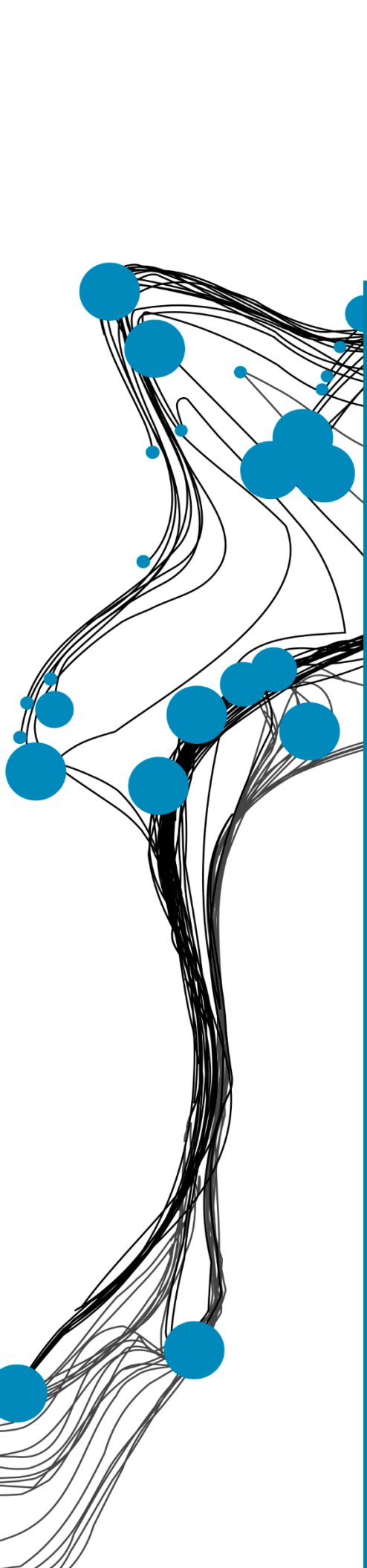

MASTER THESIS

TOWARD A HEALTHY LIFESTYLE: SIEGE ARENA AND HOW A GAMIFIED FRAMEWORK CAN BE APPLIED TO THE DESIGN OF A GAME FOR MANAGING AND TREATING CHRONIC CONDITIONS SUCH AS DIABETES AND OBESITY

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Abstract

Purpose – The aim of this research is to investigate and develop a game for managing and treating diabetes and obesity from a theoretical and practical perspective. In the wake of the Corona pandemic, having a healthier lifestyle is more important but also more difficult. To address this issue, the main research question is: *"How can a gamified framework be applied to the design of a game that seeks to manage and address treatment of chronic conditions such as diabetes and obesity?"*

Methodology – Wolfwinkel's Five-Stage Grounded Theory was used for the literature review and Peffers' Design Science Research Methodology was used to design Siege Arena and it was validated cyclically with a survey and interviews.

Findings – The theoretical results show that a gamified treatment framework should have these features: *Customizable Goal Setting, Education, Data Visualization, Reward/Feedback System, Activity Tracking, Game Element, Remote Monitoring, Social Options, Reminder System,* and *Personal Data Management*. Both theory and practice agree that the most important feature for ensuring the efficacy of a game that manages diabetes and obesity is the *Game Element.* The survey and interviews showed that the next most important features are *Reward/Feedback System, and Social Options.* Self-monitoring proves to be more difficult in practice than anticipated in theory because participants raised concerns regarding cheating when it comes to reporting nutritional intake. Theory makes a connection between *Reminder Systems* and keeping players engaged with the game for a long time, however, the interviewees reported that notifications could be intrusive. Finally, although the theory does not identify autonomy and empowerment as a feature that falls into the framework, the interview results raised this as a feature under self-motivation.

Conclusion/Discussion – Based on the results from the wireframe prototype validation, the identified framework contributes to the self-management portion of the treatment methods. The most important features of the framework are *Game Element, Reward/Feedback System, and Social Options*. Reminders should not be too intrusive so as not to put off players. Although the game is perceived to be effective in terms of living a better lifestyle, more research needs to be conducted in terms of developing a more accurate measure of self-management.

Keywords – gamification, gamifying, serious gaming, gaming, diabetes and obesity, chronic conditions

Contents

1. Introduction

This chapter introduces the problem\research area of this thesis undertaking. The problem context, being gamifying diabetes and obesity treatment is introduced and the research question, methodology and general overview of the structure of this report is also presented.

1.1 Problem Context

Obesity and Diabetes have become an increasingly significant health crisis in the recent years [1]. In the wake of the current global pandemic which has seen to an increase in sedentary behaviours and a decrease in physical activity among the general population, one might even say that the threat of obesity and diabetes and seeking to tackle and manage such issues is even more relevant [2]. This increase in sedentary behaviours and decrease in physical activity does not bode well on the already high extant levels of obesity and diabetes. Because of the comorbidity linking the two conditions (diabetes and obesity), both are associated with several other comorbidities including kidney disease, cardiovascular disease, and nerve issues [3].

Defined as a group of metabolic diseases which results in defects in insulin action, diabetes affects a large part of the population. For example, in The Netherlands in 2000, the estimated total number of known diabetes occurrence was 466,000 [4]. The treatment for diabetes lies in management and monitoring, adhering to medication, understanding the innerworkings of the diseases and gaining more knowledge about the disease, and self-management have been implemented to not only treat the disease but also to prevent it. Simply put, a combination of increased physical activity, better nutrition management, and blood monitoring have been proven to be effective means to stave of diabetes and obesity [1,3,5]. It is not only enough to have knowledge of these methods of treating diabetes and obesity. It is also important that adherence (the correspondence of someone's behaviour to the prescribed recommendations for treatments of chronic diseases) is also maintained and the key to this lies in long-term behavioural changes [5]. The complexity and need for tailoring in the treatment of diabetes means that the management of the disease often requires personalized advice and medical interference by a medical advisor. Therefore, it is important to promote personalized and suitable lifestyles that encourage being physically active as well as nutritional eating.

One promising avenue of research in terms of promoting a physically active lifestyle and nutritional eating in order to combat obesity and diabetes is that of gamification in health. Research

shows that gamification techniques applied to motivate adherence in diabetes patients has promising potential [7]. Although there is not one single agreed upon definition for gamification in the research, a general consensus is that gamification is the application or use of elements of games or game features in non-game contexts [5,6,7]. Gamification in the context of managing diabetes and obesity seeks to deploy elements of game design such as competitions, incentives, mini-games, goal setting and seeking, experience point systems, leader boards, and other such game elements in order to motivate behavioural change that adheres to managing diabetes and obesity (i.e., increasing physical activity and reducing sedentary habits) [4]. Gamification can also be taken a step further to advance daily treatment and management in a more pervasive manner by applying enjoyable game elements to keep users engaging in positive behaviours daily.

1.2 Research Questions

The goal of this thesis is to investigate a gamified treatment framework seeking to manage chronic conditions such as diabetes and obesity. In a game seeking to achieve said goal, this research aims to discover the most important features according to research to build a theoretical framework, analyse how these features translate to a game, and investigate the validity and reliability of the theoretical framework in the real world.

Thus, the main research question of this research project is:

1. How can a gamified framework be applied to the design of a game that seeks to manage and address treatment of chronic conditions such as diabetes and obesity?

The main research question was divided into the following sub questions in two parts to address the answer:

a) What are the main features of a framework for a game that seeks to manage diabetes and obesity according to literature?

b) Based on the theoretical framework developed from the literature, how can the identified features of said framework be translated to the design of a game for managing diabetes and obesity?

1.3 Research Method

The first research question was answered by conducting a systematic literature review in order to develop a model that identifies the necessary features of a game for treating and managing diabetes

and obesity. This model was developed using the Five Stage Grounded Theory method for literature review [8]. This review is further detailed in chapter 2.

The second research question was answered by developing a game prototype according to the resulting model of the first research question based on the Design Science Research Methodology developed by Peffers [23]. After the prototype design was completed, the artifact (i.e., the game prototype), was validated using a survey. Based on the results of the survey, the prototype is redesigned and validated to create a more detailed game prototype and put through a final round of evaluation through an interview. This research method is further detailed in chapter 4.

1.4 Outline

This thesis is divided into six chapters. Beginning with this chapter, an introduction to the thesis is provided. Chapter 2 delves into the methodology of the research which serves as the scientific backbone. The theoretical background and the literature review that was carried out resulting in a theoretical model is explained in chapter 3. Then in chapter 4, the theoretical model is translated into a game prototype design and the hypotheses for the validating survey are detailed. Chapter 5 shows the results of the survey and interview finally Chapter 6 details the discussion and conclusion of the research.

2. Methodology

This chapter presents the research methodology that guided this research undertaking. It starts by providing an overview of the methodology laid out by Peffers and ends with a detailing of how this research fits within said methodology.

This research makes use of Peffer's Design Science Research Methodology (DSRM) for research in the field of Information Systems [23].

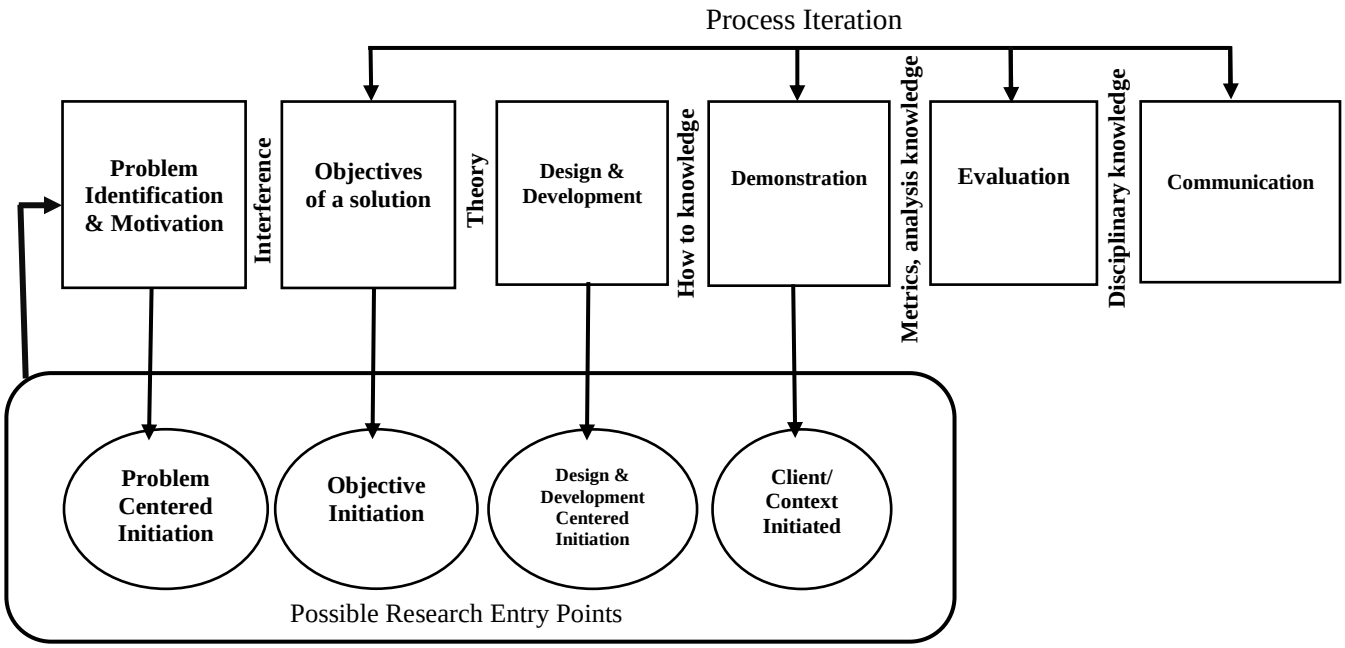

Figure 1: Design Science Research Methodology Process Model [23].

2.1 Problem identification

This involves the identification of the problem context and the justification of the research. Chapters 1 through 3 cover this aspect of the methodology because in order to identify the problem context, a literature review was carried out resulting in a model.

Based on the research, the problem context is identified to be the treatment and management of chronic conditions such as diabetes and obesity and the application of gamification to said treatment/management.

2.2 Define objectives of a solution

Here, the main objective of the research is to design or develop an artifact that provides a treatment when applied to the problem context. The requirements, features, and expectations of the artifact will be detailed in this process.

This was also done in the literature review where features for a game to manage a healthy lifestyle were identified and translated into a model. In the case of this thesis, the artifact is the game prototype that was designed, and the objectives can be found in the research questions (chapter 1). Due to time constraints and other limitations, the scope of this research undertaking was limited to only the self-management aspect of the resulting literature review model used to design the game and not the medical management aspect (meaning that the main focus was nutrition and physical activity).

2.3 Design and Development

This process involves the design and development of the artifact.

Using the features and the model resultant from the literature review, the game prototype of Siege Arena was designed and created. The design was carried out using a variety of programs namely, Justinmind Wireframe Prototyper, Adobe Illustrator, and Inkarnate Map Maker. By combining these programs, prototype screens of the game were created according to the features of the model. After the design, six hypotheses were developed in accordance with the research question to guide the next process of the research methodology.

2.4 Demonstration and Evaluation

The artifact is demonstrated and applied to the problem context for evaluation.

2.4.1 Survey

In order to evaluate the design of Siege Arena, the first prototype will be tested using a survey. Given that surveys are useful for measuring attitudes and sentiment towards an artifact, this method was chosen. Surveys can occur in a wide variety of forms and have the flexibility of being able to occur over a wide range of media (written, electronic, oral, etc.). The survey type that was selected for this research was the electronic web-based questionnaire due to the convenience and the current circumstances of the global Corona Virus pandemic. The questions of the survey were developed according to the Technology Acceptance Model questions [25] and the survey was designed to

investigate the first and second hypothesis (as these can be viewed as the more general hypothesis and the survey would garner general sentiment information regarding the prototype).

2.4.1.1 Participants

The target population of this research is young people (mostly students) within the age range of 19-35. The reason for this was that Siege Arena was designed with the target users of that age range in mind. Furthermore, due to time limitations, the limitations of the scope of this research, and accessibility options, the aforementioned age range was selected as the most accessible group. The target group of the game are explorers, achievers, and socializers and young people within the age range of late teenage years to early thirties. Furthermore, the part of the game that caters to the explorers involves the scavenger hunt, the social dashboard caters to socializers and the leader board and ranking systems cater to achievers. Therefore, the method of sampling was convenience and self-selection. All participants were required to be able to communicate in English as this was the given language of the prototype and all the survey materials. The initial aim was to reach over fifty participants, but the final number of participants involved was forty-two.

2.4.1.2 Survey Implementation

The survey made use of Likert-scale formatted questions using multiple questions to measure and operationalize constructs regarding the users' interaction with the game prototype. In addition to this, open-ended questions were used to assess the users' opinions regarding the aspects of the game they interacted with as well as a ranking system to more accurately gauge players opinions.

The survey was implemented by a social media post linking to the survey, and by contacting prospective participants (who I was acquainted with through schoolwork or social situations) through email. The former involved making a post on a closed marketplace group which only had members who were part of the University of Twente. A link to the survey was provided.

When the former implementation method proved to be insufficient, prospective participants were contacted via email with the link to the survey questionnaire. Furthermore, these participants were engaged to recruit other participants through word of mouth. This helped to ensure that participants had similar characteristics.

A total of forty-two participants participated in the survey ranging from age nineteen to thirty-five. Forty percent of the participants were female while the rest were male.

The clickable prototype of Siege Arena was uploaded to a website where participants of the survey could go through the different sections and screens of the game. This website was made accessible for mobile phones as well as websites because that was the intended platform of the game. A link to this website was provided with instructions and a brief description regarding the research to the participants before they were presented with the survey questions. Participants were also informed that should they wish to; they could withdraw from the research at any time.

The survey questions can be found in the appendix section B.

2.4.2 Interview

An important aspect of the Design Science Research Methodology framework is its iterative nature. Therefore, following the validation of the first prototype design through the survey, I implemented changes to the artifact and validated this redesign using an interview. The interview method is valuable because it allows for the narrow focus in terms of finding out user sentiments regarding the artifact. Though the questions were leading questions, they were open-ended in order to allow for more gathering of information from the participants answers. A semi-structured interview method was selected and using the interview protocol matrix as planned out by the Interview Protocol Requirement given by Yeong et al., the interview questions were mapped out onto the third to sixth hypotheses [26].

The Interview Protocol Requirement details an interview methodology that is theoretically sound and meant to guide and align the interview with the research questions [26]. The methodology includes the following steps:

Step 1: Aligning interview questions with research questions.
Step 2: Constructing an inquiry-based conversation.
Step 3: Receiving feedback from interview protocol.
Step 4: Piloting the interview protocol.

Due to the scope constraints and requirements of this research, only the first two steps were implemented into the interview methodology.

Under step 1, the interview protocol matrix will be used. This involves mapping out the questions of the interview based on the research questions or goals [26]. For the purposes of the research, the interview questions will be mapped out according to the hypotheses as they address the goals of the research.

Hypothesis 3 - Activity Tracking, Data Visualization, Education, Customizable Goal Setting, and Personal Data management contribute to users self-managing their conditions by assisting with Self-Monitoring

1. How do you think Siege Arena's activity tracking options will contribute to you having a healthier lifestyle?
2. How do you think Siege Arena's data visualization options will contribute to you having a healthier lifestyle?
3. How do you think Siege Arena's education options will contribute to you having a healthier lifestyle?
4. How do you think Siege Arena's Customizable Goal Setting options will contribute to you having a healthier lifestyle?
5. How do you think Siege Arena's Personal Data management options will contribute to you having a healthier lifestyle?

Hypothesis 4 - Reward/Feedback System, Social Options, and Reminder System contribute to users' self-motivation which helps them to manage their conditions.

6. How do you think Siege Arena's reward\feedback system will contribute to you having a healthier lifestyle?
7. How do you think Siege Arena's social options will contribute to you having a healthier lifestyle?
8. How do you think Siege Arena's reminder options will contribute to you having a healthier lifestyle?

Hypothesis 5 - Game Element contributes to users' better nutrition behaviours

9. In your opinion, how might Siege Arena contribute to having better nutritional habits for you?

Hypothesis 6 - Game Element contributes to users' Increased Physical Activity behaviours.

10. In your opinion, how might Siege Arena contribute to increasing physical activity for you?

2.4.2.1 Participants

The characteristics of the participants did not change from the survey method. Part of the survey included the participants indicating whether or not they would be interested in further partaking in this research. Out of the forty-two participants, nine indicated that they would be interested in further participation and provided their contact information. When reached out to with a request to partake in the interview, only four respondents replied and agreed to continue. Therefore, four participants were involved in the interview.

2.4.2.2 Interview Implementation

Due to the pandemic, the interview was carried out over digital means making use of zoom calls. The updated wireframe prototype was momentarily published in justinmind's website and email invitations to review this published prototype was sent out to the participants.

The first step of the interview was an introductory meeting letting the participants know the general information regarding the research and covering ethical considerations such as permissions, consent, data anonymity, and informing them that they could withdraw at any given time. When written consent was collected, the participants were asked to play around and interact with the prototype. Following this, the questions were asked, and the answers were noted.

The interview details can be found in the appendix section C.

2.5 Communication

The final process in the Peffers methodology is the communication process. Here, results of the preceding activities/processes are presented and conveyed in a meaningful manner.

This thesis report communicates the model, which was a result of the literature review, design, implementation, evaluation, results, and conclusions of the prototype of the game which will be made available on the essay database of the University of Twente. The results of this research will also be integrated into a larger research conducted by Dr. Ton Spil, one of the supervisors of this project.

3. Theoretical Background

This chapter brings together insights on information based on the authors previous research during the 'Research Topics' course and offers the theoretical background information for the thesis. The earlier research that was a systematic literature review that inspired me to develop a theoretical model for later aspects of the thesis research. This chapter serves as the problem identification and motivation processes of the Design Science Research Methodology model.

3.1 Research Questions for the Literature review

The research questions that guided the literature review were as follows:

1) *What are the main features of a framework for a game that seeks to manage diabetes and obesity according to literature?*
   a) *What are the treatment methods of diabetes and obesity according to research?*
   b) *What features determine the enjoyability, long-term playability, and quality (i.e., whether it is good or not) of a game that seeks to manage diabetes and obesity?*
   c) *What does a model seeking to identify necessary features for a game seeking to manage/treat diabetes and obesity look like?*

3.2 Literature Review Methodology

The method chosen for this literature review was Wolfswinkel's Five-Stage Grounded Theory Method for Literature Review [8]. This method was chosen because it offers a rigorous and well-structured method of reviewing the literature. The five stages include define, search, select, analyse, and present. First the literature selection was done through iterative searches in the database, SCOPUS, following this the selected literature was put through two rounds of analysis using open coding, axial coding, and selective coding to answer the research questions of literature review. The coding was done by reading the selected literature first to glean the major themes, then the major themes were coded, and the literature was reviewed again to find the relationship between major categories and answer the research questions.

3.3 Literature Review Results

The final number of literature selected for this review was whittled down from thirty-six to twenty. This section delves into the results of the review in terms of treatment methods identified, and the

most discussed gamified features for a treatment framework for diabetes and obesity as occurring in the research. Based on this, a model is developed.

3.3.1 Treatment Methods

Most of the literature indicate that there are potential opportunities to be reaped from applying game elements to the treatment of chronic conditions, yet more research needs to be done in order to understand the direct effect said elements will have on yielding behavioural change on the long run [18]. Based on existing literature, the treatment or management of diabetes and obesity can be achieved through self-management, self-monitoring, increased physical activity, decreased sedentary behaviour, and blood level monitoring [5,15, 16, 21].

3.3.2 Features of a game seeking to manage diabetes and obesity

The table below details the most important features of a game seeking to manage diabetes and obesity according to the research in terms of how frequently they appear among the selected literature (based on the coding processes).

Feature	Frequency	Percentage
Reward/Feedback System	12	66,67%
Game Element	11	61,11%
Activity Tracking	10	55,56%
Social Options	10	55,56%
Education	8	44,44%
Data Visualization	8	44,44%
Remote Monitoring	6	33,33%
Customizable Goal Setting	6	33,33%
Reminder System	3	16,67%
Personal Data Management	3	16,67%

Table 1: Frequency of occurrence of identified features in selected research

Education is a feature of the games that involves informing the users of the game or patients with relevant information regarding nutrition, health, and disease education. This helps with the self-management aspect of the chronic conditions [1,3,4]. Eight of the papers in this section highlight this as a relevant feature of a gamified treatment of diabetes and obesity [5,6,9,13,15,17,21,23].

This feature can be manifested by informing the patients about healthier food options, ways they can change their sedentary lifestyles, and risk factors regarding chronic conditions.

Customizable goal setting is a feature that has to do with the goals of the game being tailored to suit the specific user's needs and ability levels. Six of the papers in this section include this feature in the research [5,6,8,11,19,20]. As previously mentioned before, the complexity of treatment methods often means that the goals for the treatment have to be specific as instructed by medical personnel [5]. In essence, different patients or potential users have different skill levels and needs, thus the goal of the game must be flexible enough to suit this. This feature is important because it makes the game experience more relevant and effective for the user which translates to a higher investment in the game which means engaging with the game for a longer period of time [15]. This translates to the game having functions such as being able to input a "weight goal" or "having better nutrition" goal with a means of tracking the progress on said goal.

Activity Tracking is a feature that allows users to track their progress (e.g., distance walked, calorie consumption, heart rate, quality of sleep, etc.). This feature also contributes to the self-management portion of treating or managing chronic conditions such as diabetes or obesity [1,3,5,6,7,10,14,17,18,20].

Data Visualization is a feature that is tied to the education feature. Information regarding managing the levels of food intake, how much exercise is done, blood measurement levels, etc. was highlighted by eight of the papers as a relevant gamification feature for managing diabetes and obesity [1, 3, 5, 6, 7, 9, 11, 20]. While *activity tracking* deals with keeping track of the users' activities, *data visualization* differs from this because this deals with how the information is presented to the user. Furthermore, the data should be presented in way that is easily readable and understandable by the users while at the same time being meaningful for the medical professionals.

Personal Data Management. In a system with more than one user and perhaps even a social feature, it is important that users are able to track and manage their own personal data. This can keep them further informed about themselves [5-7].

Remote Monitoring is also an important feature for gamifying the treatment of diabetes and obesity. This is the aspect of the game that involves the medical professional. Health care workers

in charge of users need to have access to the user's information in order to track the users' health and provide better and more suited care to the users [1,3, 5, 6, 10, 12].

Game Element. Gamifying the treatment and management of chronic conditions does not only involve educating or tracking physical activity. The literature review shows that having game-like aesthetics and components such as a variety of activities is useful [18], and this means that the quality of being more game-like is a desirable feature for a game that addresses health issues. It is important that games seeking to manage and treat chronic conditions are enjoyable because this translates to long term use by the patients or users [3, 5-7, 9, 11, 13, 14, 18, 23]. This is the fun part of the game and how close to an actual game the treatment and management framework is. This feature includes aspects like mini-games, puzzles, fun animations and having an overall aesthetic and feel of a real game for entertainment purposes.

Reward / Feedback system. One of the most important features for a game seeking to manage diabetes and obesity is having a reward/feedback system. The system needs to incentivise users to not only engage with the game, but also engage in behaviours that target the treatment of their conditions by reinforcing good behaviours through rewards and discouraging bad behaviours through penalties. Effective incentives keep the users or patients engaged with the game for a longer time. In addition, feedback is useful in keeping patients updated with their progress and this contributes to the self-management aspect of treating or managing chronic conditions [5-7, 9-14, 16-20, 23]. This feature was separated from the *Game Element* feature because that feature deals more with the aesthetics of the treatment framework being close to those of a real game rather than the mechanics of the treatment framework.

Social Options are another significant feature of gamifying diabetes and obesity treatment. Social motivators play a significant role in encouraging users to engage in behavioural change for the better [6]. Having features such as leader boards or instant messaging systems can lead to behaviour change through peer influence and competitive behaviour can improve behavioural outcomes [10]. Furthermore, social support is associated with improving self-management practices specifically in teens with diabetes [15].

Reminder System is a feature that helps to keep users engaged with the game [6]. This can lead to an increase in user engagement by reminding users of their goals, the progress they have made, and keeping the game at the forefront of their mind [11, 14].

3.3.4 Model based on the features and treatment methods

With regards to the features and requirements of a game that seeks to manage diabetes and obesity, based on the research, the most important feature is for the game to incorporate a reward or feedback system. This helps to incentivize players to engage with the game for a longer time (i.e., more than two weeks) which is more preferable and sustainable for positive behavioural change. The next important features or requirements are game element, activity tracking, and social options. While mentioned in some of the literature, reminder systems and personal data management have an occurrence of 16,67% in the literature and this could be an indication that, according to the literature so far, these aspects might not be as significant as the others. In addition, this could also mean that this feature is one that needs further research and analysis.

The literature review shows that the ways of treating or managing diabetes and obesity are self-monitoring, self-management, increased physical activities, better nutrition, and adherence to prescribed medications [5]. These have been categorized into two sections: Self-Management and Medical Management. Self-management deals with the aspects of the treatment/management directly involving patient/user intervention and activities while Medical Management involves the direct actions of medical professionals involving the treatment/management of the chronic conditions. For example, while self-management might involve things such as eating better and exercising more, medical management would be the prescription of medication as well as monitoring patient's levels to determine treatment method. These two sections are further divided into subsections with *self-monitoring, self-motivation, better nutrition, and increased physical activity* categorized under Self-Management because they involve steps patients have to take themselves in order to treat/manage their conditions. Due to the scope of this research, the focus will be on Self-Management over Medical Management.

The model was created by categorizing the treatment/management methods into two main categories: Self-Management and Medical Management. Sub-categories of Self-Monitoring, Self-Motivation, Increased Physical Activity, Better Nutrition, or Medical Monitoring were identified and assigned to the two main categories to create a hierarchical structure. Based on the treatment methods, game features were assigned to the treatment categories according to their definitions based on the literature review and whether they fit under (or are most appropriately associated with) the subcategories. In the hierarchical representation, each feature's frequency in the literature

review (as seen by *percentage* in Table 1) is also represented by the respective size on the sunburst chart's outer hierarchy.

Treatment/Management Category	Sub-Category	Game Feature	Frequency (%)
Self-Management	Self-Monitoring	Activity Tracking	55,56%
		Education	44,44%
		Customizable Goal Setting	33,33%
		Personal Data Management	16,67%
		Data Visualization	44,44%
	Self-Motivation	Reminder System	16,67%
		Reward/Feedback System	66,67%
		Social Options	55,56%
	Increased Physical Activity	Game Element	61,11%
	Better Nutrition	Game Element	61,11%
Medical Management	Medical Monitoring	Customizable Goal Setting	33,33%
		Activity Tracking	55,56%
		Personal Data Management	16,67%
		Remote Monitoring	33,33%
		Data Visualization	44,44%
		Reminder System	16,67%

Table 2: Hierarchical Representation of the relationship between treatment/management methods and game features

Self-Management has to do with activities such as self-monitoring, increased physical activity, better nutrition, and self-motivation. The game features/functions that fall under this category are *Education, Game Element, Reward/Feedback System, Social Options, Reminder System, Customizable Goal Setting, Activity Tracking, Personal Data Management, and Data Visualization.*

In order to *self-monitor* or track own levels, the game features that fall under this purview are *Customizable Goal Setting, Activity Tracking, Education, Personal Data Management* and *Data Visualization.* These help the users/patients keep up with necessary levels such as caloric intake, amount of exercise, and other measurements that keep them in track with treatment and condition management.

Self-Motivation deals with the users/patients' being invested in continuing management behaviours and being incentivized to do so [6]. Thus, the *Reward/Feedback system, Social*

Options, and Reminder system features are key to achieving this as these have to do with keeping the game at the forefront of the users/patient's minds and increasing enjoyability and user experience of the game through social influence and rewards.

Increased Physical Activity and Better Nutrition have to do with the *Game Element* feature because the game element function includes mini-games, puzzles, quizzes, and game-like activity that is the bulk action focus of a game for treating/managing chronic conditions.

Based on all of this, the following model was developed:

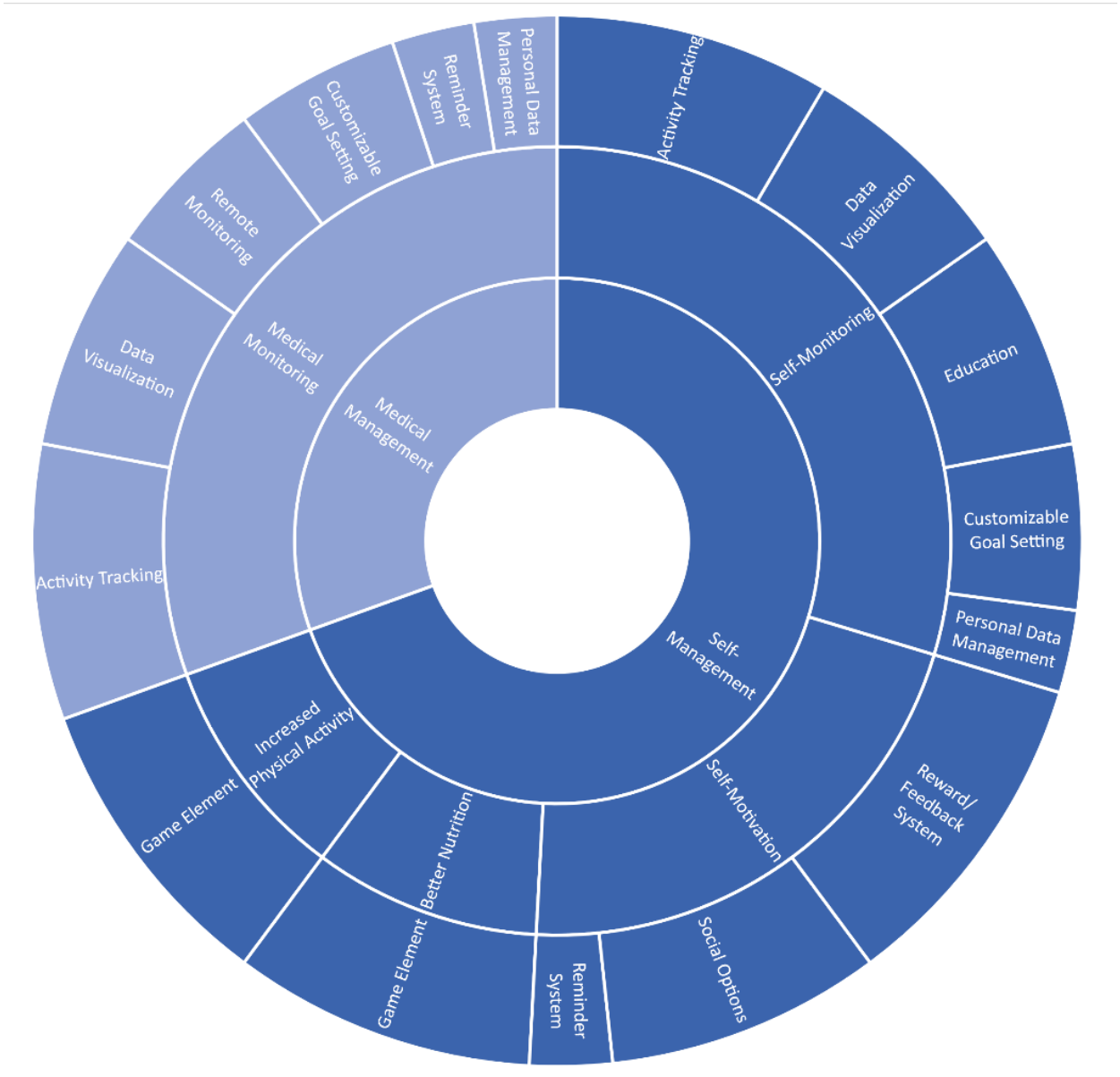

Figure 2: Theoretical model of features required for a game seeking to manage diabetes and obesity

4. Prototype Design and Hypothesis

This chapter presents the prototype that was designed based on the model from the literature review. The features of the design are explained and linked to the model. Following this, the hypothesis for the research based on the prototype design is proposed. In the Design Science Research Methodology model, this chapter deals with the objectives of a solution and design and development processes.

The research question for the main part of this thesis is as follows:

1) *Based on the theoretical framework developed from the literature, how can the identified features of said framework be translated to the design of a game for managing diabetes and obesity?*
   a) *How can the features in the theoretical research be translated to features in a game application?*
   b) *Are the features in the theoretical model relevant to treating and managing diabetes and obesity?*
   c) *Do the features in the theoretical model actually contribute to making the treatment and management of diabetes and obesity?*
   d) *Would a game seeking to treat and manage diabetes and obesity be effective?*

Based on the identified features and management/treatment methods, I developed the Mobile game **Siege Arena**. The design of the game was achieved by taking inspiration from games such as The Sims, Arena of Valor, and civilization development games such as Lord of Ultima. This was because these games included features that allowed the users to develop personal cities and avatars and interact with those of other players. The basic premise of Siege Arena is that players get to create and customize avatars and cities based on activities that feed into the self-management methods of treating/managing diabetes. Players level up and receive rewards by completing a series of minigames and activities and can either choose single player mode or co-op mode. Making use of location tracking and mapping technology in conjunction with players' cameras and pedometers in phones, players can search for items to use in developing their cities. This part of the game is presented like a scavenger hunt to the prospective players. This encourages physical activity by tying it to the reward system.

4.1 How Siege Arena fits into the theoretical model

This section explains how the features and functions of Siege Arena were developed according to the previously identified model.

4.1.1 Customizable Goal Setting

The customizable goal setting feature deals with the goals of the game being tailored to suit the users' specific needs and ability levels.

The aspect of the game that deals with *Customizable Goal Setting* is the *Customize Account* and *Goal Management* portions of the game. Here, players can not only create personalized avatars representative of themselves in the game world, but they are also able to input their personal information such as body measurements, identification, and also link this information with the goals they wish to set. Players are able to set time frames for achieving their goals as well. Furthermore, Siege Arena has an option where players can link to their coaches/trainers and his gives them the ability to see goal recommendations from their caretakers. In addition, the game is customizable for the player in terms of social options. Should the players not wish to have the social options of the game such as forming alliances or sieges, they are still able to have a full-featured game that functions for the purpose of managing and treating diabetes and obesity.

4.1.2 Education

The education feature involves educating the users with relevant information regarding nutrition, health, and disease education

Although Siege Arena is a game, it is important to note that it is meant to help users manage/treat diabetes and obesity. A huge part of the treatment/management is being educated regarding the chronic condition. However, if the game skews too much to being educational, it can come across as boring and reduce the enjoyment or fun factor for the players. Therefore, the education aspect of the model is integrated in the Siege Arena game through tip screens. For example, tips regarding maintaining and increasing "city" or "army" health scores can be interspersed throughout the game in loading screens and through push notifications. This actively engages the players with the information by linking it to vital game elements. An example of this tip can be as follows: "Your army's health score is linked to your daily food intake. Strengthen your army by incorporating healthy foods such as vegetables into your diet."

4.1.3 Data Visualization

The data visualization feature presents the data gathered by the game in a way that is easily understandable for the users as well as their coaches or trainers.

Siege Arena will make use of comprehensive dashboards to make sure that coaches or trainers are able to view player information in an easy and meaningful way. In addition, the information for activity and goal tracking will be made visible to the users by proxy of their avatars on a roadmap to make sure that not only are they getting the information, but they're also getting it in a way that preserves the *Game Element* feature of the game.

4.1.4 Reward/Feedback System

The reward/feedback system feature helps motivate the users by rewarding positive behaviour or progress made while penalizing negative behaviour or lack of progress.

The reward/feedback system of Siege Arena functions by in-game rewards such as city defence items, levelling up, gaining experience points, and being ranked in leader boards. This also serves to help the users track their progress and motivate them. On the other hand, if players fall behind their goals or are inactive in the game, this affects their city strength scores negatively and could negatively impact the outcomes of *PVP Battles* or *Sieges*. In this case, players might lose city defence items.

4.1.5 Activity Tracking System

The activity tracking system feature allows users track their progress such as distance they walked, calorie consumption, etc.

Players are able to track their progress, past activities, goals, and other activities through the *Account Customization* and *Goal Management* pages of the apps.

4.1.6 Game Element

The game element feature determines a large impact on the "fun" aspect of the game, the playability and enjoyment of the game, and how game-like the game is overall. It determines the balance of the game being an actual game or a lifestyle game.

The game element of Siege Arena lies in the *PVP Battles, Sieges, Scavenger Hunts, Alliance Building, City Building* sections of the game. By making the largest portion of Siege Arena more

game-like, it helps to ensure that players will be more engaged in the game. Furthermore, the aesthetics of the app were designed to look more game-like than serious in order to increase the appeal to the players.

4.1.7 Remote Monitoring

The remote monitoring feature involves being able to link the users with their coaches/trainers and offer them the ability to monitor the users.

By enabling the players to have the option of adding their coaches/trainers in the *Socials* dashboard of the game, the game allows for the caretakers to monitor the players and add recommended goals for the users and this fulfils the remote monitoring aspect of the model's features. This could also provide an opportunity for joint goal setting between the players and their monitors and is thus somewhat linked to customizable goal setting.

4.1.8 Social Options

The social options feature offers a social support system for the game users and allows them to manage their social environment. This gives the players the options to find people who might be on a similar health journey as they are or friends who might encourage their progress.

The *Socials* section of the game fulfils this feature requirements. Players are able to add friends to their social environment, form alliances with friends if they so wish, and also view their friends' progress along with theirs. Players are also able to send messages and reward items to their friends for accomplishing set goals. Furthermore, leader boards and ranking systems also offer a competitive social element to the game that can motivate players to engage in the activities.

4.1.9 Reminder System

The reminder system feature contributes to keeping the users engaged with the game in the right way by reminding them of their goals, progress made, and keeping the game at the forefront of their minds.

Push notifications remind players of their goals, the progress they've made, and to fulfil their daily requirements according to the goals they have set. The push notifications also serve to inform them of game and social updates.

4.1.10 Personal Data Management

The personal data management feature allows the users track and manage their own personal data, keeping them informed of their progress and other pertinent personal information.

The *Customize Account* and *Goal Management* sections of the game aids players with managing their personal data and monitoring their progress over a period of time. This includes aspects such as daily food intake and exercise (by tracking steps). The importance is that this is the information that drives the strength score of players' cities.

4.2 Prototype Design

Should they choose the single player mode, players can build and develop their avatars or cities using minigames/activities and have battles against a system generated player. In co-op mode, players can join an "empire" with friends playing the game and develop their avatars and cities to have PVP (player vs. player) matches or sieges against other cities or empires. Monthly campaigns and events with rewards help motivate the players and Leader boards help the players to track their progress in comparison with others. Weekly progress metrics inputted by the players help visualize their progress and, should the players choose to add their coaches/trainers into their social circle, and coaches can also track player progress and add player goals.

The detailed screenshots of each section can be found in Appendix A.

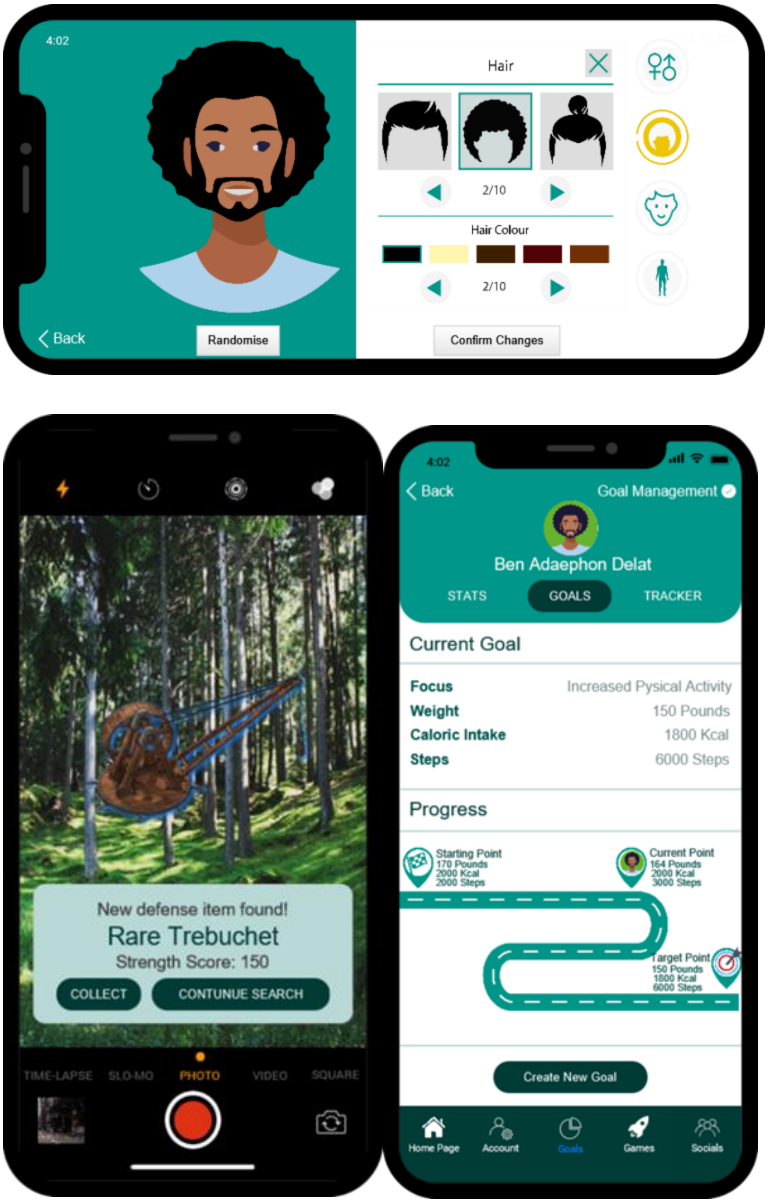

Figure 3: Siege Arena game screens (building army, avatar customization, scavenger hunt, and goal tracking) – as downloaded from justinmind mobile wireframe prototype developer

4.2.1 Goal Management

This section allows players to input their personal goals for using the app such as losing weight or healthier eating. Based on the goal selection, the gameplay is tilted towards the goal. For example, if the player selects losing weight or being more physically active as a goal, then the strength score of their city will be more based on activities that promote this such as the scavenger hunt that will lead them to search for more items to build their city. On the other hand, if players select better

nutrition, the strength score of their city will be more based on nutritional tracking and whether or not they make healthy choices.

This section also helps players track their goal progress by offering a roadmap. The roadmap displays how close the players are to achieving their goals and offers tips on how to reach that goal. Furthermore, this helps the player to track the activities they've completed, and it also offers a meal diary dashboard where they can input daily meals.

4.2.2 Player Section

The *Player* section of the game serves as a portal for players to interact with the game, customize their goals, track their progress, and have social options. The menu items/sections include *Game Library, Customize Avatar, Goal Management, Activity History, Socials,* and *About.*

4.2.3 Customize Account

In this section, players can customise their usernames, password, privacy settings, and other account information. Furthermore, the *Customize Account* section allows for players to input personal information such as their name, age, body measurements and much more.

4.2.4 Game Library

The *Game Library* section is the major portion which includes the minigames and general game activities of Siege Arena. Here players can achieve activities such as customizing their cities, adding friends and building alliances and join campaign events for rewards.

4.2.4.1 Build Avatar

The *Build Avatar* screen is meant to increase customizability for the players. Players are offered many options to customize the avatar that will represent them in the game. After the customization is complete, players are directed to the *PVP Battles* screen to progress with the game.

4.2.4.2 Build City

Under *Build City,* players can develop their own personal cities and customize the aesthetics of the city. This starts off with the players building a basic city according to their own design after selecting a location on the "World Map". Here, they get to place buildings, walls, and even resources for the maintenance of the city (such as forests, rivers, training ground for their armies, etc). After the basic city is constructed, in order to add defences, attack elements, and hire out armies to protect the cities, the players have to "find" these

items. The items can be found through scavenger hunts. In Scavenger Hunts, the players are encouraged to go for a walk and through the course of their walk, based on the distance they have travelled, they can find items to help build their cities to a defensive state. Using location tracking and mapping technology in combination with the user's cameras and pedometers in the phones, the items can be found. The further the players go, the rarer and more valuable the items they find. The goal of scavenger hunts is to make the players more physically active (through walks); the more steps the players take, the rarer items can be discovered. This encourages being physically active by incentivizing this behaviour.

Furthermore, under the *Build City* section, players can also develop their "*armies"* as part of the defensive game play. This is tracking and monitoring the daily nutrition of the players based on their input. Every day, the players will be prompted to input the meals they've had with the portions and based on that, a "strength score" and "health score" will be calculated and assigned to their armies. This score will also be added to their city's "health score" which will come into play during PVP battles, sieges, and campaign events.

4.2.4.3 Build an Alliance

In this section, players get to go the "World Map" section and can add friends by clicking on the other cities visible to them or by searching for usernames. The world map groups players into a section according to their location. This is a social option where players can form an alliance with other players. This provides them with the option of setting common goals with friends and developing their cities into larger kingdoms through the empires. Furthermore, players can track friends progress and interact with other players in game.

4.2.4.4 PVP Battles

Player versus Player Battles involve players finding other cities on the map to challenge to sieges. Here, the player's armies are moved to attack the city being challenged. The players may challenge another player, if they so opt to, or a system generated city. Based on the strength score of the player's army weighed against the strength and defence score of the city under attack, victory or defeat is decided. If the player is victorious, they may gain rewards such as lesser valued items for defending their city and experience points. If the loosing city belongs to another player, they lose lesser valued items of their cities (such as resource buildings or defence items). However, in the case of a loss, players do not lose their entire cities; they just lose defensive items they may have found in the past. The

intention for this is so that progress is not totally lost, and players are still interested in building back up their cities. If players' cities come under attack, they can also choose to retaliate (counterattack) and attack the challenging player's city. In addition, based on the total amount of victory or defeat a player has, they are assigned a ranking on the leader board.

4.2.4.5 Sieges

Sieges are attack games for Alliances. Similar to *PVP Battles,* alliances are able to attack other alliances and based on whether they achieve victory or defeat are assigned a ranking score to be added on a leader board.

4.2.4.6 Special Events

The Special Events section is the part of the game that deals with special events such as tournaments and ranked games. Here, players take part in either single player or alliance games similar to *PVP Battles* or *Sieges*.

4.2.5 Socials

This provides a dashboard for the players to manage their social options for the game. Here, they can add friends, send messages, and it generally serves the social media function. In addition, this section also provides the players with the option to link their account to their coaches or trainers who can also monitor their progress and add goal recommendations. Players can also update with their progress and goal achievements on their dashboards and can send rewards to other players based on goals that have been achieved.

4.2.6 Lifestyle Coach Section

The *Lifestyle Coach* section of the game serves for trainers and coaches to track and monitor their patience progress and find out general information regarding the game. The *Clients* page leads to a dashboard where users can track patients and visualize their progress. Information such as nutritional intake, amount of exercise, and weight changes can be viewed. Furthermore, based on the information, under each player, the coaches can set new recommended goals for the players.

4.3 Hypothesis

The results of the coding stages of the literature review (chapter 2) showed that the most important feature for a game that seeks to assist users with managing diabetes and obesity is the *Reward/Feedback System* followed by the *Game Element* feature – as shown by the frequency of their mentions in the selected literature. The least important features are the *Reminder System and the Personal Data Management* features equally.

Feature	Frequency	Percentage
Reward/Feedback System	12	66,67%
Game Element	11	61,11%
Activity Tracking	10	55,56%
Social Options	10	55,56%
Education	8	44,44%
Data Visualization	8	44,44%
Customizable Goal Setting	6	33,33%
Remote Monitoring	6	33,33%
Reminder System	3	16,67%
Personal Data Management	3	16,67%

Table 3: Ranked frequency of game features

H1: *Reward/Feedback System, Game Element, Activity Tracking, and Social Options are the most important features of a game that seeks to manage/treat diabetes and obesity.*

H2: *Reminder System and Personal Data Management are the least important features of a game that seeks to manage/treat diabetes and obesity*

The literature shows that one of the methods of managing diabetes and obesity is by self-monitoring [4]. Self-monitoring means that patients monitor their body measurements (such as weight, heart rate, etc.), physical activity, daily nutritional intake, and blood levels (for severe chronic conditions such as diabetes). *Activity Tracking* directly contributes to

this because it keeps patients/users of the game app abreast of the activities they have undertaken. *Data Visualization* contributes to *Self-Monitoring* because it deals with the presentation of information to the app users in a way that is meaningful to them. The data must be presented in a way that is clear to read in order for users to be able to use it to self-monitor their levels. *Education* contributes to *Self-Monitoring* by informing the patients about disease/chronic condition information such as what needs to be monitored, preferred levels for optimizing the treatment and management of their conditions, risk factors to be aware of, etc. *Customizable Goal Setting* also contributes to *Self-Monitoring* because it enables to users to enter and track their goals. *Personal Data Management* contributes by providing the users with the ability to manage their personal data including historic data and see their past progress and projected progress.

H3: *Activity Tracking, Data Visualization, Education, Customizable Goal Setting, and Personal Data management contribute to users self-managing their conditions by assisting with Self-Monitoring*

Self-Motivation is also one of the methods of patients managing diabetes and obesity. This deals with the patients being motivated to engage with the treatment and management of their conditions [4,]. The *Reward/Feedback System* serves this motivation by rewarding positive behaviours made towards treatment/management by the users or penalizing negative behaviour. Furthermore, having *Social Options* also contribute to *Self-Motivation* because social motivators play a significant role to encourage users to engage in positive behavioral change [5]. In addition, social support is associated with improving self-management habits in people with diabetes [14]. The *Reminder System* feature will help motivate the players to engage with the treatment/management of their conditions by keeping the game in the forefront of their minds.

H4: *Reward/Feedback System, Social Options, and Reminder System contribute to users' self-motivation which helps them to manage their conditions.*

Better Nutrition is another treatment method that falls under the *Self-Management* category of treating and managing diabetes and obesity [23]. The *Game Element* feature deals with this sub-category because it is the element that involves the users eating behaviour affecting the gameplay directly.

H5: *Game Element contributes to users' better nutrition behaviours.*

Increased Physical Activity is the final treatment method that falls under the *Self-Management* category. This involves the patients engaging in activities that reduce sedentary behaviours such as exercise. *Game Element* contributes to this treatment aspect because having participants engage with games that rely on physical activity can increase their physical activity directly.

H6: *Game Element contributes to users' Increased Physical Activity behaviours.*

No.	Hypothesis
H1	Reward/Feedback System, Game Element, Activity Tracking, and Social Options are the most important features of a game that seeks to manage/treat diabetes and obesity.
H2	Reminder System and Personal Data Management are the least important features of a game that seeks to manage/treat diabetes and obesity
H3	Activity Tracking, Data Visualization, Education, Customizable Goal Setting, and Personal Data management contribute to users self-managing their conditions by assisting with Self-Monitoring
H4	Reward/Feedback System, Social Options, and Reminder System contribute to users' self-motivation which helps them to manage their conditions.
H5	Game Element contributes to users' better nutrition behaviours.
H6	Game Element contributes to users' Increased Physical Activity behaviours.

Table 4: List of hypotheses

5. Results

This chapter details the results of the survey and the interviews. First, the purpose and result of the survey are presented with the corresponding resulting changes in the prototype, then the interview results are presented after the results of the survey are used to update the prototype. This starts off with the demonstration and evaluation processes of Peffers' methodology (survey results) then goes back to the design and development process and finally ends with another round of demonstration and evaluation processes (interview results).

5.1 Survey Results

The survey was conducted in order to gain an understanding of what aspects of the prototype were important to the players and what can be done to improve upon the design from a player's perspective towards the next prototype. Thus, the survey questions dealt mostly with the players' opinions regarding playability, perceived usefulness, ease of use, and general opinions regarding the prototype. These questions were formulated based on the Technology Acceptance Model questions as this proves to be a good foundational basis for establishing an individual's experience with new technology [25].

5.1.1 General Information

While 33% of participants reported that they played videogames often, 28,6% reported occasionally, 23,8% reported sometimes, 14,3% reported never.

76,2% of participants reported the previous use of a lifestyle app for better nutrition and increased physical activity.

In general, participants reported positive sentiments in terms of understanding the sections of the game, the information presented in said sections, the logical flow of the sections, engagement of the sections and the aesthetics of the sections as these scored above 7 out of 10 on ranking scales. However, it would seem that within the context of these positive sentiments, Siege Arena still leaves somethings to be desired in terms of the aesthetics and general engagement of the sections. An example of this is in how participants answered the open questions regarding their opinions on the game aesthetics. Comments such as "while the game aesthetics are generally nice, I would like to see more colour options" and "I think the game needs different colour scheme" were recorded. While participants never scored any of the sections below 7 in both of these segments, when asked

to rank the aesthetics of sections out of 10, participants usually ranked the aesthetics lower than other aspects (such as clarity of information).

Furthermore, 95% of participants agreed or strongly agreed that Siege Arena has adequate *customization, Education, Data Visualization, Personal Data Management,* and *Reward System.* 90% agreed or strongly agreed that Siege Arena has adequate *Activity Tracking* options. 85% agreed or strongly agreed that the *Game Element* and *Remote Monitoring* options were adequate. 80% agreed or strongly agreed that the *Social Options* were adequate and 81% agreed or strongly agreed that the *Reminder System* was adequate.

When asked their opinions on the statement that Siege Arena needs to be more game-like, 67% of participants reported that they agreed or strongly agreed with this statement. However, when the same statement was asked regarding if Siege Arena needed to be more lifestyle-like, 57% reported that they agreed or strongly agreed. Nevertheless, 77% of participants reported that Siege Arena would motivate them to be more physically active and 76% reported that the game would motivate them to have better nutritional habits (meaning the perceived motivation of the game in terms of being more physically active).

Overall, when asked what they would improve about Siege Arena, participants reported that they would improve the colour scheme, having a simpler interface, and improving the design element of the menus.

5.1.2 Customize Account Section

Participants were mostly satisfied with this section and the customization options availabe in Siege Arena. Only 4% of the participants ranked the customization option availability as a 6 (out of 10).

When discussing the strengths of this section, participants reported that the strengths included the minimalistic design, the fun aspect of creating their own avatars, and the ease with which the screens can be followed.

The most commonly reported limitation of the *Customize Account* section was the stagnancy of colour scheme. Participants responded with statements such as “some minor limits of this screen are the lack of change in the app color”, “colour combination”, “colour screen”, etc.

5.1.3 Goal Management

86% of participants reported that the goal management section would encourage them to track their goals. 82% of the participants also reported that this section would encourage them tot rack and manage their activities while 81% of participants said that this section would encourage them to track and manage their daily food intake.

Most of the participants reported the clear and detailed information regarding goal progress and tracking as the strength of this section. Furthermore, participants reported that this section was easy to use and understand as the strengths of this section.

Some participants reported that the *Goal Management* section could be improved by including Key Performance Indicators (KPIs) for measuring the goals and adding more helpful information for the users to "demonstrate how to get the right measurements."

5.1.4 Game Library

On a scale of 1-10, 95% of participants ranked the appeal (fun) of the game's *Build Avatar* section over 6 while 5% found the appeal to be low, ranking it at 3 out of 10. Most of the participants (52.4%) 'strongly agreed' that they would be motivated to engage with this section.

Similarly, 95% of participants ranked the appeal of the *Build City* Section over 6 while 5% ranked it at 2 and most participants (66.7%) 'agreed' that they would be motivated to engage with this section. 48% of participants also 'agreed' that the *Build City* section would motivate them to track their daily food intake to contribute to their city score while 38% 'strongly agreed' to this. Most participants also 'agreed' (43%) and 'strongly agreed' (38%) that they would be motivated to make healthier food choices to influence their city score.

90% of participants ranked the appeal of the *Scavenger Hunt* section over 6. Most (85%) of the participants reported that based on the prototype designs, they would be motivated to participate in the scavenger hunts of the game. 5% of the participants reported that they would not be motivated to partake in this section of the game.

95% of participants ranked the appeal of the *Battles* section over 6 and while 90% reported positive sentiments in terms of being motivated to participate in the *Battles* section, 5% reported that they would not be motivated to do so.

91% of participants ranked the appeal of the *Alliance* section over 6 and most of the participants (76%) had strong positive sentiments toward being motivated to participate in this section of the *Game Library.*

95% of participants ranked the appeal of the *Leaderboard* section over 6 and 5% reported that they would not be motivated to engage in this section of the game.

In general, participants said the strengths of the *Game Library* section was that the information was clear and usable, the interaction with other players were advantageous, and the game options were varied.

The most common limitation reported for the *Game Library* section was that the food tracking might not be effective due to self-reporting bias and the players might report false information just to boost their city strength scores. Under the *Activity Tracking* section of the survey (goal management), 67% of participants mentioned concerns with the reliability of self-reporting food intake and how that corelates to their city strengh scores.

5.1.5 Social Dashboards

15% of participants reported that social options were not important to their enjoyment of the game. However, 85% of participants reported positive sentiments toward the notion that they would be encouraged to engage in the social aspects of the game app based on the prototype screens of the social dashboards.

A common strength of this section was that it allowed users to engage with their friends and the appeal of sharing player progress through the social dashboard screen is also appealing. Under the question, “what are some percieved limitations of the social dashboards section?”, no limits were reported by the participants for this section, however, some participants reported that they would improve this section by adding more social functionality such as being able to meet new people and track their goals.

5.1.2 Survey result and redesign implications

Based on the survey, the general sentiments regarding Siege Arena are positive. Nevertheless, users reported that some surface level aesthetics such as colour scheme and implementing a simpler interface would make for a better user experience.

In terms of the mechanics or functionality of the game, users reported that they would like to have more social options. Furthermore, participants reported dissatisfaction with whether or not the food tracking functionality of the game would be effective to not only create better eating habits, but also motivate users to engage with this.

The first two hypothesis of the research are as follows:

No.	Hypothesis
H1	Reward/Feedback System, Game Element, Activity Tracking, and Social Options are the most important features of a game that seeks to manage/treat diabetes and obesity.
H2	Reminder System and Personal Data Management are the least important features of a game that seeks to manage/treat diabetes and obesity.

Table 5: Hypothesis 1 and 2

With the aim of narrowing the focus of this research for the next design phase and addressing the hypothesis, the participants were asked the following questions:

1. Siege Arena has functions that address the features of customizable goal settings, education, data visualization, reward\feedback, activity tracking, game element, remote monitoring, social options, reminder system, and personal data management.
    a. In your opinion, what are the three most important features?
    b. In your opinion, what are the three least important features?

The most important features identified by the participants (with the highest frequency of occurrence) were Game element (100%), reward\feedback system (90%), and social options (40%). On the other hand, participants reported the least important features to be remote monitoring (95%), education (78%) and reminder system (74%). This seems to provide support to Hypothesis 1 but not Hypothesis 2. 25% of participants ranked Activity Tracking as one of the most important features to them. On the other hand, 20% of participants also reported that personal data management was one of the most important features to them.

Because the main focus of this research is to gamify the framework for treating conditions such as diabetes and obesity, the focus for improvement in the redesign would be on the mechanical/functional side.

5.1.2.1 Redesign Implications

In order to address the redesign for the next validation phase, the following redesign steps will be taken:

1. Addressing surface level aesthetics issues:
    a. Adding a "theme" option under customization to allow players to select what colour scheme they would prefer.
2. Addressing mechanical issues:
    a. Redesigning the food tracking options so that it is more effective. In order to increase the effectiveness of food tracking options, Siege Arena will still calculate city strength score partly based on the daily food intake. However, rather than relying on players to just input the food they take, they are prompted to scan the barcodes of the grocery items they purchased. The aim of this change is that it will address any perceived self-reporting bias that may occur because the players report the wrong food intake in order to game the system of calculating their city strength score. This means that players are prompted weekly to scan their groceries and depending on the food items that were scanned, the health score is calculated. Nevertheless, this functionality is not a complete overhaul of the daily food tracking feature. Players will still be able to track their daily food intake and fulfil the self-monitoring aspect, however, this will not play such a huge role in the determination of their city health scores.

Peffers' Design Science Research Methodology is cyclical in nature meaning that the artifact must be designed and validated repeatedly. Therefore, the results of the survey led to slight changes in the design of Siege Arena. After changes were implemented using the result of the survey, another validation was done using volunteer participants from the surveys. The results of the interview are presented in the next section.

5.2 Interview Results

This section details an overview of the interview questions, how they are linked to the remaining hypotheses and the results of the interviews.

5.2.1 Mapping questions to hypothesis

Using the interview protocol matrix as planned out by the Interview Protocol Requirement given by Yeong et al., the interview questions were mapped out onto hypothesis 3-4.

Question	**Mapping**				
Question	Background	Hy3	H4	H5	H6
Q1	✓				
Q2	✓				
Q3	✓				
Q4	✓				
Q5		✓			
Q6		✓			
Q7		✓			
Q8		✓			
Q9		✓			
Q10			✓		
Q11			✓		
Q12			✓		
Q13				✓	
					✓

Table 6: Interview questions mapped onto the Interview Protocol Matrix

5.2.2 Interview Results

The general information regarding the interviewees and the interview processes are detailed in the table below.

Interviewee	**Gender**	**Age**	**Date**	**Duration (Minutes)**
1	M	23	08/08/2021	44
2	M	20	13/08/2021	38
3	F	22	15/08/2021	35
4	M	25	16/08/2021	29

Table 7: Interview Overview

5.2.2.1 Background

The interviewees, when asked about their opinion on the perceived usefulness of the app prototype for them, said that they would find such an app useful in terms of helping them pick up a healthy lifestyle or at least incorporate more healthy habits such as nutrition tracking, being more physically active, and being more educated about healthy lifestyle choices. Furthermore, the interviewees claimed that they not only enjoyed the premise of the game, but they thought the game would be fun to play.

"I think the idea behind Siege Arena is quite sound, especially because of the virus pandemic. I would be motivated to engage in the healthy behaviours promoted by the game because it is tied to my progress in the game." (Interviewee 2)

"The app would motivate me especially to be more physically active. I like especially the scavenger hunt because it kind of seems like an adventure and that would be fun." (Interviewee 3)

"I really liked going through the screens of the prototype. I could imagine myself actually playing the game and having a lot of fun just building my own city and challenging my friends to battles." (Interviewee 1)

The new option to choose their own custom colours was received positively by the interviewees. This meant more personalization options and it allowed for them to align the aesthetics of the game with their interest. However, the interviewees mentioned that even though the proposed improved change to the food tracking system was an upgrade, it might not be sufficient enough to eliminate self-reporting bias. This is because even the upgraded method of scanning groceries still relies on the players to report the information. It might be more difficult to game the system in terms of false reporting, but there is still a small chance.

*"The new food tracking option is improved from the old. But for someone like me who would want to improve my city really quickly**, I might just keep scanning the old packets and groceries and there is no way for the game to actually ensure that I am eating these healthy foods that I scan into the game**. I'm sure I'm not the only gamer who would find a way to game the system like this. Although, I don't know how you can directly control what someone eats through an app so maybe this is the best option that we have available."* (Interviewee 1)

For the interviewees, their favourite aspects of the prototype were the games, as opposed to the trackers and social aspects. The general sentiment was that it would be engaging to work on a customized city using items they had worked or "grinded" (according to Interviewee 1) for. Being rewarded in game (by improving their city strength score) and in their real life (by seeing the better health benefits of living a healthier lifestyle) holds a large appeal for the prospective players. Although it might take some time to actualize the real-life physical benefits, having the in-game benefits of being able to customize and grow their own city and therefore winning battles over their opponents is a strong motivator to tide them over – the physical benefits such as loosing weight or being healthier, is just an added bonus to the fun.

"I really like how you have to grind in the real world and in the game to make progress. Especially because I enjoy playing games that are not too easy and that directly reward your efforts. If the defence items on the scavenger hunts get even more rare the more steps you take, I think this would make me spend hours just trying to find the rarest items. It would even be better if we can share the rare items that we find on social platforms so other people can see it."

(Interviewee 1)

Interviewees claimed that the trainer section of the app needed to be developed further in cooperation with the goals section. This is because there is a huge potential to link possible lifestyle coaches to player accounts and to have them be more involved in the player's lives. They could even monitor their clients and provide them with guided tips and warnings if they are straying off their goal path.

"The weakest part of the game for me was the trainer part. I think it needs to be highlighted more because ***trainers would be useful to help people make better use of the game****. For example, someone like me doesn't have much knowledge about being fit or eating right and I think if the game makes an option to speak to a coach or trainer who can get to know me and help me set goals, I would be more likely to follow the game's healthy part properly."*

(Interviewee 4)

"The game is good but if I were making it, I would make it so that the trainers can even get paid or something like that. ***It would be useful if every player gets the option to choose a trainer and then the trainers can monitor their players and send updates based on that****."* (Interviewee 2)

Another point that was raised by the interviewees was that there could be more game options in terms of building the city. For example, the avatar customization could be turned into a full mini game rather than just having the avatar customization be up to the shoulders of the avatar and then making no further use of the avatar.

*"**I think the game needs to make more use of the avatar and the customizing screens for that**. Something like the sims where you can make a physical representation of yourself that isn't only for your profile but also interacts with the game. For example, I would enjoy it if I could use my avatar to plant trees or even fight battles."* (Interviewee 1)

5.2.2.2 Hypothesis 3

"Activity Tracking, Data Visualization, Education, Customizable Goal Setting, and Personal Data management contribute to users self-managing their conditions by assisting with Self-Monitoring."

Though the activity tracking and data visualization would be useful for self-monitoring their activities and the goal tracking section would help to show the users how close they were to their goals, the activity tracking wouldn't be a major focus for a user who is most interested in the game. In addition, being able to see progress made towards a healthier lifestyle would motivate players to continue practicing positive behaviours (such as eating healthier and being more physically active). Showing the data of the progress through an animated roadmap that makes use of the players avatar makes the information regarding progress more digestible and makes it easier to monitor themselves.

"I think being able to see the number of steps you take or see what foods you may have eaten would be helpful if your main goal is to use the game to lose weight and eat better. But for me, I would be more interested in the game." (Interviewee 1)

"If you want to live a healthier lifestyle, I think it would be important to be able to see how much exercises you are doing everyday and what kind of foods you eat. I like that with this app, you can track all of this in the goal management screen. It will make me motivated to continue doing exercise if I see the progress I have made." (Interviewee 2)

"If the roadmap icon can be animated, it would make the information about my progress more fun to look it. It could even be an easier visualization that just a bunch of numbers on the screen and then I can follow my progression as I play the game more." (Interviewee 4).

The education section of the game would empower the players because it would give them the right information, they need to live a physically beneficial life. This information is key to guiding the players to know when they are making the right decisions and when they are making the wrong ones.

"It's nice to be able to get tips on healthy eating disguised as a gameplay element. I think this would be useful if you are like me and you are a novice to healthy lifestyles. You can use this information to keep track of yourself and make sure you are doing the right things." (Interviewee 4)

Customizable goal setting and personal data management also contributes to self-monitoring because it gives the users more power and self-control. Being more aware of their capabilities will help make tracking the information more useful because the players would be aware of what to look out for. It also makes them feel like they have some control over their choices, and this will contribute to the self-motivation.

"Being able to customize your goals and see your personal data specified to you is empowering, I think. I would be motivated by this because it would help me to feel like I can control my life choices and because it is personalized…I would want to continue playing the game because I feel like it's just for me." (Interviewee 3)

"The customization of the goals option makes me feel like the game was made specially for me. Being able to do this would help me to keep track of how the game is helping me and I think this would be beneficial if my main use of the game was to lose weight or something like that." (Interviewee 4)

5.2.2.3 Hypothesis 4

"Reward/Feedback System, Social Options, and Reminder System contribute to users' self-motivation which helps them to manage their conditions."

The biggest factor in terms of self-motivation is the reward\feedback system. This is because the players healthy choices such as better eating and increased physical activity due to the scavenger hunts is reflected directly into the game by the rewards they will receive for their cities. Because they have spent time and expended effort working on customizing their cities, this would motivate them to continue.

"Like I said before, having to grind in the real world and see the results in the game is very satisfying for me. If my city gets bigger and bigger and stronger because I am walking more and maybe even buying healthier foods and scanning them into the game, then I would be so motivated to continue doing this and finding even rarer items on the scavenger hunts. ***If this means that I can make a strong city and defeat my opponents, then yes, I think I would do the healthier things the game recommends****."* (Interviewee 1).

Being able to look at other players and see the leader boards and being able to share their progress to the approval of friends would make motivate players to keep engaging with the positive behaviours that the game seeks to increase. This means the social options are contributing to self-motivation.

"The social options would contribute to a healthy lifestyle especially for me because I am a social person. I like to tell my friends what I'm doing, and I like to see what they're doing as well. ***Also, I noticed that with me, if my friends are doing something then I am more likely to join them in doing it so if I see my friends using Siege Arena, I will have a reason to use it as well.*** *If I can go on scavenger hunts with my friends, I would be motivated to do that."* (Interviewee 2).

The reminder system does not contribute as much to motivation as was hypothesized. The interviewees thought it might even deter motivation by being annoying if they received too many push notifications about the game. The reminder system might be helpful in terms of self-motivation if it was kept to the bare minimum.

"I think the reminder system might be okay if it is not too intrusive. If I am receiving notifications about making healthy choices all the time, I might get annoyed and delete the game. Or else, I think a few reminders after a long period of inactivity in the game might be good as a reminder." (Interviewee 1).

5.2.2.4 Hypothesis 5

"Game Element contributes to users' better nutrition behaviours."

The games element of siege arena that is linked to nutrition (i.e., tracking the food intake by scanning grocery items and corresponding this to the strength score) might contribute to better nutrition behaviours. However, because there is no way of directly and accurately tracking the food that enters the players' mouths, it is not possible to guarantee this. However, gamifying better eating habits would lead to better nutrition behaviours according to the interviewees.

"The idea of making healthy eating fun would lead to better nutrition behaviours but even though I might properly record and scan my groceries, I don't know if I will do this for a long time because I might just start faking the recording so that my city score will increase." (Interviewee 2)

"In an ideal situation where people are honest, yes, siege arena's game of scanning the groceries to make your city and army stronger would make me eat a healthier diet…also the tip screens on the loading screens would also inform me about healthy foods and this might even help me to make better eating choices." (Interviewee 1)

5.2.2.5 Hypothesis 6

"Game Element contributes to users' Increased Physical Activity behaviours."

Interviewees agreed that they would participate in game element of siege arena, i.e., the scavenger hunt, and this would make them more physically active than they currently are.

"Definitely. The scavenger hunt sounds like so much fun to me because it is kind of like pokemon go and I like to collect rare items so I would definitely go on walks to try to find rare magical weapons for my cities." (Interviewee 1)

"Yeah, a lot of people don't realize it, but we don't really do much exercise especially because of the virus that is happening now. So, if there is a fun way to even just make me take a walk, I would do it." (Interviewee 2).

6. Discussion and Conclusion

This chapter presents the discussion and conclusion of this research and includes the evaluation and communication processes of Peffers' methodology. It begins with a general discussion of the results, the implications, the contribution of this to research, and limitations and recommendations for further research.

6.1 Discussion

Siege Arena was designed to cater to the explorers with the scavenger hunt, the social dashboard caters to socializers, and the leader board and ranking systems cater to achievers. The interviewees were selected by those who indicated interest in further participating in testing for Siege Arena after completing the survey, All four of the interviewees self-reported in the survey as gamers. In addition, based on the results from the survey, the interviewees say that they are avid gamers, socializers, and achievers (e.g., interviewee who said they enjoyed grinding in the games). Based on this, it is surmisable that Siege Arena appeals to all its intended audiences according to gamer categorization except for explorers. Because of the limited number of participants for the interview, it is not possible to definitively conclude whether or not Siege Arena does appeal to explorers like it was intended in the design. Perhaps, this could be an avenue for future development. Nevertheless, indications point that Siege Arena appeals to more avid gamers as opposed to people interested in lifestyle apps, however, the exact category of gamers is hard to say.

67% of survey participants agreed or strongly agreed that Siege Arena needed to have more game-like aspects while 57% agreed or strongly agreed that more lifestyle features were needed for the game. This means that on the whole, Siege Arena as a game for managing diabetes and obesity needs more game-like features as well as needing more lifestyle app-like features because more than half of the survey participants indicated this. However, because more participants wanted more game-like features, this points that a participants might have a preference for Siege Arena to be more game-like than lifestyle app-like (or at least, they want Siege Arena to lean in more to the game side). The implication is that future game designs should seek to appeal more to gamers than to lifestyle app seekers. However, a common through line from the survey and the interviews was participants calling for simpler menus, interfaces, and designs. Being that game-like can often translate to being flashier and more eye-catching, which does not translate to being simpler, it

would be interesting to further investigate how to make Siege Arena more game-like without making the menus, interfaces, and designs more complicated.

The first research question was: What are the main features of a game that seeks to manage diabetes and obesity?

The theoretical portion of this research yielded the result that a gamified framework for treating chronic conditions such as diabetes and obesity should include the following features: *Customizable Goal Setting, Education, Data Visualization, Reward/Feedback System, Activity Tracking, Game Element, Remote Monitoring, Social Options, Reminder System,* and *Personal Data Management.*

The major difference between the results of the interview and those of the literature review in terms of the categorization of the features is that the *Personal Data Management, Customizable Goal Setting,* and *Game Element* contributes to self-motivation (as revealed by the interview). This makes self-motivation a more significant category under self-management than previously thought.

The second research question is as follows: Based on the theoretical model developed from the literature, what does a gamified framework seeking to manage diabetes and obesity look like in terms of a game?

How can the features in the theoretical research be translated to features in a game application?

This was accomplished by mapping out the sections of the game directly to the identified features (as seen in Chapter 4). In order to achieve this, inspiration was taken from existing games which had functions that fell under these features. These functions were customized and conglomerated into Siege Arena.

Are the features in the theoretical model relevant to treating and managing diabetes and obesity?

In order to answer this question, hypotheses 1 and 2 were developed. The first round of validation (survey) addressed this question. The most important features identified by the participants (with the highest frequency of occurrence) were Game element (100%), reward\feedback system (90%), and social options (40%). On the other hand, participants reported the least important features to be remote monitoring (95%), education (78%) and reminder system (74%). This seems to provide

support to Hypothesis 1 but not Hypothesis 2. 25% of participants ranked Activity Tracking as one of the most important features to them. On the other hand, 20% of participants also reported that personal data management was one of the most important features to them.

Do the features in the theoretical model actually contribute to making the treatment and management of diabetes and obesity?

Hypotheses 3-6 and the interview validation address this question specifically. Although the literature review resulted in the categorization of these features under the self-management categories as displayed in table 2, the interview resulted in the following categorisation:

Self-Management	Game Feature
Self-Monitoring	Activity Tracking
	Data Visualization
	Education
	Customizable Goal Setting
	Personal Data Management
Self-Motivation	Customizable Goal Setting
	Personal Data Management
	Reward\Feedback System
	Social Options
	Reminder system
	Game Element
Better Nutrition	Game Element
Increased Physical Activity	Game Element

Table 8: Table of new categorization of game features and self-management categories according to interviews (blue indicates newly added features to the categories in comparison to table 2)

No.	Hypothesis	Validation
H1	Reward/Feedback System, Game Element, Activity Tracking, and Social Options are the most important features of a game that seeks to manage/treat diabetes and obesity.	-
H2	Reminder System and Personal Data Management are the least important features of a game that seeks to manage/treat diabetes and obesity	-

H3	Activity Tracking, Data Visualization, Education, Customizable Goal Setting, and Personal Data management contribute to users self-managing their conditions by assisting with Self-Monitoring	+
H4	Reward/Feedback System, Social Options, and Reminder System contribute to users' self-motivation which helps them to manage their conditions.	+/-
H5	Game Element contributes to users' better nutrition behaviours.	+/-
H6	Game Element contributes to users' Increased Physical Activity behaviours.	+

Table 9: Hypothesis validation results

Would a game seeking to treat and manage diabetes and obesity be effective?

In general, the results of the survey and interviews showed that participants had positive sentiments toward Siege Arena in terms of being effective as a gamified framework for treating and managing diabetes and obesity. The major contribution of the game to this treatment is through helping participants monitor their food intake and exercise through the goal customizations options, promoting increased physical activity through the scavenger hunt, and promoting healthy eating by scanning groceries and using this to contribute to the strength score of the city. While the former two have been met with positive sentiments in terms of their effectiveness, the latter was found wanting in both stages of the validation (survey and interview) – even after the redesigning stage.

An indication from the research is that Siege Arena's nutrition tracking section might have some self-reporting bias. As the interviewees said, the temptation to cheat when recording the weekly or daily nutritional intake might be too great to ignore and players might record the wrong information. This shows a flaw in the design that needs further research. Specifically, the self-monitoring aspect of the model is one that requires more attention during the game design phase by all indication (in order to create a gameplay system that makes it more difficult or even impossible to cheat). It is possible to address this by further developing the reward\feedback system in conjunction with the food tracking system to directly reward better eating habit as opposed to healthier shopping. Nevertheless, in general, this means that a game seeking to treat and manage diabetes and obesity is on the right track to effective treatment and management methods.

This research shows that gamifying the treatment of chronic conditions has a lot of potential for effectivity. Based on the results of the survey and the interview, the perceived usefulness of such a game (as only a prototype was used during the validation and not a full featured game) would manifest in helping potential players to develop healthier lifestyle habits. The implication of the results is that any gamified framework seeking to treat and manage chronic conditions such as diabetes and obesity need to highlight game features such as the *Game Element*, *Reward/Feedback System*, and *Social Options*. According to the interview results, having a social environment as a support system could be helpful for players. *Social Options* are vital in the theoretical research, and this is confirmed in the practical. While other features as identified by the literature review play an important role in creating a well-rounded treatment/management framework, the majority of the development focus should be placed on those features.

An unexpected feature that was revealed in the practice part of this research (interviews) was the concept of empowerment as it relates to autonomy. This was not, however, a result of the theoretical research (literature review). This leads to the notion that perhaps there is more to be gleaned in terms of how empowerment and autonomy fits in the model and how these can influence the management of chronic conditions such as diabetes and obesity. A possible fit of this, based on what was said by the interviewees, is that autonomy could be a feature – just like *activity tracking* or *social options* – and it would fit in the self-motivation category. This could even translate into game functions or features by having more gameplay options for the players to choose from or emphasizing the customization options. The definition of autonomy could be given in such a way that encompasses empowerment. Given that it falls under the self-motivation category which translates to more customization options, it is even possible to expand the definition of *Customizable Goal Setting* – an already existing game feature in the model – to include autonomy.

Additionally, while the medical management aspect of the framework (result of the theoretical research) was not a focus of this research, there have been some promising results and more raised questions regarding this area. For example, data regarding the users' nutrition intake and daily physical exercise will be collected from the game. This information might prove useful for medical professionals who might want to track their patients. In addition, based on the interview results, there might be potential in attaching coaches or personal trainers to track the user's progress and

input goal advice. This could also come in handy in ensuring that users are monitored and could prove to be useful in conjunction with medical monitoring and can yield more effective results for the patients.

The contribution of this research is a theoretical framework for gamifying the treatment and management of diabetes and obesity (as seen in table 8). This research also raises questions regarding how to ensure that self-monitoring is done accurately, how to tie in the medical management part of the framework with the self-management part, and how autonomy and empowerment fit into the framework. Furthermore, this research contributes the foundation of what such a game might look like and what the most important features to focus on are.

6.2 Limitations

This research is not without its limitations. These limitations are as a result of time constraints, research concerns, and limitations due to the corona virus pandemic.

The first limitation has to do with time constraints. The major portion of this is that the time period between the literature review and the final validation stage – interviews – was too long. First of all, the literature review began in July 2020 and was completed in May 2021. The literature selected was done by July 2020 and the analysis was carried out in 2021. Because this time period was extensive, it is possible that research on the topic which would have affected the result might have come out during the intervening period. The recommendation for future research to address this would be to carry out the literature review selection and analysis in as close a time frame as possible to the design and validation stages in order to keep the research as up to date as possible.

Another time constraint limitation is that due to the extended break that occurred during the literature review stage, there was a time crunch to finish up as quickly as possible. This may have affected the amount of time available to further refine and develop the theoretical background that serves as the basis for all of this research. For future improvements, perhaps taking the appropriate time necessary to conduct the research slowly would bolster the theoretical background.

Furthermore, another limitation was discomfort caused by the corona virus pandemic. This resulted in the interview being done remotely over a video conference. Because of this, there could have been some key interactions between the interviewer and the interviewee that was missed. It is also possible that interviewees may not have responded the same way they would have or

behaved the same way they would have. However, because this limitation was due to a global unforeseen circumstance, it might have been inevitable.

One more limitation was the participant selection for the survey and the interview. Although the number of participants involved in the survey was forty-two, only four of those participants indicated continued interest and eventually agreed to participate in the interviews. This means that while the survey results could be generalized to a larger extent, the interview results can only speak for the four participants and is less generalizable. Also, if they had been selected from a population outside the University of Twente, the results from the survey could have been more generalizable. This can be remedied by expanding the population from which participants are selected. Furthermore, Siege Arena was created with the aim of managing diabetes and obesity through better nutrition and physical activity, however, the population used to validate the game design was not necessarily representative of this (i.e., the game was not tested specifically with people with diabetes and obesity because of time constraints for the research). Therefore, it is still left to be said if Siege Arena would have its intended effects specifically for people with diabetes and obesity and if the results of this research can be applied to this group. The remedy for this would be to select a population who have the specific traits that the game is centred around.

In addition, a potential limitation is that the artifact that was tested in this research was a wireframe prototype which had limitations in terms of allowing the participants or potential players to fully experience all features of the game that was designed. For example, although participants were able to click the buttons on the siege screens, they couldn't see how the battles actually played out. This could prove to be a drawback because participant opinions or understanding of features may be influenced by not experiencing them the way they would present in an actual full-featured game. This can be rectified by perhaps seeking a prototype designer that allowed for more features.

Finally, the sixth limitation is that the interview had been conducted by the researcher herself. One researcher created the questions, performed the interview, and coded the results. This means that there might be unforeseen biases of the researcher present in the review. The recommendation to remedy this would be to have minimum one more researcher present to cancel out or at the very least reduce potential biases.

6.3 Recommendations

Recommendations regarding the limitations have been presented in the previous sections, however, there are also some recommendations for possible future research.

The first recommendation would be to update the theoretical background and framework by further researching the current literature regarding gamified treatment frameworks for chronic conditions. Despite the fact that stress and sleep were not factors that came up in the theoretical research, they contribute to overall health and could also play a role in the treatment\management of diabetes and obesity. Therefore, it would also be interesting to further investigate the role this would play in the theoretical background and how this would affect the nature of a resulting game. Perhaps these could fit into the self-management category as their own sub-categories. This may also include investigating if empowerment or autonomy should be a consideration involved in the design of such games like Siege Arena and how it fits into the gamified framework developed from theory. This could lead to a more sound model for developing the framework.

The second recommendation would be to further develop the identified necessary features for the gamified treatment framework in terms of understanding how to measure them (using Key Performance Indicators, for example). This would make the theoretical background even more solid and help to bridge the gap between theory and practice by making the transitional elements measurable.

The third recommendation would be to test an actual game as opposed to a prototype. This research shows that there is potential in gamifying the treatment framework for chronic conditions just by using a prototype. The next step would be to develop this prototype into an actual game and go through series of extensive testing. The testing could even be done to see the effectiveness of such a game among different populations (age, gender, gamer vs. non-gamer), etc. In addition, this research raises the question of if a game for managing chronic conditions should lean more to the game side or the serious life-style side. While the initial indications show a preference for a more game-like leaning, more research on this is needed. Also, based on the survey and interviews, participants want a simpler aesthetic, and this could be in contradiction to wanting Siege Arena to be more game-like. Thus, more research is needed to see how to make a game like Siege Arena more game-like without losing the simplicity of the aesthetic design. These are the logical next steps for further research.

6.4 Conclusion

The aim of this research was to investigate and develop a gamified treatment framework for chronic conditions such as diabetes and obesity within a theoretical and practical context. Based on this, the following main research question was developed: "How can a gamified framework be applied to the treatment and management of chronic conditions such as diabetes and obesity?" This question was answered by first developing a theoretical foundation through a literature review. This theory was then translated into a design and this design was validated using the iterative method of Peffers' Design Science Research Methodology steps. First a survey was carried out, then the artifact was redesigned, and a final stage of validation was conducted through interviews.

The results of the literature review (theory) showed that the aforementioned treatment framework should have these features: Customizable Goal Setting, Education, Data Visualization, Reward/Feedback System, Activity Tracking, Game Element, Remote Monitoring, Social Options, Reminder System, and Personal Data Management. These elements contribute to the treatment by falling under the self-management categories such as self-monitoring, self-motivation, increased physical activity, and better nutrition. The results also show that a game based on these features does have the potential to lead to a better lifestyle.

Based on the theory (literature review) and the practice (survey and interviews), the most important feature or consideration is the Game Element. This is also supported by how all the volunteer for the interview from the surveys reported (in the surveys) to be gamers and how they reiterated this in the interviews. This means that Siege Arena is very appealing to gamers (or at least, people who categorize themselves as gamers). The implication of this is that if any game for managing or treating diabetes and obesity wants to succeed, the most important consideration is making sure that the game is fun and engaging for players.

In addition, the Reward\Feedback System and the Social Options features are the next most important features of the framework according to theory and practice. A reward system that is linked to the players progression in the game is vital for keeping them engaged with the game for an extended period of time. Given that the wanted results (i.e., weight loss, better nutrition habits, etc.) can only be properly achieved over an extended period of time, this is vital to keep the players using the game for longer. The interview results show that players find the social options to be

important because of their social proclivities such as wanting to inform their friends of their progress or track their friends' progress. In addition, adequate social options for a game aimed at managing diabetes and obesity has the added benefit of helping players not feel so alone (according to the interview results).

Self-monitoring plays a key role in the management and treatment of diabetes and obesity as mentioned in the theory and practice, however, this is an aspect that needs more addressing. During the practice (survey and interviews), participants raised concerns regarding the self-monitoring features of the game as it pertains to nutrition tracking. These issues include potential cheating when reporting nutrition. While no concrete solution to this was discovered along the lines of this research, questions regarding how to ensure no cheating under the self-monitoring aspect of the theoretical framework are raised. This affects the treatment and management because a significant portion of the treatment methods relies on accurate information gained from self-monitoring (e.g., calculating required caloric intake or tracking that the patients are engaging in proper nutritional behaviour that will not worsen their chronic conditions). This is a problem that needs to be further addressed and mitigated with future research.

As previously mentioned, a game that manages or addresses some form of treatment for diabetes and obesity would yield better results if used or played for a longer period of time. This raises the issue of how to keep players engaged for a longer period of time. Based on the theory, a suggestion for addressing this issue was by making use of a Reminder System. However, the practice (interviews) showed that players might find it annoying or intrusive to have pop-up notifications regarding a game and this could deter them from future usage. Nevertheless, the question still remains of how to get players to come back to the game and use it for an extended period. A future avenue of research along these lines could perhaps be how to strike a balance between the perceived intrusiveness of popup notifications and the reminder to use the app that subtly keeps the game in the users' minds.

Despite the limitations of the research, the possible future steps to further develop this would be to strengthen the theoretical foundation through updated research and developing the prototype to a full game in order to have a full-fledged testing. Based on the interview, there is potential to be reaped from making use of lifestyle coaches and linking this with the goal management of players. Therefore, although the focus of this research was not on the medical management of diabetes and

obesity, there is potential for future research regarding making use of the data collected from the app in a medical context. Furthermore, players reported that being able to have autonomy and customize a large aspect of the game (such as setting their own goals and building up their own cities or avatars according to what they like) is empowering. This aspect of autonomy and empowerment was not a result of the theoretical research and therefore was not included in the design of Siege Arena, however, because the practical part of this research uncovered this, it could also prove a vital area for future research and development. Perhaps there is useful information to be gleaned from how autonomy and empowerment help with self-motivation, and this could reshape the framework for the design of the game.

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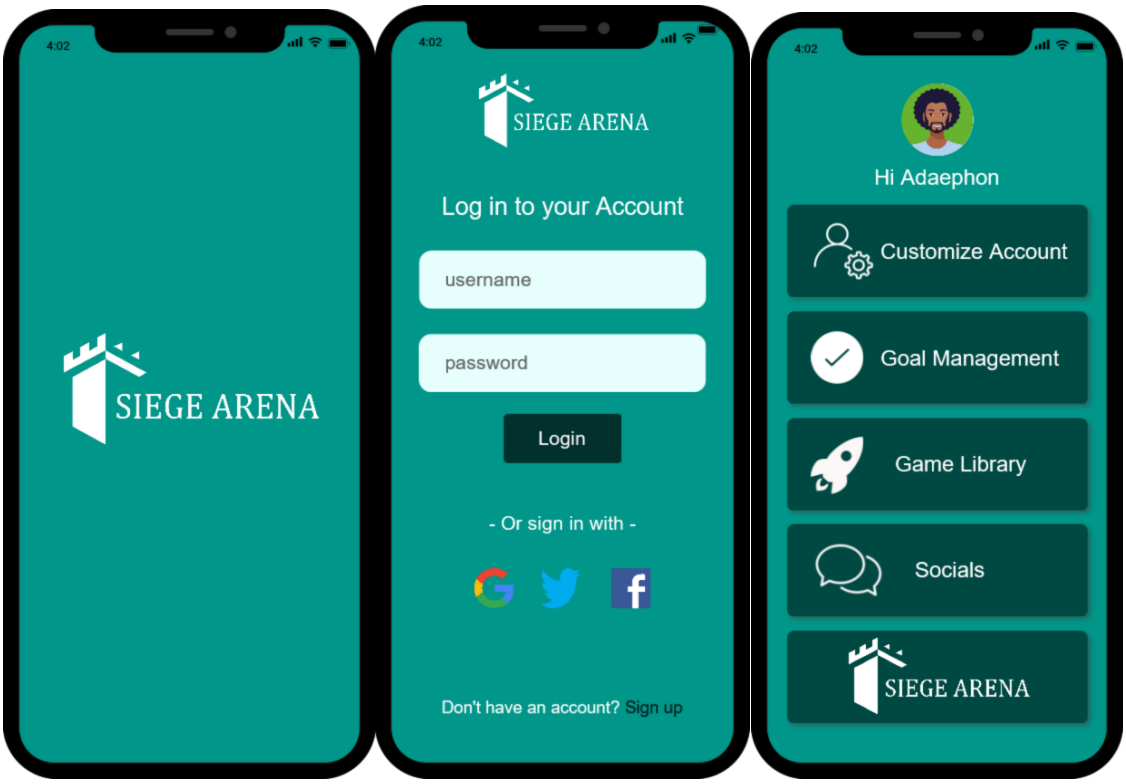
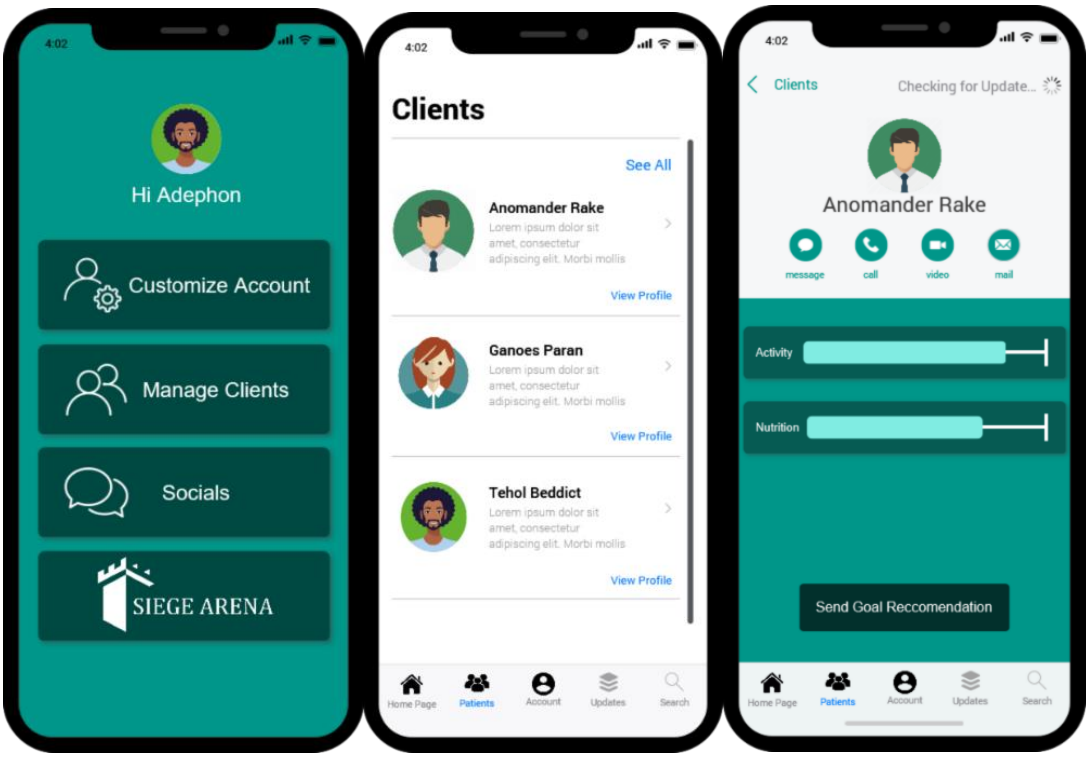
Appendix

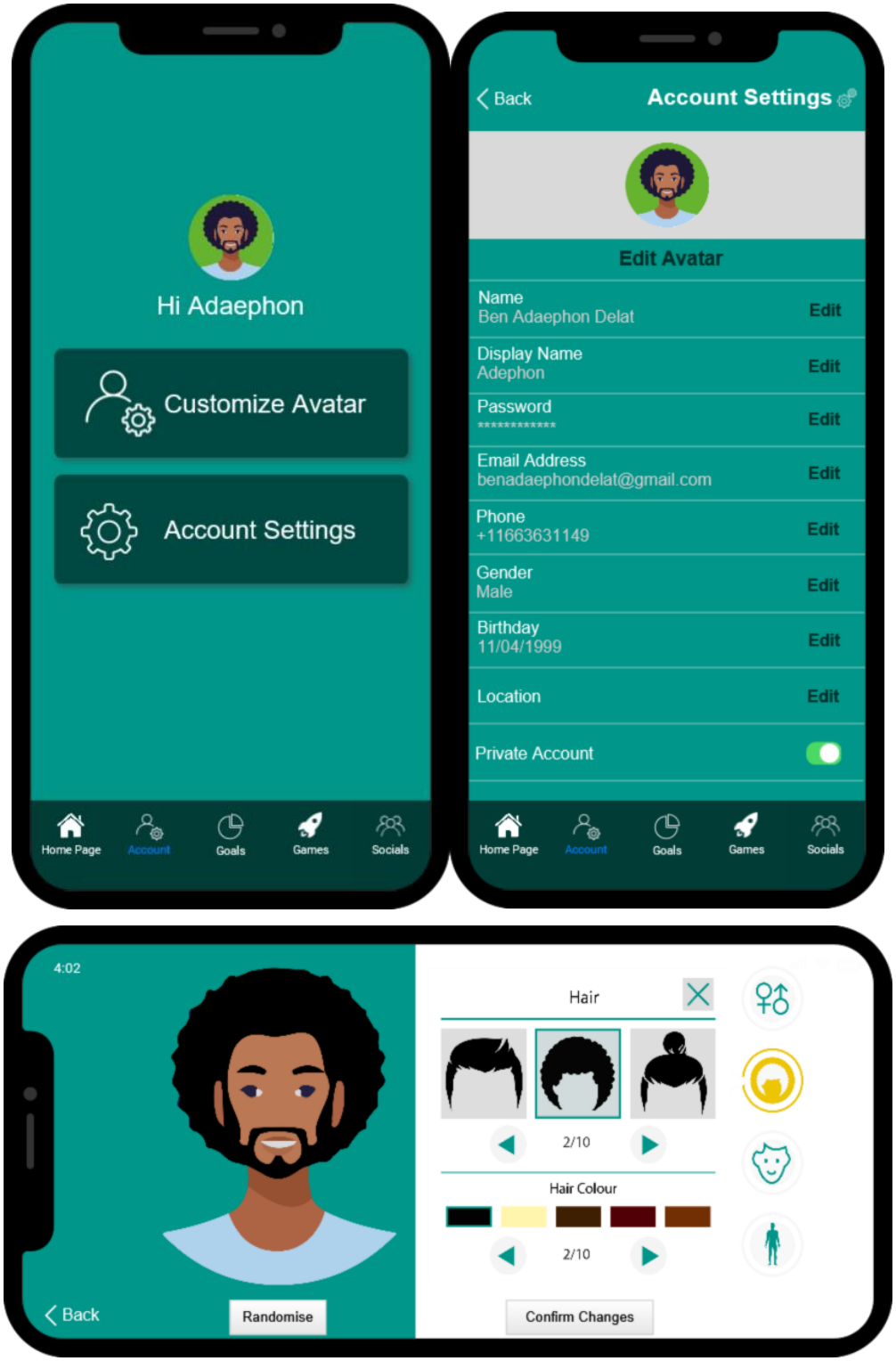
Appendix A – Siege Arena First Prototype Screenshots



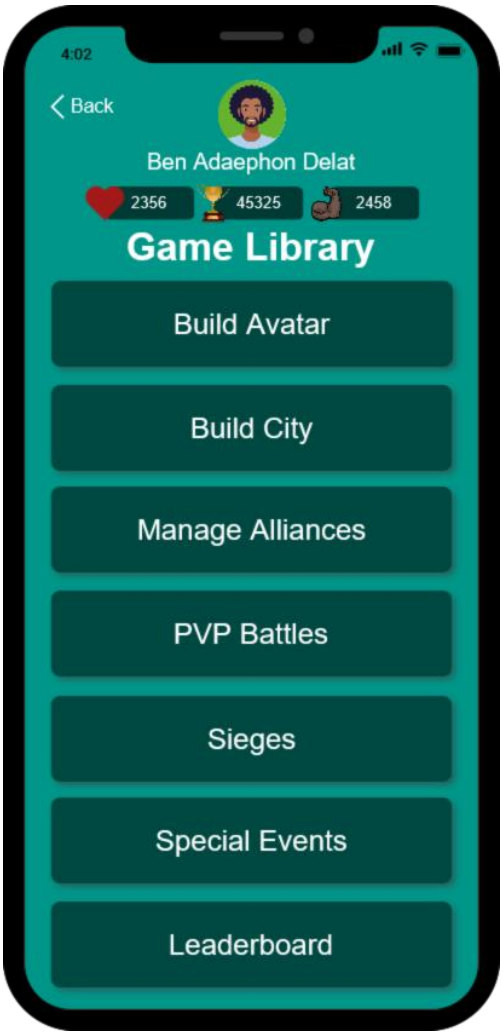
Login and start menu screens



Trainer account screens

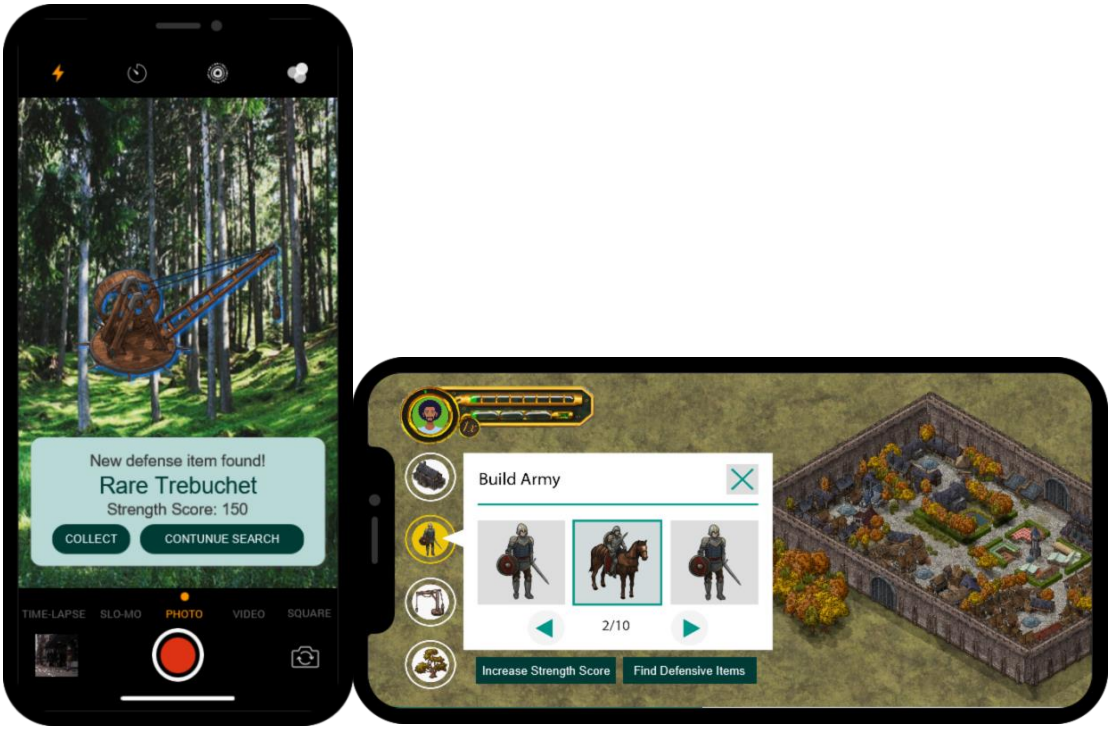


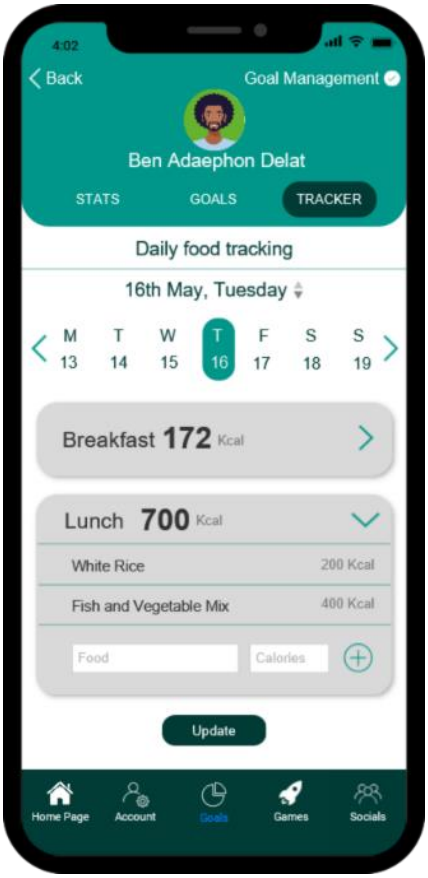
Account customization screens



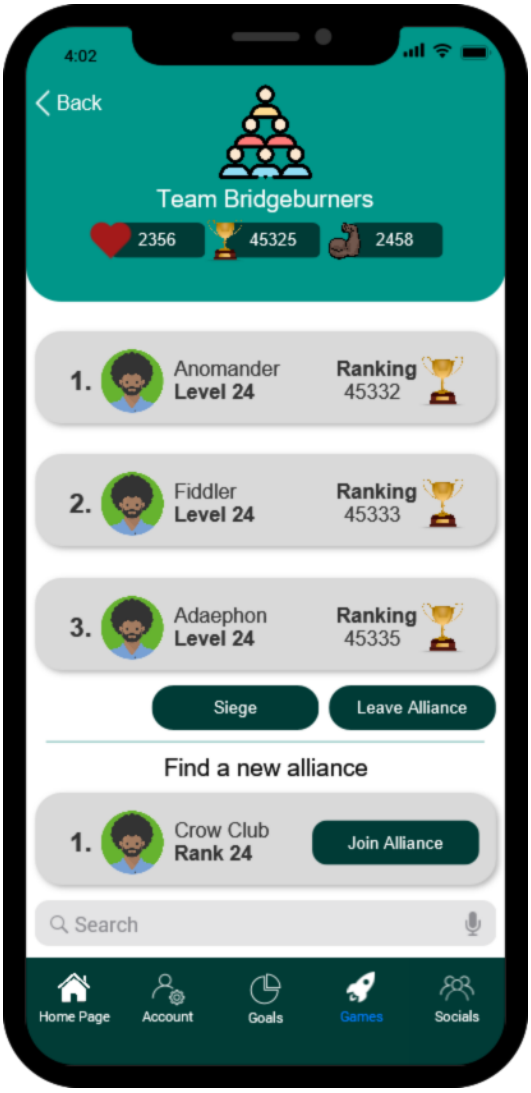
Game library menu section screens

Avatar building screens



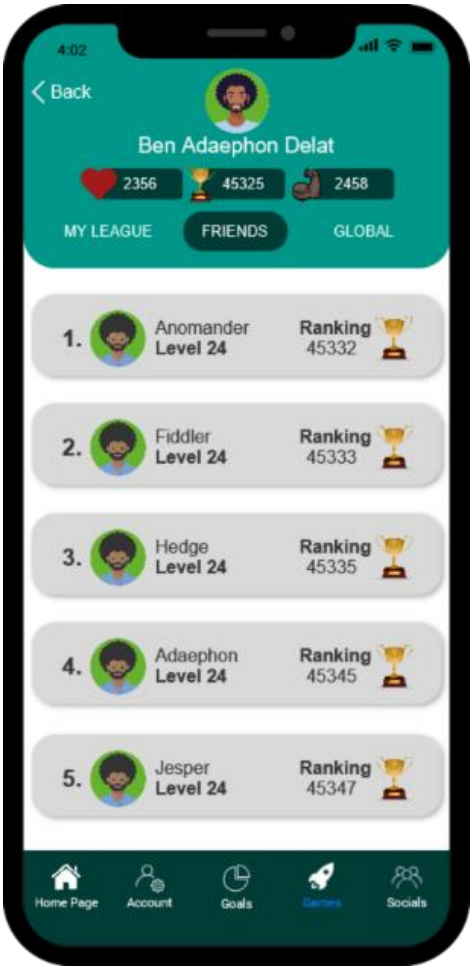


City building screens

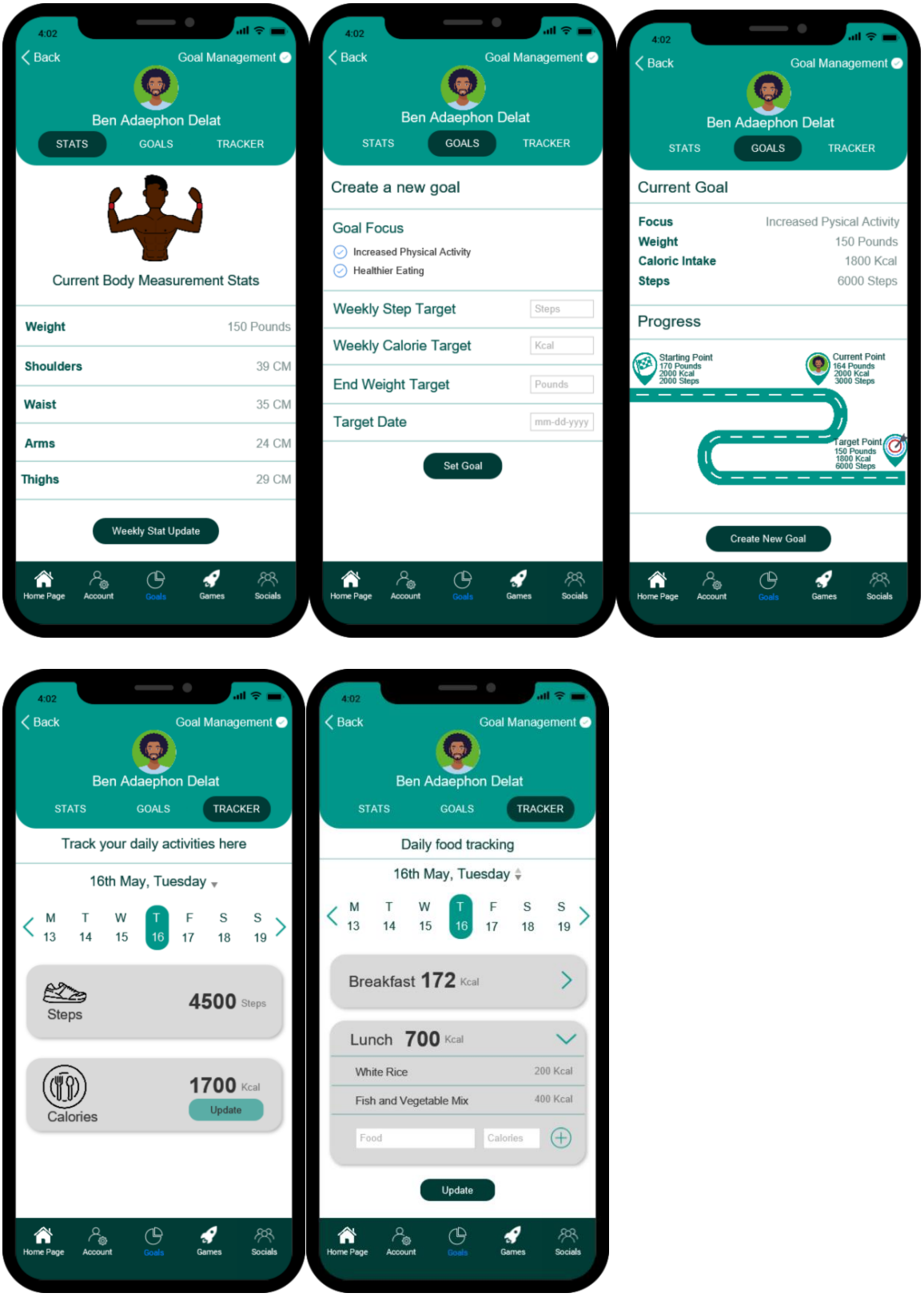


Alliance management screen

PVP Battles and Sieges screen



Leaderboard screen



Goal management screens

Social pages screens

Appendix B – Survey Questions

This questionnaire sometimes makes use of a Likert scale ranging from “strongly disagree” to “strongly agree”

1) Strongly disagree
2) Disagree
3) Neutral
4) Agree
5) Strongly agree

General Information

1. How old are you?
2. Do you consider yourself a gamer?
   - Yes
   - No
3. How often do you play mobile games?
   - Never

- ○ Occasionally
- ○ Sometimes Often
- ○ Always

4. Have you ever used a mobile lifestyle app for better nutrition and physical activity?
   - ○ Yes
   - ○ No

Customize Account Screens

5. Rank how clear the purpose of this section is

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

6. Rank how clear the information presented in this section is

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

7. Rank the logical flow of the information of this section

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

8. Rank how engaging this section is

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

9. Rank the aesthetic presentation of this section

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

10. The customization options on these screens are sufficient

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

11. In your opinion, what are the strengths of this section?
12. In your opinion, what are the limitations of this section?

13. How would you improve this section?

Goal Management Section

1. Rank how clear the purpose of this section is

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

2. Rank how clear the information presented in this section is

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

3. Rank the logical flow of the information of this section

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

4. Rank how engaging this section is

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

5. Rank the aesthetic presentation of this section

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

6. This section would encourage me to track and manage my goals

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

7. This section would encourage me to track and manage my activities

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

8. This section would encourage me to track and manage my daily food intake

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

9. In your opinion, what are the strengths of this section?

10. In your opinion, what are the limitations of this section?
11. How would you improve this section?

Goal Management Section

1. Rank how clear the purpose of this section is

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

2. Rank how clear the information presented in this section is

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

3. Rank the logical flow of the information of this section

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

4. Rank how engaging this section is

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

5. Rank the aesthetic presentation of this section

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

6. There are enough game options to keep me engaged

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

7. Rank the appeal (fun) of the build avatar section of the game to you

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

8. I would be motivated to build an avatar based on the screens

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

9. Rank the appeal (fun) of the build city section of the game to you

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

10. I would be motivated to build a city based on the screens

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

11. I would be motivated to track my daily food intake to contribute to my city strength score

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

12. I would be motivated to make healthier food choices to influence my city strength score based on this section

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

13. Rank the appeal (fun) of the scavenger hunt section of the game to you

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

14. I would be motivated to participate in the scavenger hunt based on the screens

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

15. Rank the appeal (fun) of the battles section of the game to you

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

16. I would be motivated to participate in the battles based on the screens

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

17. Rank the appeal (fun) of the alliance section of the game to you

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

18. I would be motivated to participate in the alliance section based on the screens

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

19. Rank the appeal (fun) of the leaderboard section of the game to you

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

20. I would be motivated to participate in the games based on the leaderboards screens

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

21. In your opinion, what are the strengths of this section?
22. In your opinion, what are the limitations of this section?
23. How would you improve this section?

Social Arena Section

1. Rank how clear the purpose of this section is

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

2. Rank how clear the information presented in this section is

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

3. Rank the logical flow of the information of this section

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

4. Rank how engaging this section is

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

5. Rank the aesthetic presentation of this section

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

6. Social options are important to my enjoyment of the game

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

7. This section would encourage me to engage in the social aspects of the game

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

8. In your opinion, what are the strengths of this section?
9. In your opinion, what are the limitations of this section?
10. How would you improve this section?

Miscellaneous Questions

1. Siege Arena has adequate customization options

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

2. Siege Arena has adequate options for educating players about better nutrition and managing a healthy lifestyle

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

3. Siege Arena has adequate data visualization options

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

4. Siege Arena has adequate reward system options

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

5. Siege Arena has adequate activity tracking options

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

6. Siege Arena has adequate game element options

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

7. Siege Arena has adequate remote monitoring options

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

8. Siege Arena has adequate social options

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

9. Siege Arena has adequate reminder system options

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

10. Siege Arena has adequate personal data management options

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

General Siege Arena Questions

1. Siege Arena is an enjoyable game

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

2. Siege Arena needs to be more game-like

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

3. Siege Arena needs to be more like a lifestyle app

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

4. Siege Arena would motivate me to be more physically active

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

5. Siege Arena would motivate me to have better nutritional habits

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

6. What did you like about Siege Arena?
7. What would you improve about Siege Arena?

Appendix c – Interview

Consent Form

Consent Form for Siege Arena Prototype Validation

YOU WILL BE GIVEN OR SENT A COPY OF THIS INFORMED CONSENT FORM

Please tick the appropriate boxes	**Yes**	**No**
Taking part in the study		
I have read and understood the study information dated _____, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	○	○
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	○	○
I understand that taking part in the study involves a survey questionnaire with closed and open-ended questions completed by the participants.	○	○
Use of the information in the study		
I understand that information I provide will be used for report purposes and further developing a game prototype.	○	○
I understand that personal information collected about me that can identify me, such as [e.g. my name], will not be shared beyond the researcher.	○	○
I agree that my information can be quoted in research outputs	○	○

Signatures

_____ _____ _____

Name of participant [printed]

Signature Date

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

_____ _____ _____

Researcher name [printed] Signature Date

Study contact details for further information: [*Oluwaremilekun Emmanuella Ogunjide, o.e.ogunjide@student.utwente.nl*]

Information Sheet

Purpose of this research project

The purpose of this research is to investigate the features of the game Siege Arena. This game has been developed based on features identified in a literature review and it aims to help users with increasing exercise and positive nutritional behaviour. The goal of this interview is to validate the features identified in the results of the literature review and to confirm the reliability of said identified features. This is done by presenting the participants with the screen prototypes and asking questions regarding said screens.

Withdrawal

If at any point participants do not wish to continue, then they are free to withdraw from the research. This can be done by contacting the researcher whose details are on the consent form attached and the final section of this information sheet.

Personal Information

While the personal information of the participants (such as name, electronic contact information) may be collected by the researcher, the identifying information of every participant will be anonymized (by assigning an identifying number to the participant) to ensure the anonymity of the participants. Participants reserve the rights to request access to their personal information for rectification or erasure of personal information should they wish to. The confidentiality of the participants will be maintained by ensuring that only the researcher listed in this information sheet will have access to the personal non-anonymized information of the participants.

Usage of Data During Research

In order to safeguard the personal information of participants, the collected information will be anonymized (by assigning an identifying number to the participant). Access to the data of this research will be controlled by making use of the information anonymization process. Furthermore, participants' answers to questions will be used for reporting purposes and to further develop the prototype of the game. The data gathered from this research will be retained for a maximum period of one year.

Researcher Contact

Oluwaremilekun Emmanuella Ogunjide

o.e.ogunjide@student.utwente.nl