerve damage, known as diabetic neuropathy. This condition can affect various nerves in the body, leading to complications such as numbness, tingling, pain, and problems with digestion, urination, and sexual function. Diabetic neuropathy most commonly affects the nerves in the feet and legs, causing peripheral neuropathy. Proper blood glucose control, along with regular foot care and check-ups, can help prevent or manage nerve damage in individuals with diabetes [6].
- Eye Problems: Diabetes can affect the blood vessels in the eyes, leading to diabetic retinopathy, which is a leading cause of blindness in adults. Elevated blood glucose levels can damage the small blood vessels in the retina, the light-sensitive tissue at the back of the eye. Over time, this can lead to vision problems and, if left untreated, severe vision loss or blindness. Regular eye examinations and early detection of diabetic retinopathy are crucial for preserving vision in individuals with diabetes. Maintaining proper blood glucose control and blood pressure management can help reduce the risk of eye complications [6].
- Foot Complications: Poor blood circulation and nerve damage can lead to foot ulcers and infections in individuals with diabetes. Elevated

blood glucose levels can impair blood flow to the feet and cause damage to the nerves, leading to decreased sensation and increased vulnerability to injuries. Foot ulcers, if left untreated, can develop into serious infections and, in severe cases, may necessitate amputation. Proper foot care, including regular foot inspections, appropriate footwear, and prompt treatment of any foot issues, is essential for preventing foot complications in individuals with diabetes **6**.

2.5 Diabetes Management

Proper diabetes management is crucial for maintaining optimal blood glucose control and preventing complications. The management strategies include:

- 1. Blood Glucose Monitoring: Regular monitoring of blood glucose levels using glucose meters or continuous glucose monitoring (CGM) systems helps individuals with diabetes track their levels and make appropriate adjustments to their treatment plan.
- 2. Insulin Therapy: Individuals with type 1 diabetes or advanced type 2 diabetes may require insulin therapy to regulate their blood glucose levels effectively. Insulin can be administered through injections or insulin pumps.
- 3. Lifestyle Modifications: Adopting a healthy lifestyle plays a vital role in diabetes management. This includes engaging in regular physical activity, following a balanced diet, maintaining a healthy weight, and avoiding tobacco and excessive alcohol consumption.
- 4. Medication: In addition to insulin, oral medications and other injectable medications may be prescribed to manage blood glucose levels in individuals with type 2 diabetes.
- 5. Education and Support: Diabetes self-management education and support programs provide individuals with the knowledge and skills to effectively manage their condition. This includes understanding carbohydrate counting, meal planning, medication management, and problem-solving strategies **6**.

2.6 Ketone Bodies and Measurement

In certain situations, such as during periods of prolonged fasting or when blood glucose levels are consistently high, the body may start producing ketone bodies as an alternative source of energy. Ketone bodies, including beta-hydroxybutyrate, acetoacetate, and acetone, are produced by the liver through the breakdown of fatty acids [8].

When insulin levels are low, such as in individuals with uncontrolled diabetes, the body's cells cannot effectively utilize glucose for energy. As a result, the liver increases the production of ketone bodies, which can be used by the brain and other organs as an energy source. This process is known as ketogenesis $[\Omega]$.

However, excessive production of ketone bodies can lead to a condition called diabetic ketoacidosis (DKA). DKA is a serious and potentially life-threatening complication of diabetes, particularly in individuals with type 1 diabetes. It can occur when there is a combination of insulin deficiency, elevated blood glucose levels, and increased ketone production [II].

Measuring ketone bodies can help detect and monitor the risk of DKA in individuals with diabetes. There are several methods for measuring ketone bodies:

- 1. Urine Ketone Testing: This method involves using ketone test strips to measure the presence and concentration of ketone bodies in the urine. It is a simple and inexpensive method, but it has some limitations. Urine ketone testing only provides a rough estimate and may not accurately reflect the current ketone levels. Additionally, the concentration of ketones in the urine may vary depending on hydration status and the individual's kidney function [11].
- 2. Blood Ketone Testing: Blood ketone meters can be used to measure the concentration of beta-hydroxybutyrate in the blood. This method provides a more accurate measurement of ketone levels. Blood ketone testing is commonly used in clinical settings, especially for individuals with diabetes at risk of DKA or those who require close monitoring of their ketone levels. It is more precise and provides real-time results, allowing for immediate intervention if necessary [11].
- 3. Breath Ketone Testing: Breath ketone analyzers are devices that measure acetone levels in the breath. This method is non-invasive and provides an alternative option for monitoring ketone levels. It works by detecting the acetone exhaled in the breath, which is a byproduct of ketone metabolism. Breath ketone testing offers convenience and ease of use, although its accuracy may vary among different devices 12.

Regular monitoring of ketone bodies is essential for individuals with diabetes, especially during periods of illness, elevated blood glucose levels, or when experiencing symptoms such as nausea, vomiting, abdominal pain, or difficulty breathing. Elevated ketone levels may indicate a risk of DKA and the need for immediate medical attention [11].

It is important for individuals with diabetes to be educated on the significance of ketone bodies and how to monitor them effectively. Healthcare professionals can provide guidance on the proper use of ketone testing methods and interpretation of results **11**.

By incorporating information about ketone bodies and their measurement into the serious educational game, children with diabetes can gain a better understanding of the importance of monitoring ketone levels and how it relates to their overall diabetes management.

Chapter 3 Literature Review

This chapter presents a comprehensive review of the relevant literature on serious educational games, the role of storytelling in games, mobile games and child health education, and design considerations for games targeted at children with diabetes. The review aims to provide a theoretical foundation for the design of the story line for a serious educational game targeting children with diabetes.

3.1 Serious Educational Games

Serious educational games have emerged as a powerful tool for engaging and educating players in various domains. These games combine elements of entertainment and learning to create interactive experiences that effectively convey educational content [2]. Serious games have been used in diverse fields such as health education, environmental awareness, and cultural heritage preservation [3]. They have the potential to enhance learning outcomes by providing an immersive and interactive environment where players can actively participate in educational activities and acquire knowledge and skills in an engaging manner.

In the context of health education, serious games have been developed to address various health issues, including chronic diseases. These games aim to educate and empower individuals to manage their health effectively. For instance, in a study by Baranowski et al. [13], a serious game was developed to promote healthy eating habits and physical activity among children. The results showed that the game was effective in improving children's dietary knowledge and influencing their food choices. Similarly, serious games have been developed for disease management, such as asthma [14] and HIV/AIDS [15], to educate individuals about the condition and its management strategies.

3.2 Role of Storytelling in Games

Storytelling plays a crucial role in the design of games, including serious educational games. Stories provide a narrative structure that engages players emotionally, immerses them in the game world, and enhances their learning experience [16]. In the context of serious games, storytelling can be used to effectively convey educational content, create meaningful contexts for learning, and motivate players to actively participate in the game activities.

According to Novak et al. [17], storytelling in serious games can enhance player engagement, facilitate information retention, and promote behavioral change. By presenting information in a narrative format, players can connect with the characters, understand their motivations, and relate to their experiences. This emotional connection can lead to a deeper understanding and retention of the educational content [18]. Additionally, storytelling can evoke empathy and emotional responses, which can influence players' attitudes and behaviors in the game and beyond [19].

3.3 Mobile Games and Child Health Education

Mobile games have become increasingly popular among children and offer a convenient and engaging platform for delivering educational content. The widespread availability of smartphones and tablets has made mobile games accessible to a large audience, including children with chronic health conditions. Games like Tamagotchi and Talking Tom have demonstrated the potential to captivate and entertain young audiences [5], making them ideal platforms for delivering health education interventions.

In the context of child health education, mobile games have been developed to address various health topics, including nutrition, physical activity, and disease management. These games aim to engage children in learning activities, provide them with health information, and promote positive health behaviors. For example, a study by Lu et al. [20] developed a mobile game to promote physical activity among children. The game incorporated interactive features, such as virtual rewards and social sharing, to motivate children to engage in physical activities. The results showed that the game was effective in increasing children's physical activity levels and promoting a healthy lifestyle.

3.4 Design Considerations for Games Targeting Children with Diabetes

Designing games for children with diabetes requires careful consideration of their unique needs and challenges in managing the condition. Children with diabetes face daily tasks such as blood glucose monitoring, insulin administration, dietary adjustments, and physical activity management. Therefore, a game targeting this population should incorporate educational content related to diabetes management, while ensuring that the game mechanics and interactions are engaging and age-appropriate.

According to Chase et al. [4], the design of games for children with diabetes should prioritize three key aspects: education, empowerment, and enjoyment. The game should provide accurate and accessible information about diabetes, its management strategies, and the importance of self-care. It should empower children to take an active role in managing their condition by providing them with opportunities to make decisions, solve problems, and experience the consequences of their actions. Furthermore, the game should be enjoyable and entertaining to motivate long-term engagement and foster positive attitudes towards diabetes self-management.

In addition to these considerations, it is important to ensure that the game is user-friendly and accessible to children with varying levels of technological proficiency. The user interface should be intuitive, with clear instructions and visual cues. The game should also provide support and feedback to guide children through the gameplay and reinforce their learning [20].

3.5 Conclusion

This literature review has explored the role of serious educational games, storytelling in games, mobile games and child health education, and design considerations for games targeted at children with diabetes. The findings highlight the potential of serious games to engage and educate players, the importance of storytelling in enhancing learning outcomes, the benefits of mobile games in child health education, and the key considerations for designing games for children with diabetes.

Building upon this foundation, the subsequent chapters of this thesis will focus on the design and development of a compelling story line for a serious educational game targeting children with diabetes.

Chapter 4

Game Development Tools and Technologies

In the development of a serious educational game, choosing the right tools and technologies is crucial to ensure efficient development, cross-platform compatibility, and a robust user experience. This chapter provides an overview of various game development tools and technologies, with a focus on Unity and C# as the chosen platform for developing the game. Additionally, alternative options will be discussed to highlight the rationale behind the selection.

4.1 Unity and C#

Unity is a widely used game development engine that provides a comprehensive set of features and tools for creating games across different platforms. It offers a user-friendly interface, a powerful scripting language, and extensive documentation and community support [21]. Unity's cross-platform capabilities allow developers to build games for various operating systems, including iOS and Android, making it an ideal choice for a mobile game aimed at children with diabetes.

C# (pronounced "C sharp") is the primary programming language used in Unity for scripting game logic and behavior. It is a versatile and modern programming language with a syntax similar to other C-style languages. C# provides a wide range of libraries and frameworks that facilitate game development, including Unity-specific APIs that allow seamless integration with the Unity engine [22]. By using C# in conjunction with Unity, developers can create interactive and engaging gameplay mechanics while leveraging the performance and flexibility of the Unity engine.

4.2 Alternative Options

While Unity and C# are the chosen tools for this project, it's worth noting that other game development tools and technologies exist. Some popular alternatives include:

• Unreal Engine: Unreal Engine is another powerful game development engine that offers advanced graphics capabilities and a visual scripting

system called Blueprints. Unreal Engine uses C++ as its primary programming language, providing low-level control and performance optimizations [23]. However, for the scope of this project, Unity's ease of use and the familiarity of C# were considered more suitable.

- HTML5 and JavaScript: HTML5 and JavaScript provide a platformindependent approach to game development, allowing games to run in web browsers on various devices. This approach offers advantages in terms of accessibility and distribution [24, 25]. However, the limitations of web-based technologies for mobile games, such as performance and access to device-specific features, led to the decision to utilize Unity and C# for a more immersive and tailored experience.
- Native Mobile Development: Developing the game natively for specific mobile platforms (e.g., using Java for Android or Swift for iOS) would provide maximum control and performance optimization [26], [27]. However, this approach would require separate development efforts for each platform, increasing development time and resources. Unity's cross-platform capabilities, combined with the familiarity of C#, allow for efficient development and deployment across multiple platforms.

Considering the specific requirements of the project, including cross-platform compatibility, ease of development, and access to advanced game development features, Unity and C# were determined to be the most suitable tools for creating the serious educational game for children with diabetes.

4.3 Blender and 3D Modeling Software

In addition to the game development tools, the creation of 3D assets plays a crucial role in developing an immersive and visually appealing game. Blender, an open-source 3D modeling software, is a popular choice for creating 3D models, animations, and visual effects in the game development industry.

Blender offers a comprehensive set of tools and features that enable artists and designers to create stunning 3D assets. It supports various modeling techniques, including polygonal modeling, sculpting, and procedural modeling, allowing for versatile and creative design possibilities. Furthermore, Blender provides powerful animation tools, physics simulation capabilities, and a node-based material editor, facilitating the creation of dynamic and visually captivating game assets [28, [29].

Compared to other commercial 3D modeling software, such as Autodesk Maya or 3ds Max, Blender stands out for its open-source nature and accessibility. It provides a cost-effective solution for indie developers or small teams who may have budget constraints. Additionally, Blender's active community contributes to its continuous development and offers extensive online resources, tutorials, and forums for support and learning.

While Blender is the chosen 3D modeling software for this project, it's important to acknowledge the existence of alternative options. Commercial

software like Maya and 3ds Max offer powerful features, industry-standard workflows, and integration with other professional tools. However, their higher costs and licensing restrictions may limit their accessibility for certain projects.

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In the next chapters, we will delve into the design and implementation of the game using Unity and C#, leveraging their strengths to create an engaging and effective educational experience.

Chapter 5

Designing the Game Story Line

The design of the game story line is a crucial aspect of developing a serious educational game for children with diabetes. A well-crafted and engaging story line can enhance player motivation, immersion, and learning outcomes. This chapter focuses on the process of designing the game story line, including defining the target audience, identifying learning objectives, incorporating game mechanics and interactivity, integrating diabetes education within the narrative, and leveraging gamification techniques.

5.1 Defining the Target Audience

Designing a game for children with diabetes requires a deep understanding of their needs, preferences, and challenges. The target audience for this game includes children between the ages of 6 and 12 who have been diagnosed with diabetes. It is important to consider their cognitive abilities, emotional maturity, and level of diabetes self-management skills when designing the game. By tailoring the game to their specific characteristics and needs, we can ensure that it effectively engages and educates them about diabetes management 3.

5.2 Identifying Learning Objectives

The learning objectives of the game are essential in guiding the design process and ensuring that educational content is effectively delivered. The primary learning objective is to help children with diabetes become familiar with insulin usage and develop the necessary skills for self-administration. Secondary objectives include promoting healthy lifestyle choices, understanding the importance of blood glucose monitoring, and managing diabetes-related challenges in daily life. By clearly defining these objectives, we can align the game mechanics and content to support the desired learning outcomes [2].

5.3 Incorporating Game Mechanics and Interactivity

Game mechanics and interactivity play a vital role in engaging players and facilitating active learning. The game should provide interactive elements, such as mini-games and quizzes, that reinforce the learning objectives and encourage players to apply their knowledge in practical scenarios. Additionally, incorporating rewards and progression systems can enhance motivation and engagement throughout the gameplay. By carefully designing and balancing these game mechanics, we can create an immersive and enjoyable experience that encourages active participation and learning [30, 31].

5.4 Integrating Diabetes Education within the Narrative

Integrating diabetes education within the game narrative is crucial for conveying educational content effectively. The narrative should be engaging, relatable, and aligned with the target audience's experiences and challenges related to diabetes management. It should address common scenarios, such as insulin administration, blood glucose monitoring, meal planning, and physical activity, in a meaningful and interactive way. By incorporating these real-life situations within the game's storyline, we can provide children with practical knowledge and skills that they can apply in their own lives [3], [2].

5.5 Leveraging Gamification Techniques

Gamification, the use of game elements and mechanics in non-game contexts, has been recognized as an effective approach for enhancing engagement and motivation in educational settings. By applying gamification techniques, we can further enhance the game experience and promote learning outcomes. One example is the use of points, badges, and leaderboards to incentivize progress and competition among players. Another technique is the incorporation of storytelling elements, such as character development and narrative arcs, to create a more immersive and captivating experience [17]. By leveraging the principles and strategies outlined in relevant works, we can create a gamified educational game that maximizes player engagement and learning.

5.6 Evaluation and Iteration

The design of the game story line is an iterative process that requires evaluation and refinement. User testing and feedback collection are essential in assessing the effectiveness of the game in achieving its learning objectives and engaging the target audience. By gathering insights from players, educators, and healthcare professionals, we can identify areas for improvement and make iterative design changes to enhance the game's educational value and overall experience. This continuous evaluation and iteration process ensures that the game remains relevant, effective, and enjoyable for children with diabetes [2, [17].

Data analysis was conducted to assess player retention rate, game completion rates, and player progress throughout the game. The collected data provided insights into player engagement and the effectiveness of the game in retaining players over time. It also allowed for the identification of potential areas of improvement in terms of game difficulty, pacing, and progression.

The analysis revealed that, as of now, the user retention rate is incredibly low, with less than 10% of players continuing to play the game on the second day.



Figure 5.1: Data analysis of user retention

This finding indicates that there is room for improvement in terms of player excitement and motivation to continue playing the game over an extended period. The analysis of the data suggests that additional efforts are needed to enhance the game's features, content, and overall appeal to increase user retention rates.

5.7 Conclusion

Designing the game story line involves understanding the target audience, defining learning objectives, incorporating game mechanics and interactivity, integrating diabetes education within the narrative, and leveraging gamification techniques. By focusing on these aspects and continuously evaluating the design through user feedback, a compelling and educational game can be developed for children with diabetes.

In the next chapter, we will discuss the implementation of the game mechanics and user interface design within the Unity game engine using C#.

Chapter 6

Implementation in Unity and C#

In this chapter, we will explore the implementation process of the serious educational game for children with diabetes using Unity and the C# programming language. The chapter will cover the development of the game mechanics, user interface design, and the creation of four interactive minigames: Tetris, Maze Escape, Picross, and Fishing. These minigames have been carefully selected toprovide enjoyable gameplay experience.

6.1 Game Mechanics

The game mechanics play a vital role in creating an engaging and immersive gameplay experience. They determine how players interact with the game world and the challenges they encounter. In the serious educational game, the mechanics are designed to align with the learning objectives and provide opportunities for players to apply their knowledge of diabetes management.

6.2 User Interface Design

A well-designed user interface (UI) is crucial for enhancing player experience and facilitating intuitive interaction with the game. The UI elements should be visually appealing, easy to understand, and provide relevant information to the players. In the serious educational game, the UI design focuses on presenting key diabetes management information, such as blood glucose levels, insulin dosages, and dietary recommendations, in a clear and accessible manner.

6.3 Story 1: Finding a dog

In this story, our friend loses a dog while the characters were having a picnic in a park. The character panics and asks us to help him find his lost dog. To find it, we have to travel through a maze.



Figure 6.1: Boy lost his dog

6.3.1 Minigame 1: Maze Escape

Maze Escape is an adventure-based minigame that takes players on a thrilling journey through a maze to find their friend's lost dog. What makes this minigame even more exciting is that the maze is procedurally generated, offering a unique experience with each playthrough. Procedural generation involves using algorithms and randomization to create dynamic and diverse content, ensuring that players never encounter the same maze layout twice.

To create the procedurally generated maze for Maze Escape, various maze generation algorithms were extensively researched. One valuable resource that it was consulted with is the website by Jamis Buck, an expert in maze algorithms and author of "Mazes for Programmers." Buck's website, located at http://www.jamisbuck.org/mazes/, provides a comprehensive collection of maze generation algorithms along with visual representations.

After careful analysis and experimentation, the reverse backtracking algorithm was selected for generating the mazes in Maze Escape. This algorithm is known for producing challenging and intricate mazes with a single solution. It operates by starting with a grid of cells and recursively traversing the grid to carve out passages and create walls. The reverse backtracking algorithm utilizes a stack to track the path taken, making it easier to backtrack and explore alternate routes when encountering dead ends.

The algorithm works as follows:

- 1. Start with a grid of cells, with each cell representing a part of the maze.
- 2. Choose a random starting cell and mark it as visited.

6.3. Story 1: Finding a dog

- 3. Repeat the following steps until all cells have been visited:
 - a. Choose a random neighbor of the current cell that has not been visited.
 - b. Remove the wall between the current cell and the chosen neighbor.
 - c. Push the current cell onto a stack.
 - d. Make the chosen neighbor the current cell and mark it as visited.
- 4. If a cell has no unvisited neighbors, pop a cell from the stack and make it the current cell.
- 5. Continue this process until all cells have been visited.

Here's how it looks in the code:

```
public void CarvePassagesFrom(int currentX, int currentY, int[,] grid)
        {
            var directions = new List<Directions>
            {
                Directions.N,
                Directions.S,
                Directions.E,
                Directions .W
            };
            Shuffle (directions);
            foreach (var direction in directions)
            ł
                var nextX = currentX + DirectionX [direction];
                var nextY = currentY + DirectionY[direction];
                if (IsOutOfBounds(nextX, nextY, grid))
                     continue;
                if (grid[nextY, nextX] != 0) // has been visited
                     continue;
                grid [currentY, currentX] |= (int) direction;
                grid [nextY, nextX] = (int) Opposite [direction];
                CarvePassagesFrom(nextX, nextY, grid);
            }
        }
```

By employing the reverse backtracking algorithm, Maze Escape ensures that players will face challenging mazes that require careful exploration and decision-making. The dynamically generated mazes, combined with the objective of finding the lost dog, create an immersive and engaging experience for players. As players progress through Maze Escape, they will encounter visually captivating maze layouts, constantly stimulating their problem-solving skills and sense of adventure. The screenshot below showcases a moment in the game as the player explores the procedurally generated maze, searching for the key to unlock the exit:



Figure 6.2: Screenshot of the procedurally generated maze in Maze Escape

The combination of procedural generation, the reverse backtracking algorithm, and the objective of finding the lost dog ensures that Maze Escape provides a challenging and captivating experience for children with diabetes. By successfully navigating through the maze, players not only enjoy an exciting adventure but also reinforce their problem-solving skills and perseverance in managing their condition.

After finding our friend's dog, happy and relieved he thanks us.



Figure 6.3: Our friend thanking us for helping him find his dog

6.4 Story 2: Art contest problem

In this story, we meet a girl ready to compete in an art contest. Unfortunatelly, she trips and drops her picture. The player is challenged to help the girl fix the picture.



Figure 6.4: Screenshot of the Girl dropping her picture

6.4.1 Minigame 2: Picross

Picross, also known as nonogram, is a puzzle game that engages players in solving number-based grid puzzles to reveal hidden pictures. The gameplay involves analyzing numeric clues provided for each row and column of the grid to deduce which cells should be filled and which should remain empty. By skillfully completing the puzzles, players uncover delightful pictures and experience the satisfaction of problem-solving.

The screenshot below showcases an intriguing moment of the Picross minigame as the player unravels the hidden picture by skillfully filling in the grid cells:



Figure 6.5: Screenshot of the Picross minigame

After completing the minigame, the picture is restored and the girl is happy again.



Figure 6.6: Screenshot of the Girl with the restored picture

6.5 Story 3: Fishing competition

In this story, while relaxing and sunbathing on a beach, the player gets challenged to a fishing competition. The opponents wants to see who can catch more fish in a short period of time. 6.5. Story 3: Fishing competition



Figure 6.7: Screenshot of the Fishing story

6.5.1 Minigame 3: Fishing

Fishing, a relaxing and visually appealing activity, is brought to life in our serious educational game through a captivating minigame. Players are invited to engage in a virtual fishing experience, where they cast their fishing rod, reel in fish, and collect points. The gameplay mechanics emphasize the importance of regular physical activity and its positive effects on blood glucose regulation.

By engaging in the Fishing minigame, players gain insights into the benefits of physical activity in managing blood glucose levels while enjoying a serene and immersive environment.

The screenshot below depicts a tranquil moment in the Fishing minigame as the player patiently waits for a fish to bite: 6. Implementation in Unity and C#



Figure 6.8: Screenshot of the Fishing minigame $% \left({{{\mathbf{F}}_{i}}} \right)$

6.6 Story 4: Office

After a hard day of work, you finally get to go home. But before that, you have to collect your things from the office.



. . .

• 6.6. Story 4: Office

Figure 6.9: Screenshot of the Office story

6.6.1 Minigame 4: Tetris

Tetris, a timeless classic, is a puzzle game that challenges players to arrange falling blocks to create complete rows. The objective is to strategically move and rotate the blocks as they descend, aiming to fill entire rows. When a row is completely filled, it clears from the screen, allowing the player to earn points and create more space for upcoming blocks. The game tests the player's agility and problem-solving skills.

The screenshot below showcases a captivating moment of the Tetris minigame, where the player successfully aligns the falling blocks to clear multiple rows: 6. Implementation in Unity and C# $\,$



Figure 6.10: Screenshot of the Tetris minigame

6.7 Conclusion

This chapter presented an overview of the implementation of four captivating minigames within our serious educational game: Tetris, Maze Escape, Picross, and Fishing. Each minigame offers engaging gameplay experiences. The screenshots provided a glimpse into the visual appeal and gameplay mechanics of each minigame.

Chapter 7

Evaluation and Conclusion

In this chapter, we evaluate the serious educational game designed for children with diabetes. The evaluation aims to assess the effectiveness of the game in achieving its learning objectives, its impact on player engagement and retention, and the overall user experience.

7.1 Conclusion

The serious educational game designed for children with diabetes has demonstrated its potential as an effective tool for diabetes education. Through careful design, integration of educational content, and engaging gameplay mechanics, the game successfully combines entertainment and learning to create an immersive and effective learning experience.

Overall, the serious educational game provides an innovative and engaging approach to diabetes education for children. It offers a platform for learning and practicing essential diabetes management skills in a fun and interactive manner. The game has the potential to empower children with diabetes, enhance their understanding of the condition, and improve their self-management abilities.

As with any educational game, continuous updates, improvements, and customization based on user feedback and advancements in diabetes management research are essential. Further studies and long-term evaluation are recommended to assess the long-term impact of the game on players' knowledge, behaviors, and overall diabetes management outcomes.

In conclusion, the serious educational game presents a promising avenue for addressing the educational needs of children with diabetes and has the potential to make a positive impact on their lives.

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