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A Gamification and Avatar Self-representation Application for Diabetes Self-management

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ABSTRACT

Diabetes affects a person's lifestyle, in particular, their nutrition intake, daily activities, and exercise. Individuals with diabetes are encouraged to learn more about their condition. This will help them to control and manage diabetes and thus, nurturing self-management. Introducing gamification for diabetes, using a gamified avatar as self-representation to reflect the patient's condition may offer different experiences in learning about the disease. In this study, we describe the gamification design applications that integrate games and the patient's avatar for learning about diabetes that could help them to self-manage. We report our preliminary study on implementing the user experience approach, in evaluating the designs of the application. The study revealed that the gamified designs are considered suitable for diabetes self-management, however, there are still some concerns about the reality of the avatar reflection. We discuss challenges and suggestions for further research and implementation in the development of pervasive avatar gamified applications.

Key words: Gamification; Avatar; user experience; diabetes self-management.

1. INTRODUCTION

Many games are commonly available in the market to help individuals with diabetes with their condition, for example; *Monster Manor*, *Coco's Cove*, and *Diabetes Dash*. These games focus on different purposes and targets in supporting the learning process of people with diabetes. A platform that provides fun learning environment, games are more convenient and easily accessible via mobile devices. Researchers such in [6], [17] studied the effect of games on motivating the users and the impact on transforming the healthcare. As the game concept evolved, different approaches to fun learning have been introduced and one of it is through gamification. Gamification offers different entertainment concepts to a new experience in the healthcare [1], [21]. As gamification grows, the concept in healthcare has been widely explored [1], [8], [21] and one significant concept is through the gamification of an avatar as self-representation.

An avatar in a gamified application may influence the way user interact and play. However, the gamified application itself and the avatar gamification, particularly on how the avatar being gamified could promote and enhance the user's motivation for continuously using the application are still actively being researched in finding a solution to accommodate a specific context of implementing it in the healthcare [2], [8], [19]. Thus, this has led to the need for research projects that study a suitable gamification design approach for individuals with diabetes and develop the gamified application accordingly. The research will provide a gamified application that offers people with diabetes to learn about their condition in a way that is fun but educational. This could serve as a starting point in offering a better healthcare approach for self-management.

In healthcare, educating people with specific conditions or diseases have become a great challenge to medical practitioners, allied healthcare professionals and nurses. Newly diagnose diabetes patient often find it difficult to manage their own health [3], [8], [16]. This can include, for instance, memorizing medications and treatments, managing appointments, or understanding the consequences of not following the right medication instruction. As a result, they always come back to the hospital/clinic to get assistance with their situation. On the other hand, the pressure to manage their health condition has demotivated and stopped them from getting proper help and advice. With the aid of technology such as a gamified application, it has increasingly getting more attention among researchers, developers, and the healthcare bodies. Earlier research in avatar and gamification in healthcare such as [8], [21], have limited the strength of the gamification concept towards the use of points, badges, levels, and a Leaderboard. Discovering other game elements such as avatar, would offer different potential of gamification, by presenting potentially positive effects and outcome to enhance users' motivation to self-manage.

Previous work by Ruiz *et al.* [16] on computer games for diabetes, indicated that there is no significant improvement to the patient's knowledge preservation on medication instruction. Also, research in gamification for diabetes, such as diet management [5, 8], medication intake [16], and carbohydrate counting [20], were conducted in isolation. Designing a platform containing several aspects of diabetes related information and conditions would contribute to a more integrated design approach and practical applications in healthcare [2], [13]. Darejah & Salim [4] also suggested that future research on gamification should focus more on resolving difficulty in learning software, as well as using real identity in software. This of course is very closely related to this research, which is gamifying diabetes

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information for self-management and using avatar as virtual self-representation to improve engagement and motivation. Wonggom et. al [22] has shown that avatar-based technology in healthcare education, had a significant improvement in knowledge. However, researching the suitable way for avatar implemention in gamification could give another insight to the patient's engagement in diabetes self-management.

Thus, this research presents how the avatar gamification should be designed and implemented for diabetes self-management. We used user experience approach for the design works in order to have a direct involvement user (i.e. individuals with diabetes) with various knowledge background on the diabetes condition itself, gamified design and healthcare needs. The main aim is for them to provide a more specific input towards designing the application that is relevant for this particular population. Thus, in this research, we are reporting findings from our preliminary study in designing the application. The preliminary study was also conducted as to explore and evaluate the feasibility of the development process that was aimed for this research. Following this, we summarised the findings and suggestions for executing the actual research study.

2. BACKGROUND RESEARCH

In healthcare, diabetes is a chronic condition that requires careful monitoring and cares from both the healthcare professionals and the patients. Diabetes self-management is important to maintain a good long-term health status. Since 2015, diabetes was found as one of the major public health problems in Malaysia, with an increase of 20.8% of Type 2 diabetes in adults above the age of 30 [7]. To this, various initiatives, programmes, awareness, and problem-solutions have been introduced and conducted by the Malaysian healthcare bodies. One of it is the use of technologies like educational mobile applications [2], [5], [8]. Computer games are popular and has significantly affected the users [2], [8-9] due to the fact that people can learn and understand their condition effectively at their own pace while having fun.

Serious games for health education have been widely explored and demonstrated such as in [8], [20], [22]. Recent works by Vassilakis [20] on carbohydrate counting and Hwang [8] on nutritional choices were focused on providing fun games that were not directly about the health. However, indirectly while playing, the patients learnt certain knowledge and information through the activities embedded within the game. For example, information on knowing the right and healthy food intake on daily basis, routine on recording daily blood sugar level and knowledge on the maximum amount of carbohydrate intake for each meal. It seems that the games become a digital diabetes diary for the patient. A game developed by Rønningen et. al [15] called *Diaquarium* taught patients about diabetes including how nutrition, blood glucose levels and insulin are connected and affected to each other. They applied the reward techniques in their game, which demonstrated significant effect on patient's progression in the gameplay.

Other than serious games, a gamified application or gamification also gained a lot of attention in healthcare. The gamification concept is recognised as applying game elements or mechanics into non-gaming perspectives such as education and healthcare, while maintaining the playfulness environment [2], [4]. The aspect of gamification such in [8], [15], [21] only related to in-game rewards, where patients will be given a reward (points, badge, trophy) for their participation, such as updating their diary and logged their blood sugar level. Those rewards can be re-used in the game-play. Following these research findings and other aspects of gamification as listed in [6], [17], different application of gamification techniques could be implemented. It may offer different effect to patients' engagement and motivation to diabetes self-management. For instance, applying avatar gamification could bring more fun in the learning process [5], [19].

An avatar is perceived as a user's presentation that involved personalisation or customization of a game element in gamification [5], [11], [18], [19]. Implementing avatar gamification offers a more stimulating environment, which will indirectly motivate the users to engage and use the application [11], [18], [19]. An avatar in a gamified application may influence the way people play and perceive themselves in the gameplay [2], [3], [5]. This is because having the ability to change or customize own character make it more exciting and brings immersion into the gameplay. Other than avatars, the elements of reward in gamification such as Points, Badges, and Trophies, will motivate the users and promote continuous usage of the application [1], [6]. This situation may have resulted in a change in player's daily routine from the effect of feeling fun, maintaining engagement, getting immerse with flowing rewards when using the gamified application [1], [6], [18].

A study on avatar in game by Peter et.al [13] had implemented avatar as a personal assistant in taking care the users' healthy lifestyle as a diabetic. The personal assistant will monitor the user's medical diary, health progress and learning achievement. The personal assistant aims to promote diabetic self-management and their research showed that their application design does meet with the objectives of using a personal assistant. However, some in-game design required further refinement for it to be more usable. In Baranyi *et.al* [3], among other features, an avatar is used as a user's profile picture in a Leaderboard. The profile picture can be customized according to the user's preferences. The research has significantly showed that avatar is one of the motivation aspects in the application. In Akker *et. al* [2], the game offered virtual coach to guide the patients and impart feedback on patient's daily activities related to diabetes. The feedback will be used by the patients to make progress in the game. The virtual coach is expected to motivate the patients to constantly engage with the game and thus, will affect their learning process for diabetes self-management. However, a larger scale of evaluation for this application is needed in order to see the effectiveness of gamification towards self-management for patient with a chronic condition.

Among all the game research in diabetes such in [2], [3], [13, 20], avatar implementation is likely acts as an agent (personal assistant/health coach) or used as a profile avatar, which is the user's representation in the dashboard/leaderboard. However, different avatar application affects participants differently, as studied by Hwang [8]. The avatar application has positively affected the way participants make choices of snack after the gameplay (post). In Hwang, avatar was used as a message

framing in-game where any choices of snack (with high or low calorie) will impact the appearance of their avatar. This kind of effect will indirectly teach the participant about overconsumption and unhealthy food choices in real life. This avatar application is still under research and was not yet the State-of-The-Art focus, in particular towards diabetes self-management. Applying avatar as user's self-representation is kind of a reflection to the condition of patient in a game-play. This application could help the patients to further visualize the consequences of their actions towards their condition. Besides, by framing how well the patients are through their avatar could bring a different experience and perspective to the patients while having fun in learning. Recent research by Fuchs [5] applied the concept of avatar as user self-representation. This was applied as a future-self avatar that showed dietary sodium intake in user's nutrition. A balance intake will show a healthy avatar, but imbalance consumption would reveal an avatar in a negative health stage, which will raise awareness for the users to change their unhealthy diet.

Following Wonggom *et. al* [22], avatar-based technology applied in health education has significantly imparted positive impact on various healthcare outcomes, namely on self-management, self-efficacy, change in behaviour, and knowledge improvement on related diseases. However, the effectiveness of applying gamified avatar for promoting adherence to medication, reducing hospital readmission, and improving quality of life are still under research. The other study by Sardi *et. al* [10] reviewed that gamification application in e-health for chronic disease management such as diabetes, Alzheimer and anxiety are among the most researched topic in the healthcare domains. However, the gamification aspect researched was related to rewards, feedback, and socialization (leaderboard and dashboard).

Thus, gamifying an avatar in a gamified application should be taken into further consideration in research. Besides, previous research [10], [20] in diabetes gamification or gamification in e-health are still lacking and established evidence, and literature were only focused of the effect with short-term engagement. Ideally, the gamification should accommodate and boost long-term engagement for better monitoring towards self-management [2]. Therefore, as we research, there is a plausible opportunity to suggest alternative solution for diabetes self-management using avatar and gamification.

3. DESIGN PRINCIPLES

People living with diabetes need to have a good understanding of their condition and be able to self-manage throughout their lives [2-3]. Thus, the main objective of the design of this gamified application is to instil these individuals with knowledge on the effect that will happen to their body (as body health condition) when they are performing different levels of activities, being tired, having low or high blood sugar and other behaviours related to diabetes. Therefore, they should pack the essential items inside their bag. With that in mind, we designed the gamified application by following the gamification concept (game elements & mechanics).

The gamified application is a platform that offers a function or apps for managing patient's health record. The platform can be plug-in with a series of mini apps/games from time to time to accommodate problem areas in diabetes. In the application, there will be one main mini game as the centre of the application. It will be the main activity that must be completed, and the player should always be aware of it in order to survive in the game. We created some avatar figures using an online tool (www.DoppelMe.com) to visualise the type of effects on user's avatar based on their in-game condition. The avatar-effect-conditions can be understood as shown in Figure 1.

The designed mini apps/games will be a pack-a-bag game (Figure 2), where the patient needs to pack an important item in their virtual bag before they start to play other mini games in the gamified application. These items include water, a chocolate bar, insulin, pills and others. This bag will act as their source of energy while playing other mini-games, with in-game consequences applied in the event if too much activities have occurred, forgetting medications on time, or not taking adequate break in between activities. The consequences will then affect the appearance of the patient's avatar. The player has to come back for 1) check their conditions, 2) top up their energy, 3) get rest, and 4) timely medication intake.

For the first design exercise, we designed three other mini games to be included in the gamified application. These three mini games are based on the objective of instilling knowledge of diabetes. Two important diabetes conditions that every diabetic should know are *hypoglycaemia* and *hyperglycaemia* [2], [3], [7]. In hypoglycaemia condition, the blood glucose level is below the threshold level that can be attributed by overdose of insulin, low food intake, effect from high or prolonged physical activities, or possibly from alcohol consumption.

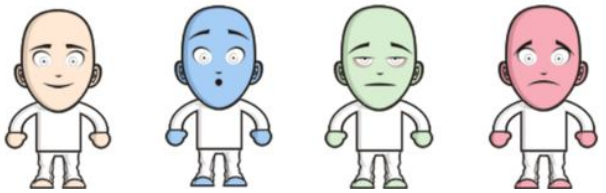

Figure 1: Storyboard – Avatar Condition

Figure 2: Storyboard - Pack a bag

Hyperglycaemia happens when the blood sugar level is too high as a result of lack in insulin in the body. This can occur due to insufficient dose of insulin or wrong food intake. Both conditions have serious consequences if the *hyperglycaemia* is not treated

leading to a series of life-threatening events including hypotension (significant drop in blood pressure), paralysis, and coma.

Among other diabetes games that were studied previously; 1) counting carbohydrate intake [20], 2) choosing the right food and insulin (commercial game such as diabetes dash, Coco's cave), and 3) nutrition intake [3], [5]. In this gamified platform, choosing the right food intake will be designed and applied into two games, 1) memorizing games, and 2) bad/good food game. The third game will be about physical activities. This could be a running game (while collecting the important things for diabetes) or doing exercises as to note the important of exercising for a good health. The gamified application also has a setting for the patient to set their personal details and game preferences. With these design in mind, we presented it to a group of experts for further input, enhancement and verification.

Thus, in this gamification platform, there are three goals that should clearly be comprehended by the users. The ideas of this proposed gamification application are;

1) The bag pack –task related to packing the important things that should be carried by a diabetic in their bag (implies significant tools for managing diabetes in their daily activities)
2) Mini Games – task related to grasping general knowledge and information about diabetes.
3) Profile – task related to the setting of avatars (selection).

To realize the proposal, we transformed the designs of the gamified applications into storyboards (example is shown in Figure 3). The storyboards will be evaluated by the experts through focus group discussion.

4. USER EVALUATION

The user evaluation was conducted to understand further about the subject matter and obtain feedback from the users on how the proposed design for the gamified application can support people with diabetes to self-manage. We used user experience approach for this exercise as to gain as much involvement from the users as well as to elicit potential future experiences

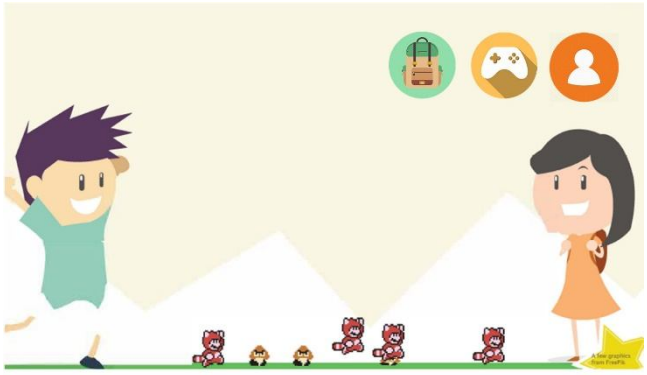

Figure 3: Storyboard - the environment

of using the gamified applications. Moreover, the user experience approach can inspire and immerse user emotions through interaction [23]. A small group of potential users are identified and invited to participate in the design decision activities. The users will become the design informant by sharing their experiences, knowledge and expertise, so that it can be transformed into the design of the gamified application. This potential user include consultant, physicians, game designers, application developers, computer science researchers and people who are living with diabetes.

The methodology of this research consisted of three phases and the phases are show in Figure 4. The initial phase started with brainstorming from the literature followed by application review and analyses of related games and gamification. At the end of this phase, we came up with a general design idea as explained in section 3.0. The next phase is the user experience phase where in this phase we collect requirements from the users in focus group discussion. In this phase, the suitable participants are approached and invited to the discussion session. To collect the user requirements, we used storyboard and mock-ups to present our designs as well as creating sets of task-scenarios for the mock-ups. The final phase is the confirmation phase. We revisited the agreed features and functions and come out with the agreed designs. The designs will be transformed into a prototype for another series of enhancement.

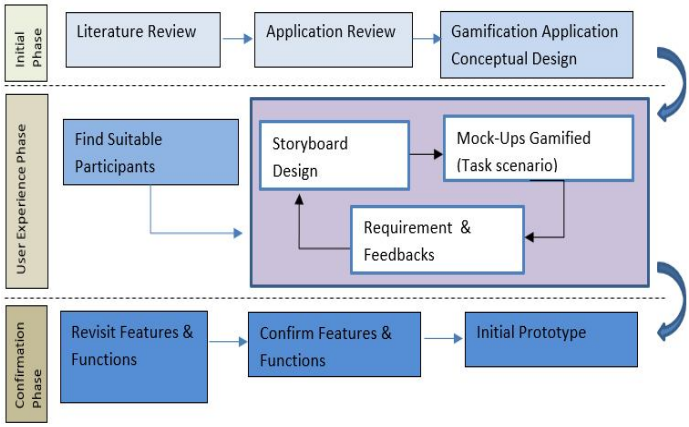

Figure 4: The process of the user evaluation

4.1 Study Design

The user evaluation was conducted in 2 weeks period of time. The participants were first scrutinized so that they met the eligibility criteria for this study. We invited them to participate in the study through phone and once consented, we gave them the details for the focus group discussion meetings. The discussion started with introductory session, briefing on the overview of the study followed by a presentation of the proposal using storyboard and mock-ups. The mock-ups are the details on how the gamified applications should worked. For each of the storyboard, we listed the task that should be conducted by the user. These mock-ups will help the users to visualize the design idea for the gamified application. Table 1 listed the mock-up tasks for this data collections exercise. For the first storyboard – game environment, there are four tasks involved for the mock-up where in this storyboard, the tasks are about setting the avatar, health information, health status, and checking if there is pending tasks left. For the second storyboard – pack a bag, two tasks are involved. This storyboard is about selecting an activity and the things that the user feels are needed to be packed for one day

activity. For the last storyboard – the mini games, three tasks are involved where the users need to select one game, then play the game for 2 minutes (example game) and check the avatar progress/status. The users need to check their avatar status as to ensure when they active they have enough of blood sugar level.
After each storyboard has been presented, we asked them the following questions;

1. What do you think about the functions? (as provided in the storyboard).
2. How do you think the storyboard can help the designers or developers to develop the gamified application?
3. What needs to be improved?

There was no particular personal information gathered during the discussion. However, participants were asked to provide informed consent. Afterwards, the insights from different aspects of the participants were gathered and summarised. After a week, a summary of the discussion was sent to them for verification and approval. They were given another week to revert their approval to the researcher.

Table :. Lists of mock-up tasks

Storyboard	Task	Description
Game Environment	T1	Set Profile (Avatar)
	T2	Set health info
	T3	Check health status
	T4	Check any pending tasks
Pack a Bag	T1	Select type of activities
	T2	Select (3) Things to be packed for a day activity
Mini Games	T1	Select 1 example game (choosing the right meal and avoid monsters)
	T2	Play for 2 minutes (example)
	T3	Check Avatar Status

4.2.The Participants

There were 10 participants involved in the study. We divided the participants into two sessions where small number of participants were arranged together. Following Onwuegbuzie & Leech [12], around 3-5 homogenous participants are typically sufficient to reach saturation. With a small number of people in a group, each participant will have a sufficient space and opportunities to give their opinions on the subject matter. Also, it is easier for the researchers to schedule the focus group discussion meeting in terms of availability and place, as well as to facilitate them during the discussion. Therefore, the first session (F) consisted of 6 participants and the remaining 4 participants were segregated in the second session (S). Table 2 is the summary of the participants.

Table 2: Summary of the research participants

ID	Gender	Age	Role
F1	F	28	Apps Developer & Designer
F2	M	45	Game Researcher
F3	F	40	Game Design Researcher
F4	F	35	Software Developer/Designer
F5	F	35	Doctor 1
F6	M	38	Doctor 2
S1	M	40	People with Diabetes 1 (Type1)
S2	F	39	People with Diabetes 2 (Type1)
S3	M	28	People with Diabetes 3 (Type2)
S4	M	35	People with Diabetes 4 (Type2)

5. FINDING & DISCUSSION

Through the focus group discussion, we aimed to provide the specific input towards designing the gamified application as well as to explore and evaluate the feasibility of the user experience method in designing the application. We gathered all the related requirements, and summarised them according to the following points;

The Features/Functions of the Gamified Applications

The participants found that using the avatar gamification as mean to reflect the patient's conditions were quite stimulating towards user engagement. However, they added that the applications should also allow avatar personalisation, so that patients would have a higher level of sense of presence and perceive more about their character in the gameplay [11], [19].
There was also a suggestion to provide a multiplayer platform to allow the avatar to communicate with other avatars (i.e. between players communication). Although this is not within the scope of the research, however, it was a worthy suggestion for future enhancement. The discussion also included issues related to game narrative. We agreed that narrative or storyline is one of the important elements in gamification that need to be focused in this gamified application as discussed in [6], [17]. A game narrative would guide the user as well as enhancing immersion in the gameplay. Nevertheless, the narrative does not have to be revealed explicitly. It can be conveyed through the design of the game and the game elements used in the game. Thus, we believed that the avatar itself can be part of the narrative in the game. This is based on the fact that the developed self-representation avatar would generate a spontaneous narrative in a gameplay which will affect the way the player's play in the game

as well as the player's virtual identification [14], [19]. Adding a narrative particularly related to the patient's condition and reflected through their avatar would be more interesting and potentiate higher degree of engagement and involvement from the patients.

The Features/Functions to elicit future experiences

The storyboard approach has helped the researcher to gain more insights on what the participants had in their minds. Several ideas were discussed that focused more into the future experiences of the patients in using this gamified application. One of the ideas was related to the diabetes learning game. Having a game that could teach the patients about the 'safe level' of blood sugar level and importantly the ways to control them should also be plug-in as one of the mini games in the application. Adding a fun quiz to test the patient's awareness is also beneficial. This include awareness of *hyperglycaemia* and *hypoglycaemia.*

Other than that, diary-based applications such as from one of the commercialise apps- Monster manor, were also discussed. However, as diary-based is not the focus of this application but sought by the subjects, this feature would be made available in the future enhancement. Similarly, future gamified application would include features on blood sugar reading and logbook (keeping record). This feature is commonly available in several commercialised diabetes application such as *Monster Manor*, *Coco's Cove*, and *Diabetes Dash with additional new games* in research [2-3]. It requires additional tool (blood sugar reading meter) to be connected that enable the patients for daily updates on their sugar level reading.

All of the comments and feedbacks may at least give some short-term diabetes related outcomes for self-manage. One can yield insights on the related features or functions that would be beneficial to be embedded in the design of the gamified application, but it might not possibly be relevant to incorporate them all in this research.

The feasibility of the development process

From the focus group discussion, the storyboards and mock-ups have positively helped the participants to visualize the proposed design easily and clearly. Generally, the participants found that the designs were logically make sense when applied to the context of diabetes self-management. They also expressed that using storyboard methods were very helpful in generating the ideas during the discussion. Apart from that, it also benefitted the developer or the designer to directly adopt the design and idea into the real application, which, could potentially lead to shortening of the development phase time. However, they added that the mock-ups were not just limited to the given tasks and could be made for other activities related to the applications. For instance, additional mini games such as running and collecting a bucket of fruit would be intriguing.

6. CONCLUSION

In summary, applying gamification approach for diabetes is seen as a promising approach for fostering self-management. Let them play and learn concept has offered a platform that can motivate the patients to manage their condition, which can be realised through the application of avatars, the game elements and the mini games plugged-in in the gamified application. This avatar gamification application for diabetes self-manage study provides several contributions to the theory and practice. First, the study extends the current body of research on gamification application on diabetes through avatar-based design that is gamified based on patient's condition while playing and learning in the gameplay, and an application that can motivate the people with diabetes to self-manage. Second, this study proves that user experience approach using storyboard and mock-up tasks is very helpful in brainstorming ideas, collecting feedbacks and exploring further on the design of the gamified application. The storyboard and mock-up tasks set-up for the gamified application were well accepted by the participants. Third, it seemed that the focus group discussion has created a conducive environment for the participants to share their experiences and opinions for the enhancement of the gamified application designs. Thus, the study approach can be adopted into other similar setting of research. As this paper presents findings from a preliminary study on having a consensus design of the gamified application, our future work will be translating the design into a prototype for future testing and verification.

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