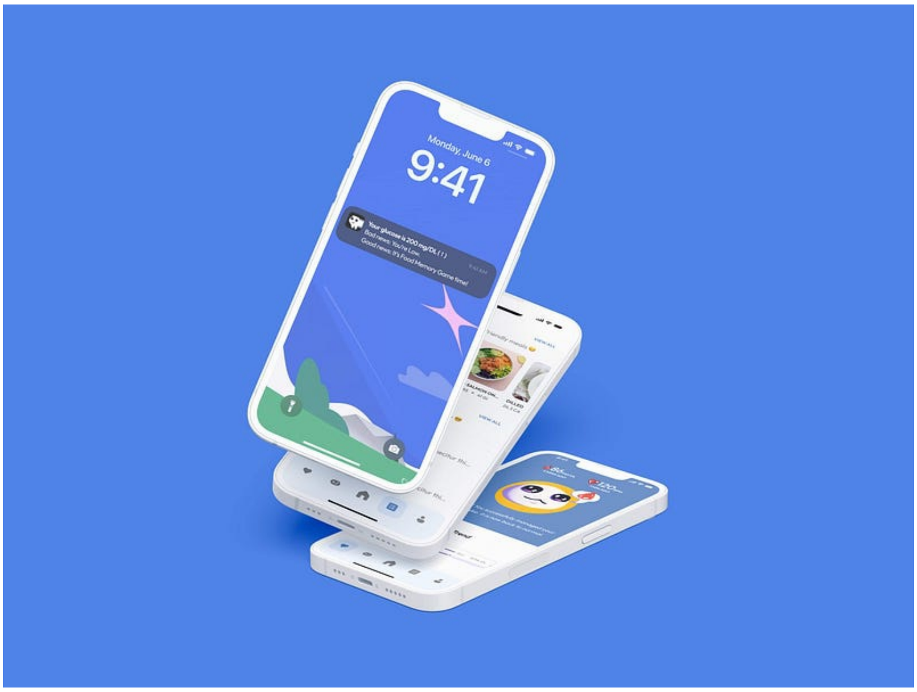
Sugar Slay (Summer '23 @ Northeastern Uni)

A Gamified Approach to Minimize Blood Glucose Variability with Sensor Integration I co-developed in Unity under ReGame-XR Lab



I interned as a game developer at ReGame-XR Laboratory at Boston's Northeastern University. The lab utilizes sensor technology to enhance the lives of those with medical challenges. We focus on interactive games that improve rehabilitation science research (Northeastern University, n.d.). This summer, I worked on gamifying diabetes management.

The use of HCs brought value to the project while I spent the first two weeks learning Unreal Engine and Unity—which is similar to learning two new programming languages. Specifically, I used HCs to learn more about the rationale behind the focus of our projects to make design decisions. I was in a team of six people the same age as me, so wearing multiple hats was expected to finish a working game in two months.

The Problem

This portion was laid out by Dr. Leanne Chukoskie for funding. I have tried my best to paraphrase and avoid plagiarism.

Type 1 Diabetes (T1D) is an autoimmune condition. It affects glucose metabolism and leads to a lifelong reliance on insulin (Centers for Disease Control and Prevention, 2023). The National Diabetes Statistics Report (2020) states that around 210,000 children and teenagers <20 years in the United States have been diagnosed with Diabetes (American Diabetes Association, 2022). Type 1 (T1D) diabetes is more common in young people than type 2 diabetes. However, the rates of both types in young people are increasing (CDC Newsroom, 2022). Borus and Laffel

(2010) emphasized that adolescents with T1D present more significant adherence challenges and have fewer tools uniquely designed to support them. A quote from the Diabetes National Service Framework (2001) summarizes the situation effectively, "Diabetes is often more difficult to control during the teenage years and in early adult life due both to the hormonal changes of puberty and to the emotional roller-coaster that often characterizes adolescence. Young people have higher rates of diabetic emergencies, and death rates are significantly higher than in young people without Diabetes. Greater effort is required to ensure effective diabetes control at this time than at any other stage of life by health professionals and young people themselves." (Dovey-Pearce & Christie, 2013).

T1D necessitates daily management through a combination of lifestyle adjustments, including diet and exercise, and medications like insulin injections and oral drugs to mitigate the potential harm caused by elevated blood glucose levels (BGL) to various organ systems (Mayo Clinic, 2022). Controlling blood glucose variability (GV) remains the primary challenge. People with diabetes have unique patterns in their blood sugar levels. This makes it challenging to consistently predict and manage their insulin needs, especially since insulin resistance is high during puberty (Jeffery et al., 2012; Kovatchev, 2019).

Advances in sensor technology, including continuous glucose monitors (CGM), insulin pumps, and smartwatch technologies, unlock a treasure trove of data about and for each patient user. Researchers discovered how technology-based intervention (TPT) is better compared to standard care (SC) in Diabetes management (Signos, n.d.; Shamanna et al., 2022). However, such efforts are shrouded in black box technologies. Their solution informs actions for clinicians, but it disables an individual's learning about their glycemic variability (The IQVIA Institute, 2020). The information typically goes to highly-trained and diverse teams of clinical partners who, in the best cases, have integrated patient data available to them and can make informed recommendations for specific scenarios the patient experiences (Sutton et al., 2020). However, clinician time is limited, and visualizations of biometric-integrated data can be complex and challenging to interpret, especially for non-experts.

Figure 1

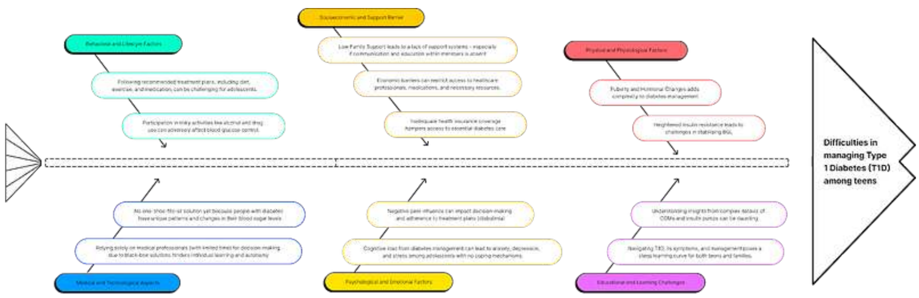
The Diabetes-Monitoring Sensor Technology

Note. An example of a continuous glucose monitor (CGM) (lower right) with its companion app full of bio information and statistics (center). An Apple watch is shown as it is another device used to gather more holistic data such as heart rate, number of steps, and more (lower left).

I created a fishbone diagram highlighting multiple factors contributing to difficulty in diabetes management for teenagers newly diagnosed with T1D. Doing this helped the team create a mold a.k.a constraints for the solution.

Figure 2

Factors contributing to difficulties in managing T1D among teens.



Note. A Fishbone Diagram to dissect problems. [Click me for a higher-resolution photo.] Due to limited word space, I have simply listed the sources I used in the creation of this diagram in the appendix.

The goal state is for tailored data-driven decision support for the patient-user that is delivered in real-time and in a supportive, educational, and engaging manner; to design a unique tool that accounts for biological needs, ultimately reducing diabetic emergencies and mortalities for young adults <20 years old without much clinician involvement. Technology and adherence are our key obstacles because the latest CGMs can only update their readings every 5 minutes. Additionally, adherence could be compromised due to overwhelming routines with this newly-diagnosed condition (Kalra et al., 2018). Teenagers' limited attention span also demands engaging content to maintain their involvement (Lodge, 2019). For now, the scale of this project will be within Northeastern's immediate reach: Boston.

In diabetes management, guidance is essential. To help us build toward a more intentional solution, I drew from my prior civic project on Airport Wayfinding (Kho et al., 2023). I likened our personalized diabetes management decision support tool to a GPS navigator for first-time travelers—Google Maps—adhering to Gavetti's framework (2014) in analyzing, understanding, and adapting analogies.

A GPS uses satellite data and maps to determine a traveler's location, speed, and direction, offering custom route suggestions based on factors like traffic and distance. Similarly, our continuous glucose monitor (CGM) support tool gathers glucose data to analyze blood glucose levels, insulin dosing, and other factors. Just as a GPS navigator adjusts directions based on deviations, our tool dynamically notifies patient-users of blood glucose fluctuations. While the ideal solution is for advanced personalization through advanced prediction algorithms, we've opted for a gamified notification system to instill foundational habits given our constraints. By drawing an analogy between our personalized diabetes management tool and a GPS navigator like Google Maps, I not only simplified the explanation of our solution but also found a clear path to guide our design decisions, which was especially helpful since we lack personal diabetes experience.

The Solution

Our solution is Sugar Slay. We wrapped sensor-based notification technology in an educational game that is designed as an engaging decision-support tool. Patient-users will make decisions about caring for a virtual pet based on their own sensor data. For example, a high glucose spike after a meal. This allows game-based simulation of potential outcomes safely, and in a manner that encourages learning, exploration, and habit-building. We began designing for adolescents with T1D who need to navigate their own glycemic control as they approach independent young adulthood.

For the newly diagnosed, the amount of GV information and changes to longstanding routines can lead to cognitive load. There is demand for the visualization of and interaction with complex data patterns. We propose to use incidents identified in a participant's data stream, such as glucose highs and lows, reduced sleep, physical activity, and atypical macronutrient intake to create learning scenarios in an educational game that is based on a Tamagotchi model.

Specifically, when the CGM detects a spike in blood sugar level, the player is notified. After confirming the application of insulin, the player goes through a series of mini-games sequenced to form healthy habits needed for Diabetes management.

Simon Food Memory Game

This game engages memory and cognitive skills. Associating ingredients with recipes encourages players to understand the nutritional value of various foods. By completing the game, players unlock healthy recipes tailored for diabetic individuals. This promotes better eating habits by teaching them how to prepare balanced and diabetic-friendly meals. It empowers individuals to make informed food choices, control portion sizes, and maintain stable blood sugar levels. As players repeat this game, they reinforce their knowledge of ingredients, recipes, and healthy cooking practices, creating a strong foundation for their dietary management.

Word Search

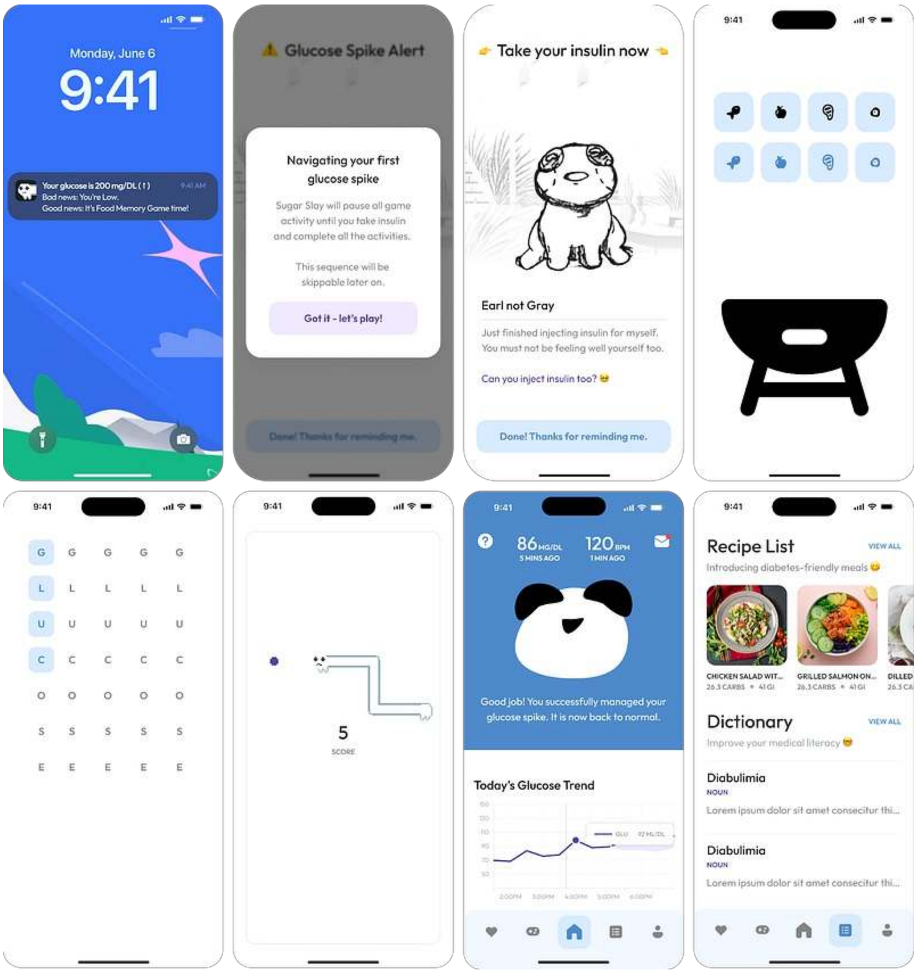
Learning about diabetes-related terms is crucial for effective self-care. The word search game not only enhances vocabulary but also encourages players to understand the meanings behind these terms. By completing the game, players add new words to their diabetes vocabulary. This helps them communicate more effectively with healthcare professionals and better comprehend the information they receive. Increasing their medical literacy empowers them to take ownership of their condition, ask relevant questions, and make informed decisions about their treatment and lifestyle choices.

Snake Game for Insulin Management

The Snake game serves a unique purpose by addressing the drowsy effects of insulin. Insulin management is essential for individuals with diabetes, but it can sometimes lead to fluctuations in energy levels (Farizani, 2023). The game's fast-paced nature keeps players mentally alert. By playing the Snake game, individuals can break the monotony of their day and reduce the risk of hypoglycemia-related drowsiness.

Figure 3

The mini-game sequence on high blood glucose trigger



Note. This series of Figma screens depict the sequential mini-games and interactions within Sugar Slay, aimed at habit-building and diabetes management skills through engaging educational games.

Dealing with Diabulimia

Diabulimia involves manipulating insulin doses to induce hyperglycemia and weight loss (Poos & McGowan, 2022). The roots of diabulimia can be understood through the concepts of conformity on multiple levels of analysis.

At the individual level, diabulimia may stem from adolescents' desire to conform to societal standards of attractiveness. Struggling with diabetes, they may feel self-conscious and yield to the pressures of fitting in, even if it means resorting to harmful practices like diabulimia. The influence of social networks and support groups is evident at the meso level. Peer interactions and virtual communities may inadvertently promote diabulimia by prioritizing weight loss over proper insulin management (Al-Sheyab et al., 2018). The normalization of such practices within these circles reinforces the idea that extreme measures are needed for appearance-based validation (Within, 2022). Societal emphasis (macro) on appearance contributes significantly to diabulimia. Cultural narratives and media representations perpetuate unrealistic body ideals, reinforcing the belief that conformity to these standards is crucial

(Coleman & Caswell, 2020).

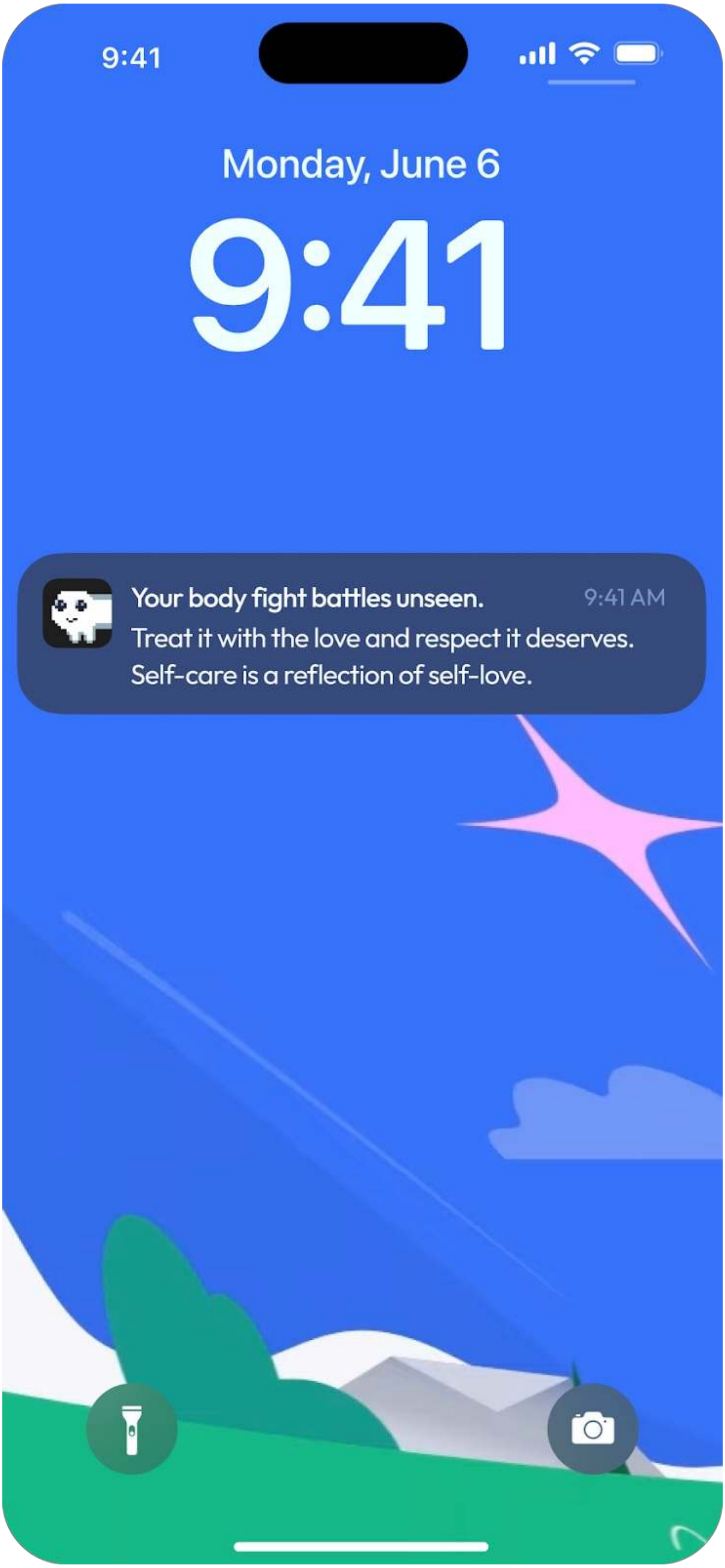
There is an interplay between levels, the individual's desire to conform to societal standards is amplified by peers and virtual communities at the meso level. Moreover, the societal emphasis on appearance at the macro level perpetuates these conformist ideals, reinforcing extreme measures for validation, ultimately culminating in the harmful practice of diabulimia.

In recent years, a notable contrarian effort has gained momentum on a larger societal scale. Mainstream media outlets have started diversifying representations of body types, prominently featuring plus-size models (Anderson et al., 2022). This deliberate departure from the conventional portrayal of beauty challenges prevailing conformity-driven ideals. This contrarian movement can exert a top-down influence on societal values, emphasizing health and well-being over appearance.

Building upon this contrarian notion, we have integrated motivational quotes into our personalized diabetes management tool. These quotes appear randomly on the lock screen, providing unexpected moments of encouragement and empowerment. This design decision not only counteracts the conformity-driven pressures but also serves a dual purpose. By associating positive affirmations with the app's notifications, we help alleviate potential stress and anxiety triggered by high blood glucose warnings.

Figure 3

A Screen displaying a "Positive Quote" Notification from Sugar Slay.



Note. A visual representation of a sample notification from Sugar Slay. The design aims to encourage patient users to prioritize their well-being and embrace a positive mindset in their journey with diabetes.

Dealing with Cultural Assumptions about Diabetes

While brainstorming about possible mini-games, I remembered my Filipino family advising against eating food with high sugar due to apparently being the sole cause of diabetes. Considering Filipinos' consistent emphasis on health rooted in generations of shared knowledge (National Integrated Research Program on Medicinal Plants, 2013), it is reasonable for me to assume that their stance on sugar stems from this accumulated wisdom.

I investigated further. In 2012, Goran et al. conducted a study exploring the connection between the availability of high fructose corn syrup (HFCS) and the prevalence of type 2 diabetes. More HFCS tended to have around 20% higher diabetes rates, even after accounting for factors like body weight, population, and economic indicators.

Formally, my argument aligns with a modus ponens format. If accumulated traditional knowledge suggests sugar causes diabetes (P), then studies such as Goran et al.'s might back the claim that sugar consumption contributes to diabetes (Q),' and (P) is supported by my family's beliefs, then based on Goran et al.'s study (Q), we can conclude that there's evidence to support the idea that sugar consumption might contribute to diabetes.
However, it is important to note that modus ponens is only a valid form of argument. It does not guarantee that the conclusion is actually sound. The premises of this argument could be false, even if it seems supported by evidence. It is also important to note that finding a correlation doesn't necessarily prove that one thing causes the other.

Skeptical of the simplistic causal mechanism, I scrutinized Goran et al's paper and discovered the use of ecological data, rather than individual-level data, introduces the possibility of an **ecological fallacy**, a fallacy of composition wherein correlations at the country level may not directly translate to causal relationships at the individual level (Nikolopoulou, 2023).

The study's mere observational nature prevents the establishment of definitive causality, leaving room for uncontrolled factors to influence observed associations. More rigorous methodologies, such as randomized controlled trials and individual-level data analysis, are needed to establish more understanding of HFCS in diabetes development.

In fact, a closer examination by Van Buul et al. (2014) of the cited study reveals a potential flaw. The HFCS consumption data for EU countries, portrayed as consumption data, were, in reality, production data. The article points out that HFCS in the EU is freely traded across borders, and thus, consumption and production figures represent different aspects of HFCS use. While I appreciate the thorough statistical analyses in Goran et al.'s paper, numerous flaws rendered this source unusable. I, instead, integrated being conscious of scientific soundness into the game by adding a subtle feature: **health facts during idle moments on the home screen**.

Figure 4

Engaging Fun Facts During Idle Moments on the Home Screen

Note. A visual representation of our virtual pet mentioning scientifically sound health facts to entertain our users while idling at the home screen, encouraging critical thinking for our young adults

In future internships with a similar code-heavy role, I will learn to ask for help from the right person earlier (#networks). Doing so will accelerate not only the project's progress, but it will also help me learn more about best practices and processes (#algorithms) earlier.

Word Count: 2,093 *(excluding in-text citations and figure notes)*

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Appendix A

Links used in the Fishbone Diagram

Al-Sheyab, N., Gharaibeh, T., & Kheirallah, K. A. (2018). Relationship between Peer Pressure and Risk of Eating Disorders among Adolescents in Jordan. *Journal of Obesity*, *2018*, 1–8. https://doi.org/10.1155/2018/7309878

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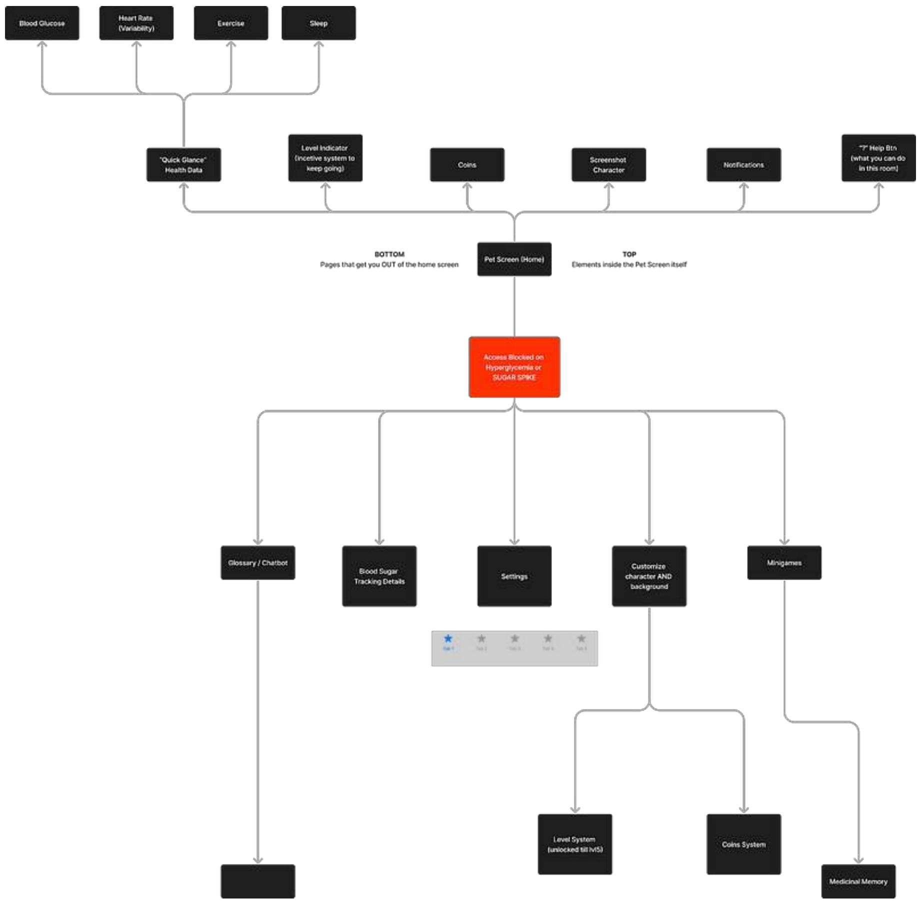
Appendix B

Sugar Slay User Interface (UI) Style Guide

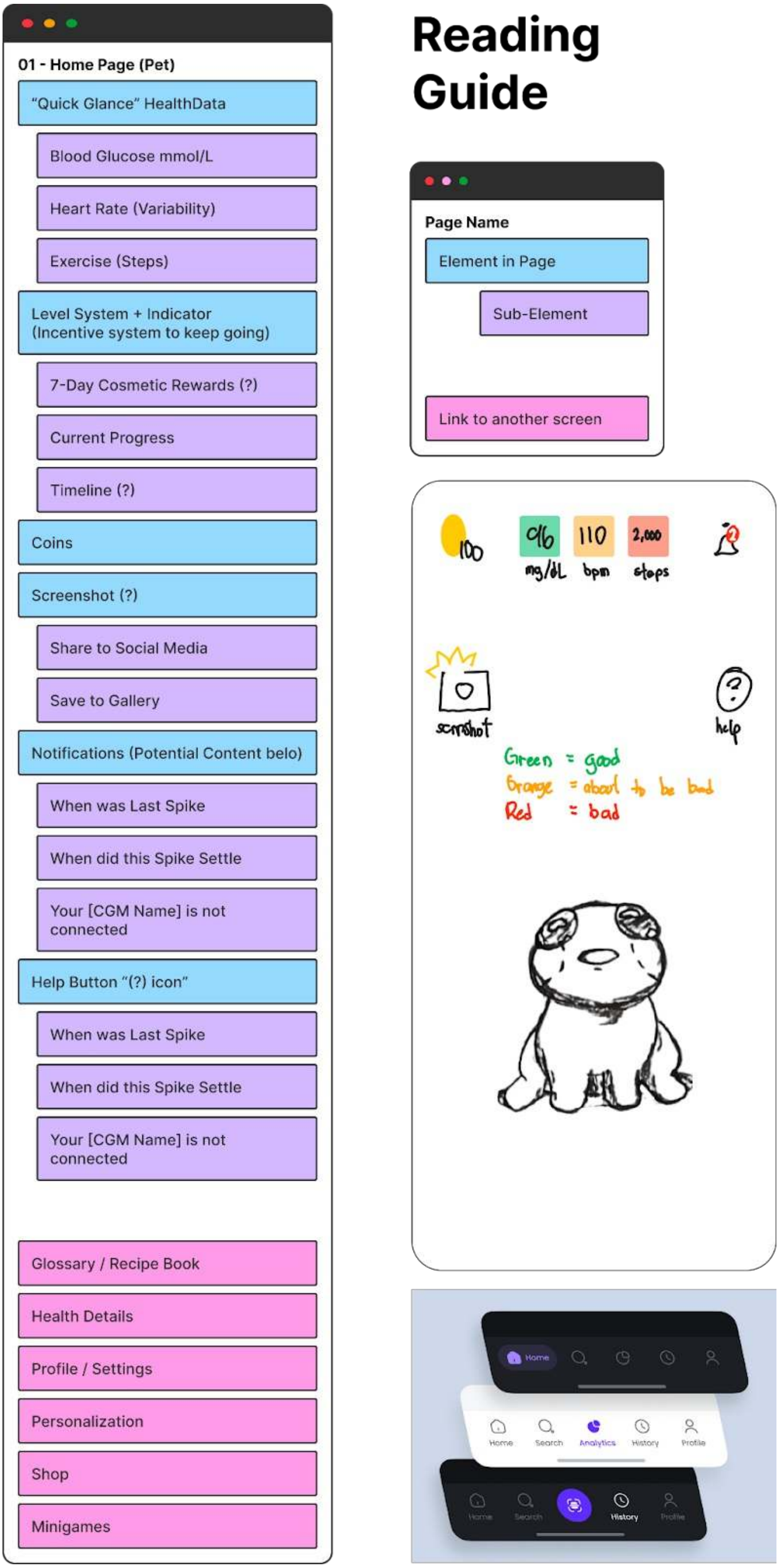
This figure provides a visual representation of the "Sugar Slay" style guide, highlighting its modern, clean, and playful design approach. The guide incorporates diabetes-themed colors and emojis to create a friendly and engaging atmosphere. Key elements such as typography, UI color scheme, and iPhone 14 Pro Max screen dimensions are featured, along with details about the free chosen font ("Outfit") and various emojis that contribute to the overall aesthetic.

Appendix D

Lo-Fi Screens—App Architecture



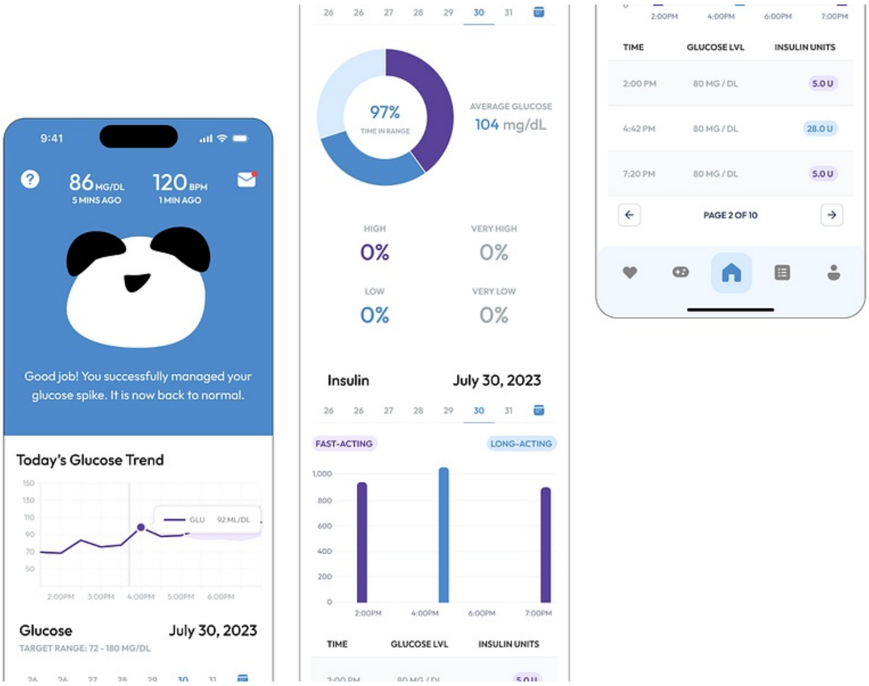
Blood Glucose
Heart Rate (Variability)
Exercise
Sleep
"Quick Glance" Health Data
Level Indicator (incetive system to keep going)
Coins
Screenshot Character
Notifications
"?" Help Btn (what you can do in this room)
BOTTOM
Pages that get you OUT of the home screen
Pet Screen (Home)
TOP
Elements inside the Pet Screen itself
Access Blocked on Hyperglycemia or SUGAR SPIKE
Glossary / Chatbot
Blood Sugar Tracking Details
Settings
Customize character AND background
Minigames
Level System (unlocked till lvl5)
Coins System
Medicinal Memory



Note. A visual representation and detailed description of the app architecture for the health and diabetes management application "Sugar Slay." Accessible in Figjam [(link)](link).

Appendix E

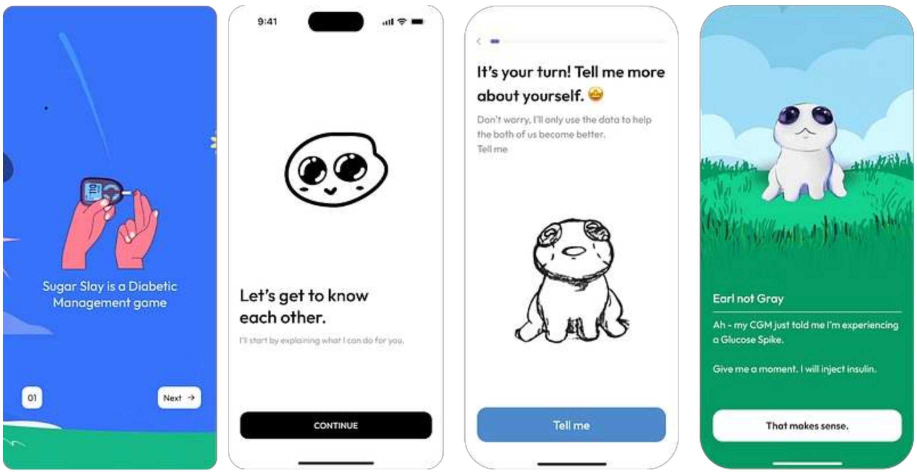
The Health Report Screen after every Sequence



Note. A visual representation of a glucose management dashboard displaying real-time glucose levels, heart rate, recent spike management, glucose trends, and insulin administration, offering users comprehensive insights into their diabetes management. This will be shown at the end of every mini-game sequence.

Appendix F

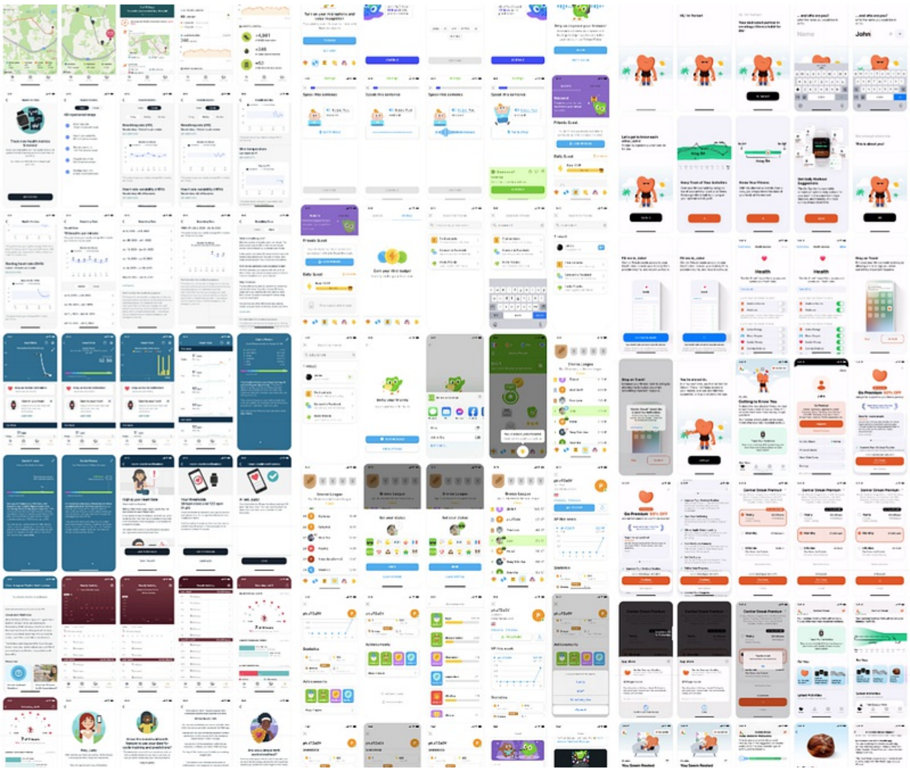
The User Interface and Aesthetic Evolution of the Game



Note. The evolution of the UI for the diabetes management application exemplified the design thinking process, navigating initial concerns about excessive cartoony elements to achieve a balanced fusion of playful aesthetics and the professional essence of a medical app.

Appendix F

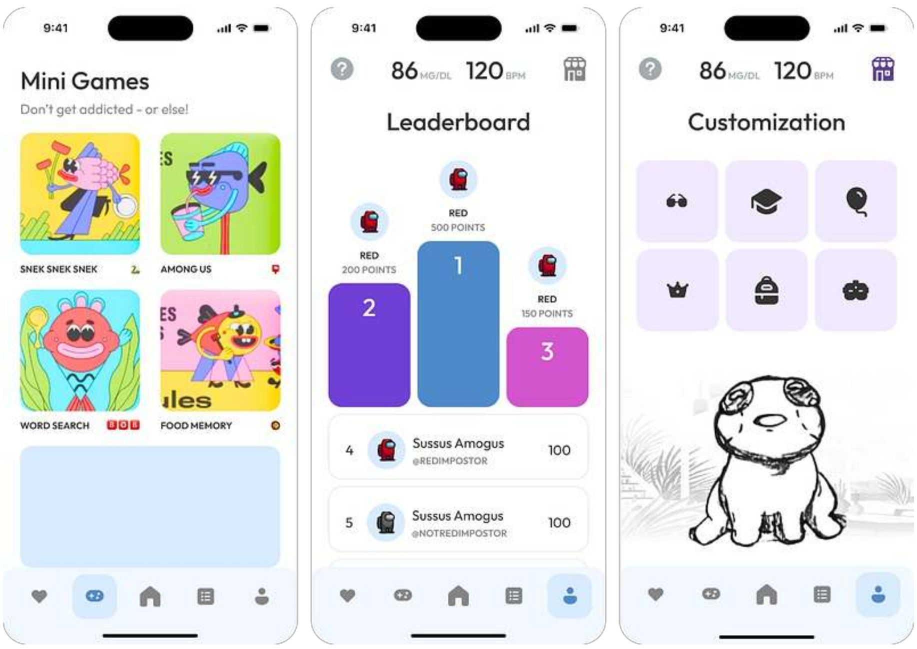
Competitor Analysis



Note. The compiled screenshot collection of various medical app screens analyzed for this project demonstrates a comprehensive review of the diverse design approaches, user interfaces, and functionalities across healthcare/education applications.

Appendix G

Other Screens in Sugar Slay



Note. The "other" Figma-designed screens encompassing mini-games, a leaderboard, and pet customization offer a visual representation of the interactive elements within the app, highlighting engagement through diverse game formats and a competitive ranking system, while also enabling personalization and playful pet costume customization.

By Carl Kho on August 18, 2023.

Canonical link

Exported from Medium on October 31, 2025.