Gamification to Encourage Increase on Healthier Physical Activity in Younger Users

A thesis submitted to Middlesex University for the degree of MSc by research in Ambient Assisted Living of Computer Science Department

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Abstract

This research is the first part of a greater project with the aim to encourage increase in physical activity in different groups of population. The main goal of this part of the project was to develop a cross-platform mobile application that would use gamification elements and to focus on younger group of population. Because of the targeted group, the design of the application was based around an approach, usually used to make profit in popular video games through microtransactions, which provides the user with virtual avatar that can be customised through virtual collectibles. This approach has proofed to work efficiently for many developers as it can generate significant profit from video games that are available for free. The application rewards the user with in-app currency for a physical activity by completing different goals or going to a different facility such as gym. The in-app currency can be then exchanged for the virtual collectibles or for a tangible real reward such as voucher for a swimming lesson. As this research is a part of a greater project, many different stakeholders were involved through the development. The application was developed and tested closely working with the stakeholders, especially the targeted group of younger population, considering everyone's requirements.

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Introduction

As a part of a greater, long term project, this research has been conducted with the contribution of different stakeholders. Due to the nature of the research and the number of different stakeholders, different requirements had been proposed through the development process that had to be fulfilled on certain levels. At the beginning of the research, there were two fundamental requirements set by the main stakeholders, built a cross-platform smartphone application that would encourage increase on physical activity in younger users using gamification.

Considering the main requirements for this research were to develop a smartphone application using a well-established technique called gamification which uses gaming elements in a non-gaming scenarios, the very first proposal presented (*figure 1*) to the close stakeholders featured a simple mock application with system that would offer different tangible rewards for physical activity using gamification elements. The presentation of the mock application demonstrated the use of gamification elements in the project, showcasing the use of daily goals and challenges. The user would be rewarded with in-app currency for physical activity and for the completion of the daily goals and challenges. The concept of the mock application was then agreed by all the core stakeholders allowing to proceed with the development.

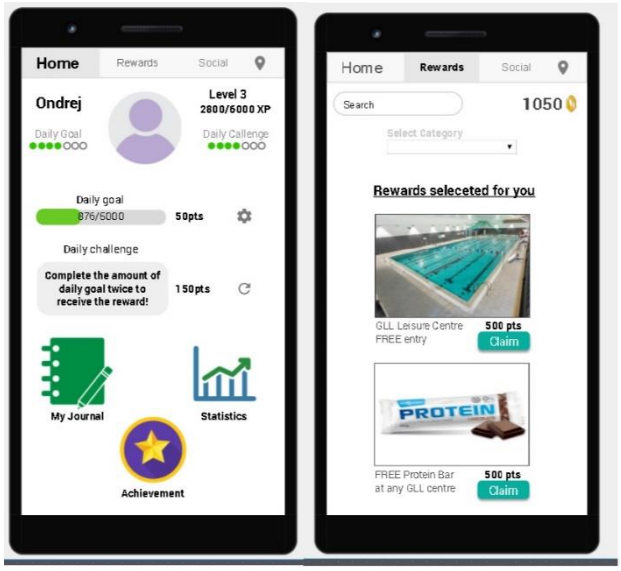

Figure 1

As for the gamification and smartphone capability requirement for the research, the initial proposal of the mock application was satisfactory, for the core stakeholders, providing the rewarding system using gamification elements. The research, however, must deal with another, more important, group of stakeholders. The most important group of stakeholders has already been mentioned in the title of this research and it is their opinion and interest that should matter the most at the end. The younger users, children and teenagers, the targeted group of this research. Offering this group of users with tangible rewards such as protein bars, swimming lesson or any other sport related items for obtained in-app currency might not be as big incentive as to other groups of population. It is safe to say that some part of the targeted group would be interested in such rewards and they would be keen to use the application on daily basis but this type of rewards does not provide much flexibility and options in the everyday changing world where trends are shifting rapidly.

Because of the targeted group of this research and gamification being such an important element, another concept that would be built on top of the rewarding system, presented in mock application, was introduced to the core stakeholders. This concept also takes inspiration form the world of video games where such approach has proven to work very well. There are many video games on the market, using this concept, which draw attention of millions of people, especially younger users, and generate great financial profits for its developers while being available completely for free. Such games create the profit by, usually, offering microtransactions or virtual collectibles that the user has to purchase. The users spend their money to customise their characters, buy different cosmetics, dance moves or anything that the developers can incorporate into the game providing almost limitless options for new content to be added over time and adjusting to current trends. The idea is to use this concept of virtual collectibles and cosmetics in an application that rewards the user for being active and therefore trying to generate more physical activity rather than profit which can be generated alongside by the users visiting different leisure centre, gyms etc. associated with the application and core stakeholders.

A demo application (*figure 2*) was created to demonstrate the concept of virtual collectibles built on top of the basic rewarding system mentioned before and such demo was then presented to the core stakeholders who agreed to proceed with the development.

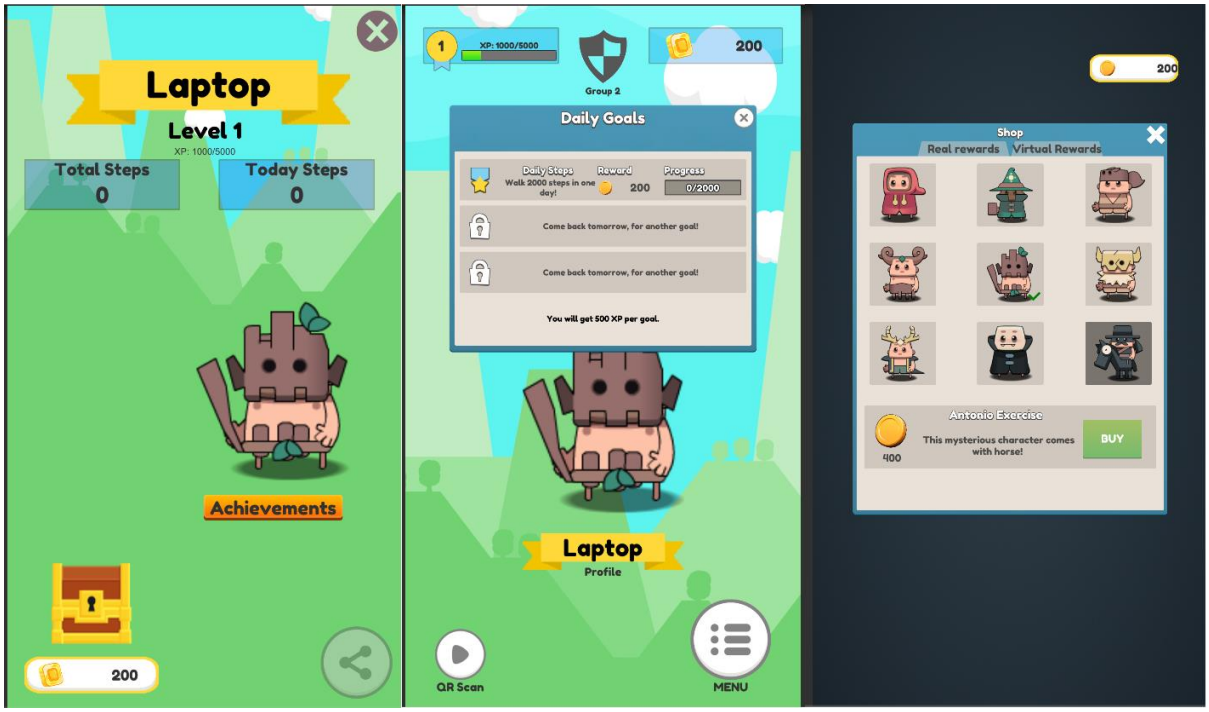

Figure 2

Similar Applications on the Market

There are many relevant applications on the market that match the similar concept of this gamification project but there is one application that has been successfully increasing physical activity in its users for the past few years, Pokémon Go [9]. Due to its vast fan base of more than 100+ million users and worldwide popularity, Pokémon Go and its influence has been used or mentioned in many researches on physical activity and gamification and how applications using gamification elements can affect the increase in physical activity. Due to the vast amount of papers released on Pokémon Go, the motives for playing Pokémon Go [10], the physical activity improvement over time [6], and the reasons why people started to play Pokémon Go, continued Playing or eventually stopped playing Pokémon Go [14] were determined. These and many other studies, articles or group discussions provided valuable information about how to approach the development of the initial prototype of the application.

The research on Pokémon Go, especially helped to clarify which elements are important in order to keep an active user base. There are three different types of users considered when it comes to Pokémon GO [10] active players, former player and non-players and there are different reasons for each group for starting to play, keep playing and quitting.

Reasons to play

- Curiosity
- Pokémon fan
- Augmented reality function (especially for Former Players)
- Telling the right story or Theme

Reasons to continue playing

- Rewards, competitions, and fun elements (Gamification)
- App design and specific App features
- Reaching next level (especially for Active Players)
- Catching stronger or rare Pokémon (especially for Former Players)
- Improved AR, new features over time, updates (This would probably maintain more users if applied)

Reasons to quit playing

- Boredom
- Repetitivenesss

Other applications that fit the concept of the project, such as The Walk or Zombie Run, have been reviewed but due to the lower number of active users, compared to Pokémon Go, there are not many relevant papers describing the effectiveness of these applications. In the case of, above mentioned, less popular and less promoted applications, the reviews and comment sections of each product acted the main source of useful information that helped to determine strengths and weaknesses of each application. Some of the limitations of these applications and reasons for users to stop using mentioned applications are:

- Lack of frequent updates
- Not addressing issues
- Failure to keep the user updated
- Ignoring the users' feedback

The research done on Pokémon Go suggested the main issues that caused many people to quit playing Pokémon Go after short period of time. In case of Pokémon Go, the main reasons for quitting the game after short period of time were mainly increasing repetitiveness or boredom, lack of social interaction in the application or not addressing users' feedback promptly or at all. Followed research on the community of Pokémon Go revealed, that the company failed to deliver frequent updates in terms of new features, events, challenges etc. which caused the application to become repetitive and stagnating. This caused vast number of users to quit playing Pokémon Go after short period of time, even shorter than the time of use for activity trackers.

The Goal

As this is the first part of a continuous research, one of the goals is to do the initial groundwork, design and to develop a solution in form of cross-platform application with basic reliable features that could be extended and improved during the future development of this project. The concept of virtual collectibles proved to work well in area of video games industry and this research sets a goal to examine whether that concept could be efficient enough to encourage increase on healthier physical activity and if the same concept that draws people to games could encourage people to be more physically active.

The initial research on existing products on the market indicates some limitations and failures which lead to the decrease of active users. This project aims to design and implement different features that could prevent from these limitation and from the decrease of active users in short period of time, trying to create a platform that could attract and keep active user base. The research aims to provide basic features that could be easily expendable in the future making sure the final public version is capable of adding a new content frequently, providing social interactions in form of teams, competitions etc. or to connect the application with real places and facilities that would help to encourage more physical activity.

All the development and testing are set to be done working closely with the key stakeholders, especially the target group of users adjusting the development and features based on the immediate feedback from such stakeholders.

Literature Review

Gamification

Gamification is one of the main elements of this research. The main idea behind gamification is to take video game elements that can motivate people and use them in non-video game context [5]. The gamification as a term appeared in the early 2000s [7] and has been getting quite some attention.

To achieve gamification, the solution should use badges, trophies, and leader boards [7] as they can increase the motivation and productivity of the users. The gamification is a very versatile term and different incentives other than badges, trophies, and leader boards such as experience points, levelling system rewarded for some non-gaming activity.

In this research, the gamification is used to encourage physical activity, this combination is usually called "exergamification" or "exergaming" [8]. The usage of gamification in physical activity related solutions should reward with the previously mentioned badges or it should provide different

incentives in form of leader boards, trophies, competitions etc. but many applications [8] tend to focus only on the input in form of physical activity rather than on the gamification element.

Behavioural Change Techniques

The Behavioural Change Techniques (BCTs) [12] were implemented in cooperation with the psychology department from Middlesex University. The reason to include the BCTs was to encourage the target group to change their behaviour associated with physical activity. From the list of 93 hierarchically-clustered techniques, 14 BCTs relevant to the project were chosen and their implementation was required in the application.

1 Goal setting

This BCT was implemented in form of fixed and personal, customisable, step goal which are used as an incentive for the user. The fixed step goal is used to motivate the user over longer period of time as it requires higher number of steps for its completion. The customisable personal step goal is used to give the users the ability to customise the difficulty based on the ability of each user. Another goal set for the user is to visit a facility, such as gym, or event that is associated with physical activity. This goal also supports one of the stakeholder's requirement to include facilities and leisure centres owned by the stakeholder.

2 Goal setting (outcome)

The outcome of the goal setting is presented, in the application, in form of progression bar. The user can, at any time, see the current progression of each goal. The application also highlights any goal that has been completed and is ready to be completed.

3 Discrepancy between current behaviour and goal

This BCT is supposed to draw attention to discrepancies between a person's current behaviour (in terms of the form, frequency, duration, or intensity of that behaviour) and the person's previously set outcome goals, behavioural goals or action plans (goes beyond self-monitoring of behaviour). The implementation of this BCT was meant to be in form of weekly or monthly notifications providing the performance overview for the user. This feature, however, was not introduced in the final application as it became less important over the course of development. The BCT is still considered as mandatory for the future development as it should provide the user with overall performance overview.

4 Feedback on Behaviour

The implementation of Feedback on Behaviour was implemented in form of a simple dashboard that displays overall performance in form of total steps done, steps done in the current day and the number of visits in a supported gym or facility. This feature could be then used in further development as it provides an important incentive in form of overall performance overview that can lead to higher motivation or to create a competitive element among other users.

5 Self-monitoring of outcome(s) of behaviour

Self-monitoring of outcome(s) can be very important incentive for the users as it provides them with the results of their performance and the outcomes of the behaviour change. It was proposed to implement this feature in form of journal that would allow each user to keep the record of the set outcome such as weight loss. Later discussion, however, suggested that some elements of this feature could be rather off-putting and could discourage the user form using the application,

especially when targeting younger audience, as the topic of weight can be unpleasant area for some users.

6 Social support

The social support BCT suggests that advise on, arrange or to provide support from e.g. friends or relatives can increase the interest in the application and to provide the retention needed to keep the user active. The implementation of this feature was suggested and executed in form of simple scoreboards and team function that lets the users form teams. In the teams the users should be able to take part in team competitions as well as individual competitions held internally in each team.

7 Information about health consequences

Providing the user with the right information about health consequences or providing an advice on how to be more physically active can have a great impact on the user's retention. The requirement for this implementation consists of a section within the application that lets the user discover different health related topics. This can be very helpful in cases where the user would like to improve the overall health situation or become more physically active but does not have enough information on how to achieve this goal.

8 Monitoring of emotional consequences

It is important to realise that each person is an individual and different incentives work for different people. The feedback on each feature, fixed or personal goal and the overall emotional consequences is important in order to deliver a tailored solution for each user. There are limitations in the development and technology and is impossible to make sure everybody will get the perfect solution, but by collecting enough feedback, it is possible to get closer to the ideal incentives for each user. In the application, this has been done via feedback form that lets the user to share any emotional consequences directly with the developer and people participating on the project.

9 Material incentive

This BCT suggests that the user to change one's behaviour about anything, it is helpful to provide material incentive that the user is promised only if there has been effort or progress in performing the behaviour. In the case of this project, the incentive for the user is an in-app currency (11 Non-specific reward) that can be later exchanged for different material rewards. It is important to provide the user with a list of available material rewards to create the incentive. The list of rewards was implemented in form of in-app shop, where the user can see all the available material rewards.

10 Material reward

When presenting the user with the material incentive, it is also important to arrange the delivery of such reward. When the user is promised with a reward, but the delivery of such reward is not fulfilled, the user can get discouraged and demotivated which could eventually lead to less activity and, eventually, the user abandoning the goal. A system that lets the user exchange the in-app currency for a material reward was implemented in the application to represent this BCT.

11 Non-specific reward

The non-specific reward is, in the application, implemented in form of in-app currency. This can be very important BCT for users that either do not want any, currently available, material reward

listed in the application or do not prioritise the material incentive. This BCT provides with incentive for such users as it gives different options, where the user is still rewarded for being physically active but does not have to claim any material reward immediately.

12 Social reward

As in social support (6 Social support), social reward can also create an incentive for some users. The suggestion of implementation for this BCT was to create a list of achievements or virtual badges/medals that the user could collect. Different competitions and challenges can be also associated with this BCT as for some users the competition element can pose as a strong incentive or be rewarding which can lead to an increase on physical activity.

13 Social incentive

Social incentive is directly connected with social reward (12 Social reward) as it plays an informative role of the BCT. It is important to provide the user with all the information about the social reward and how to make sure that such reward will be obtained only if effort or progress has been made. The implementation of this incentive is represented by the list of achievements, badges, or medals available for the user alongside with the information on how to obtain such reward.

14 Non-specific incentive

This BCT is directly connected with the non-specific reward (11 Non-specific reward) and it works as an informative element for the user. The user should have access to the reward information which works as an incentive. An implementation in form of information for each goal or challenge provides the user with the exact description of the non-specific reward, the amount of in-app currency.

Development Process

Because of the nature of the research where number of different stakeholders including a specific group of people that the project is targeting, appropriate software engineering approach had to be chosen. Because of the fact, that each stakeholder consists of number of people with different ideas and requirements, the approach would need to be centred around the stakeholders and their needs. It is important that the final solution developed, is made in cooperation with those stakeholder to make sure it is relevant to the specific group.

For this project, the User-Centred Intelligent Environments Development Process [4] was chosen as the most suitable as it proposes a use centred development process which includes methodology, development, and testing. The process and its experiment suggest that we should go beyond the standard stakeholders' engagement which should be increased in both quality and quantity involving them in more stages of the development process. This is also important in order to create a meaningful solution coming from close interaction between the developers and stakeholders.

The application of the User-Centred Intelligent Environments Development Process was overall successful in its experiment addressing the needs of all the stakeholders while preserving flexibility to adapt over the course of development. This process requires willingness to engage from the stakeholders' side and ability to listen from the developers' side which is a perfect match for this particular project.

Methodology

From the initial research and because of the nature of the project, it was suggested that a close cooperation with the stakeholders and primary and secondary users should be the main development approach. As the findings suggest, lack of interaction with the target users can lead to a number of failures of otherwise successful or innovative solution. It was also discovered that the collection and addressing of valuable feedback from the target audience is important in order to maintain large community of active users.

As a methodology, the User-Centred Intelligent Environments Development Process [4] was determined as the most suitable as it closely engage with stakeholder and the primary and secondary users. The methodology of the development (*Figure 3*) consisted of three iterations, the stakeholder's validation of the project idea (November 2018), first functioning prototype release (March 2019) tested by internal testers at Middlesex University and the release of the final prototype in June followed by series of testing with external groups of users. There were, in total, three sessions organised by one of the stakeholders where the project and the application were presented followed by instructions on how to use the application.

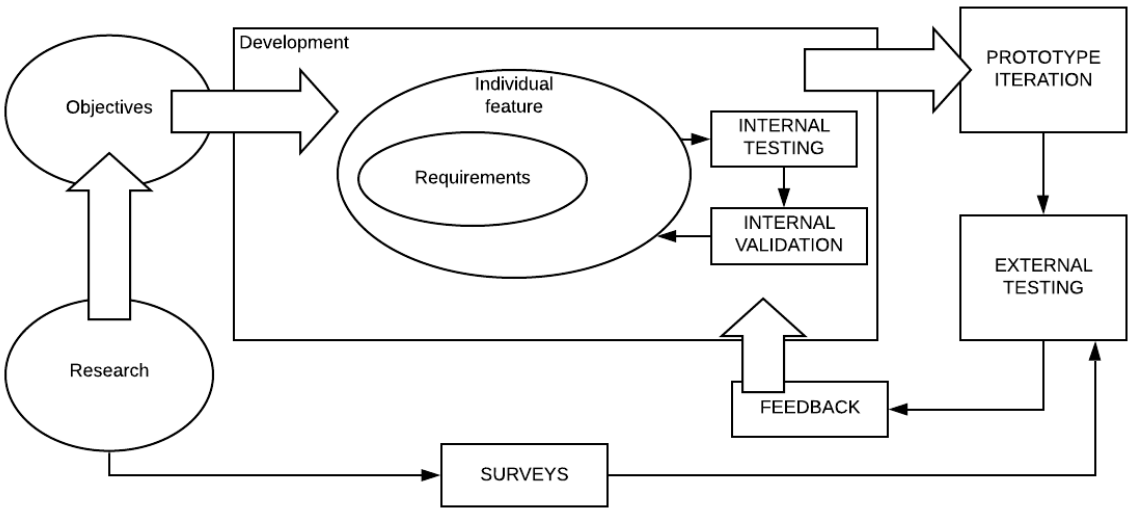

Figure 3

Methodology Approach

To create the most suitable solutions for the application, the project was closely discussed with colleagues from the Middlesex university representing different areas such as sociology, sport, or business. Additional, important, aspects were identified based on the collaboration with colleagues from different departments that were used while developing the final prototype. For example, based on the sociological insight, the relevant Behaviour Changing Techniques [12], 14 in total, were identified and the core features of the application were developed accordingly in order to keep the user motivated about the physical activity and to get frequent traffic in the application. This has been done via features such as material or virtual rewards, creating different goals for the user such as personal step goal, achieving 20 000 steps or to visit a leisure centre or gym.

Using the U-CIEDP approach, each feature and functionality of the application, in most cases, was developed separately and tested closely with the first, internal, users to ensure stability and reliability. Testing each feature separately with the internal testers enabled to discover most errors

during the development process and allowed for proper validation before the next stage. After each successful feature development, that feature would be included in the following prototype iteration. After completing each prototype iteration, the application was presented to the external testers accompanied by surveys[1] [2] that were based on the initial research. The application prototype was delivered to the external testers in form of sessions where the idea of the application would be explained, each feature demonstrated, and important feedback collected in form of discussions. After each iteration testing another feedback from the actual usage of the application would be collected to better understand the effectiveness of each iteration. The feedback from each iteration testing was then used to improve the development of the application, to improve existing or add new features or to discover new errors in the iteration allowing to address them immediately. During each iteration testing, the users would be frequently notified about any improvements being done and the discovered errors or concerns would be addressed to keep the close interaction.

The group of external testers was composed, mainly, of younger people or children. Because of the nature of the external testers group, the promotion and testing of each iteration was sometimes difficult as some the testers were not always overall interested. The main difficulty was to encourage the group to participate in the online surveys or to provide any valuable online feedback. In this case, the close interaction with the external and even internal users, proved to be efficient as the discussions during different session provided with valuable feedback about the application and its features.

[1] https://docs.google.com/forms/d/e/1FAIpQLSczELL6dMWVDi81yolNU2GTgbS4X2gF6s_M1_O9GJe-QTK0Lw/viewform?usp=sf_link

[2] https://mdxl.eu.qualtrics.com/jfe/form/SV_1FfkgLvthyPA0hT

Design

The design of the developed application was created based on the key requirements set at the beginning of the research. The gamification element, the targeted users, the need for the application to be available on both Android and iOS platforms, and to be focused on increase in physical activity were the key requirements, set by the main stakeholders, which lead to the main design. The design also considers the limitations, failures or missing elements in the researched, similar applications discussed in the literature review section as well as the behavioural change techniques (BCTs) and their importance, also discussed in the literature review section.

Gamification

For the gamification requirement, the application design needs to incorporate the elements of the gamification. Virtual badges, levelling system or providing an avatar are some example of the gamification elements that the application should provide to the user. The key design parts for the gamification were:

- Virtual reward such as achievements or badges
- Requirements to obtain the rewards
- Creation of virtual avatar
- Naming of the avatar
- Levelling system for the user, giving the ability to progress
- Short-term and long-term goals
- Points system
- Reward redemption system
- Team creation
- Scoreboard
- Overview of user's progress
- Creating profile to store the user's progress
- Competitions

Target Group

Because of the specific group that the research is targeting, the design of the application should incorporate concepts or elements proven to work with such group of people. Similarly like the gamification the project took inspiration in the world of video games. A popular concept in gaming industry is to offer the user with virtual collectibles that can be used in the actual game. Games such as Fortnite are very popular among the group of people targeted by this research. The game Fortnite was able to generate $2.4B[6] in revenue for its developer in 2018, despite being completely for free. Fortnite, and many other similar games, generates its revenue through microtransactions, offering its users virtual collectible such as costumes, dance moves, voice lines and many more for the avatars. Another example of the importance of virtual collectibles can be taken from video games such as Counter Strike Global Offensive, where the collectibles can be actually traded with other users. The virtual collectibles in some games, such as Counter Strike, have different rarity based on their looks or difficulty to collect them, and as the items can be traded with other users, the rarity sets the price of each item which can, in some cases, grow to very high amounts. Because of the target audience of this project, the concept of virtual collectibles should be implemented in the design of the application and should offer these key features:

- Virtual collectibles
- Place and requirements for obtaining the collectibles

- Ability to browse and swap between collectibles such as avatar costumes
- Ability to add additional collectibles over time
- Ability to offer limited time collectibles

Cross Platform

As one of the key requirements is for the application to be available on both Android and iOS powered devices, the design should implement such technology. Such technology should also be able to allow for future development and expansion of the application. The design of this feature should ensure the application is:

- Providing same features on both platforms
- Providing the same performance on both platforms
- Able to implement additional content and features over time

Physical Activity

The last key requirement for this research is to create application that would encourage increase on healthier physical activity. The design needs to implement such features that would create incentives for the user to be more physically active, and that would allow the connection between the physical activity, leisure centres, gyms, and the application. For this requirement, the features should:

- Allow the user to track progress of physical activity
- Associate the application with places that offer physical activity services provided by the stakeholder
- Reward the user for physical activity
- Provide incentives for the user

Implementation

The implementation of all the features listed in the design requirements of the project was done in close collaboration with the key stakeholders of the project. Each feature was developed and first tested with a small, closed group consisting of the students and colleagues from the Middlesex University of London. The aim of these testing was to purely focus on the functionality of each feature, covering any bugs and errors that might occur during the development and to gather initial feedback about the main functionality. After each closed group testing, the feature tested was included in the version designated for the wider testing group consisting of younger users who are mainly targeted by this research. Once the version designated for the wider testing group included all the features that were agreed to the specific release date, that version would be distributed among the targeted group of users.

Gamification elements

Achievements

List of achievements and the requirements for obtaining them was implemented in the application (*figure 4*) offering the selection of default goals related to physical activity. To complete the achievement, the user has to, for example, walk 10,000 steps for the first level of that particular achievement, 50,000 for the second level and 100,000 steps for the last level of the step related achievement. The implementation allows to add any new relevant achievements or to scale and reuse the existing achievements creating more content and goals for the user.

Figure 4

Virtual avatar

During the development of the application, the design and options of the avatars had changed over the time. Each change was based on the feedback received from the key stakeholders, providing more option, flexibility, and design improvements with each design. It is important to highlight that despite the avatars plying an important role in this research, the application was developed with no previous avatar or GUI design experience. All the graphics used within the application, including each version of the avatars, were outsourced from the asset store offering vast number of resources for the Unity environment. As seen in the screenshot, (*figure 5*) there were in total 3 different implementation of the avatar design. In all the implementation, the user also has the option to name the avatar during the process of account creation.

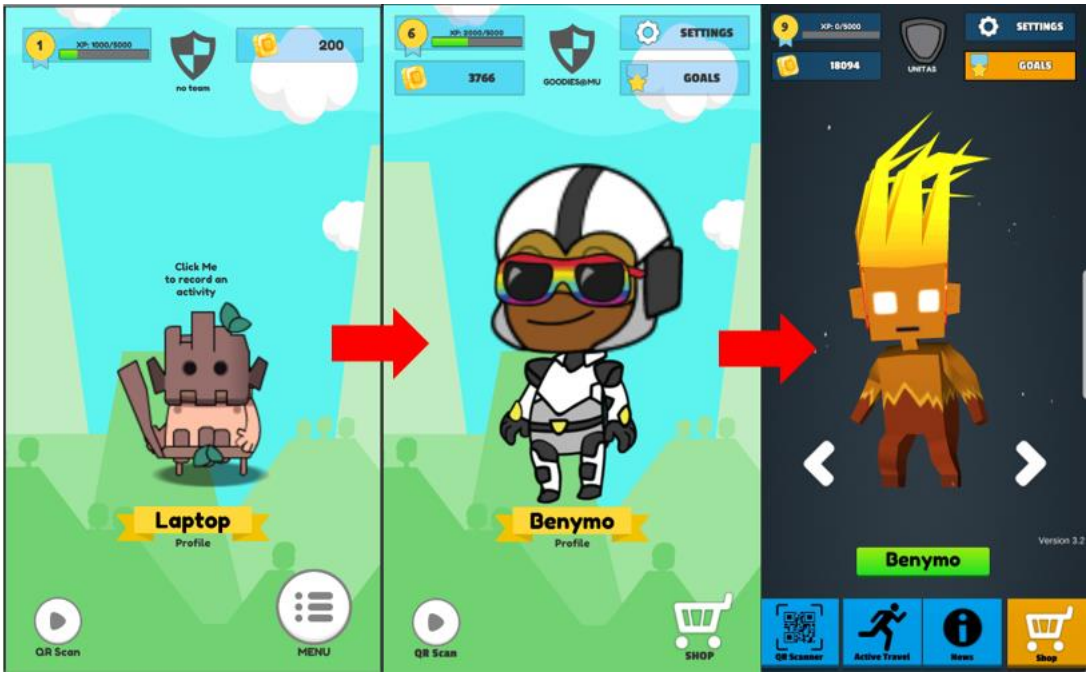

Figure 5

Goal, Levels and Points

One of the design requirements is to provide different goals providing content and activities for the user, for which the user would be rewarded upon competition. This was implemented in form of different daily or long-term goals (*figure* 6) available to the user every day. Upon competition, the user is rewarded with coins, used as in-app currency in case of this project, and experience points which are added towards the next level, allowing the users to level up their account. The implementation of the levelling system does not have wider implication other than providing the user with a sense of progression but can be used in many other implications in the future development.

User's current level and number of experience points and the experience points needed to reach next level

Selection of different goals displaying the requirements and rewards for successful completion.

Figure 6

Reward Redemption

The reward redemption was implemented in form of a in-app shop (*figure 7*), where the user can exchange the obtained in-app currency for different rewards. At the beginning, the application would only offer virtual collectibles in form of cosmetics for the user's avatar. The user can browse between different rewards and make a purchase using the coins collected for competition of different goals or for being physically active. In the later stage of the project, one of the key stakeholders was able to provide real tangible rewards consisting of different refreshments offered by cafeteria located at one of the youth centres run by one of the key stakeholders.

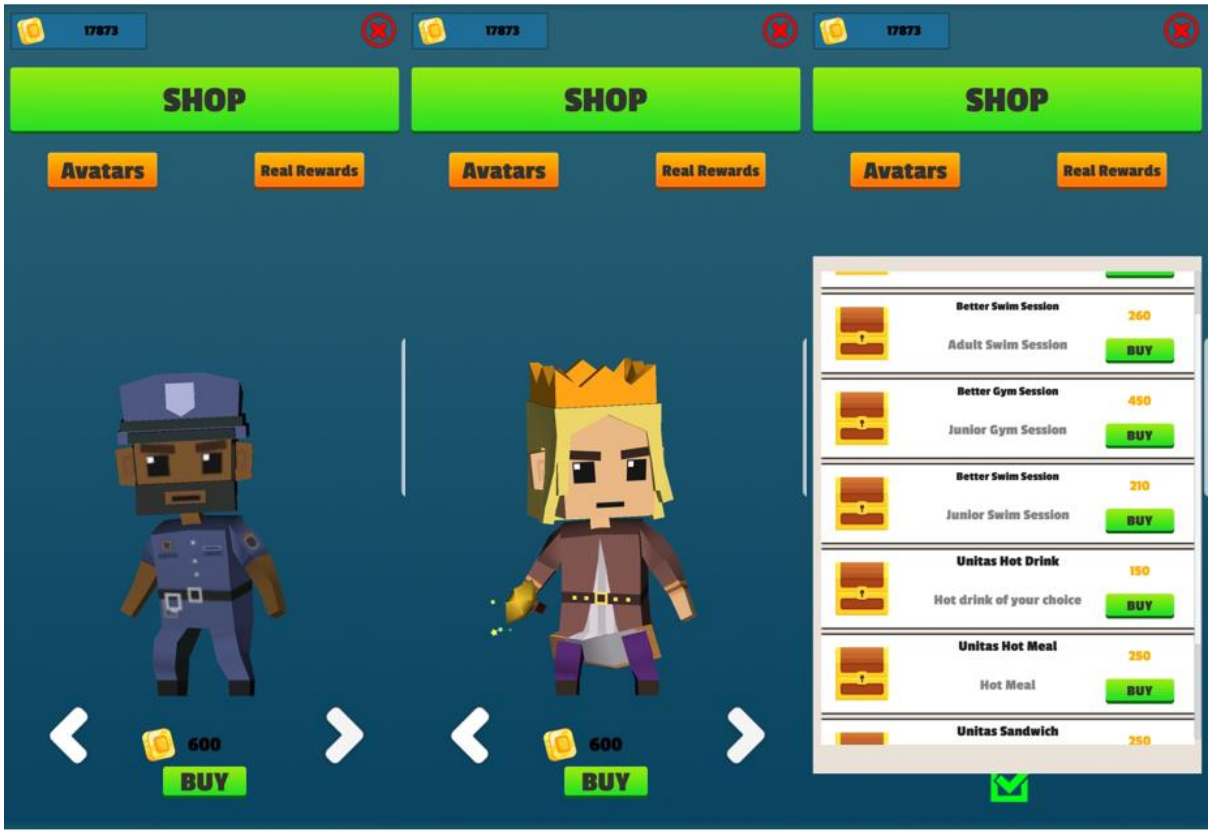

Figure 7

Team Creation

Creating or being a part of a team is one of the gamification elements which can increase the user's interest by bringing the competitiveness and teamwork into the application. It is also apparent, from the literature review focused on the similar applications, that some of the users of these applications, especially the Pokémon Go, pointed out the lack of social elements in the application. The implementation adds a team creation feature (*figure 8*) to the application, where the users can create and join their own teams. The implementation provides competitive element where all the users can see each other's score within the team as well as the result of collective effort in terms of team's score which can be than compared with other teams. The implementation provides a lots of possibilities for the future development as the key stakeholders can run competitions both within the teams or among the teams or different events.

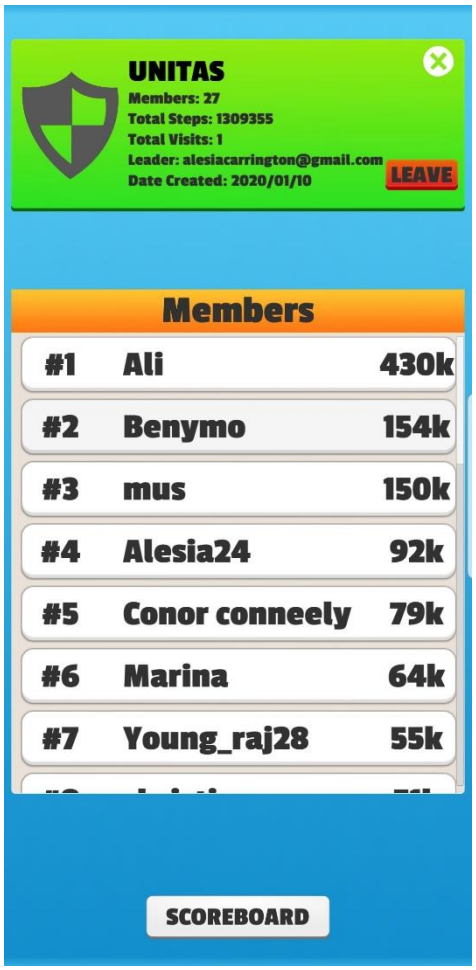

Figure 8

Scoreboard

This feature is very straightforward, the scoreboard should display the results in the user's activity. It was implemented as a part of the team feature where the user can see a scoreboard of all the teams from sorted by the team's collective points. This implementation, again, adds additional competitive element to the application and is very flexible and reusable. The implementation of the scoreboard can be, in the future development, customised and reused for any kind of competition or event. The limitation is very low due to its simple implementation, but it can increase the user's interest or create a great incentive as one of the gamification elements.

Overview of user's progress

It is very important to provide the overview of the user's progress so that the user can see the results of the efforts put into the application and into the physical activity. This feature was implemented in form of user's profile section (*figure 9*) where the user can see all the progress achieved over time as well as all the virtual collectibles obtained for the in-app currency alongside with the name, level and experience points of the avatar.

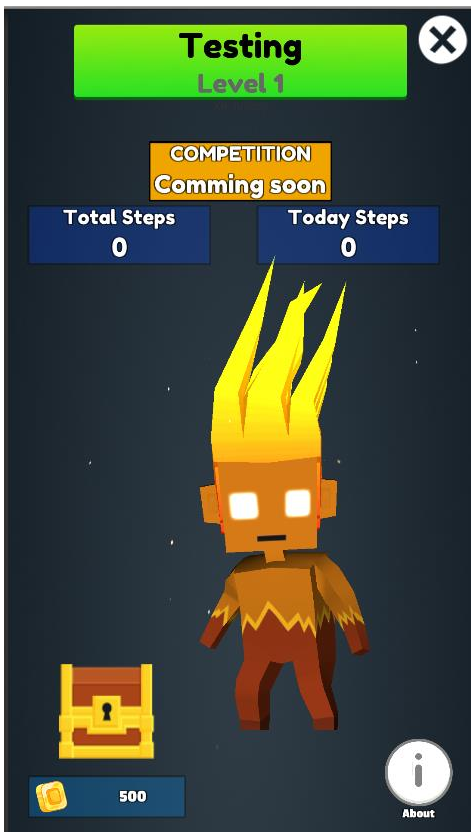

Figure 9

Profile Creation

In order for all the features to work properly, especially the gamification elements, the application needs to be able to store the user's progress. This is important as in the case of losing all the user's progress, points, collectibles etc. the user could get easily discouraged. The implementation of this feature offers the user the simple email and password account creation as well as naming (*figure 10*) and choosing the default virtual avatar. The user's credentials are then encrypted and stored in the cloud database together with all the progress and information about the account such as what team the user belongs to what avatar is currently equipped on the account etc. Because of this implementation, the user can access the account from any Android or iOS device ensuring that even in the case of, for example, losing the current device, the user can easily log in on a new device without losing any saved progress.

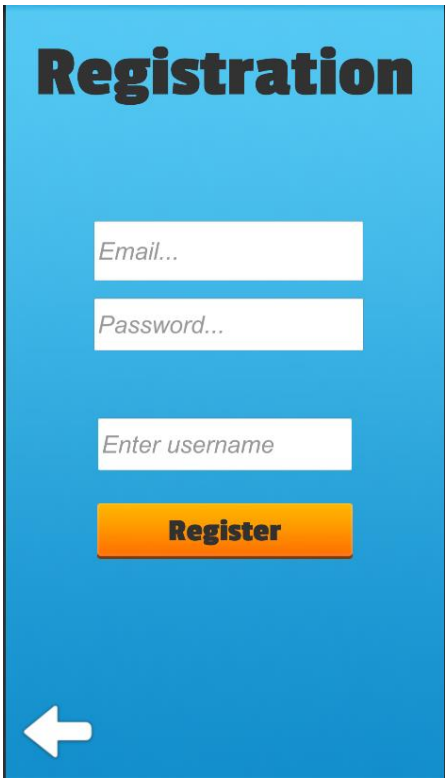

Figure 10

Competitions

By combining different feature, mentioned in this research, the application can easily offer the competition feature for the stakeholders. The key stakeholders can create any competition, relevant to the project, and it can be easily implemented into the application. By using the scoreboards, teams, user's progression, points etc. the stakeholder can announce any given competition, for example in the news feed of the application, and implemented customised elements into the application very swiftly or use the ones already implemented. There were some competitions held during the development of the project to test the efficiency and the difficulty of the implementation which are discussed later in this paper.

Target Group

Based on the targeted group and initial proposal of the application to the key stakeholders, the design was created around the concept of virtual collectibles as an incentive for the user. The implementation of this concept incorporates different features allowing these incentives, their flexibility and customisability in the future development. Adding a new content frequently over time is one of the important factors in keeping active base of users interested in the application and this implementation allow this as new collectibles can be easily introduced in the future development.

Virtual Collectibles

The feature of virtual collectibles was implemented into the application in different ways over the course of development based around the type of collectibles and the nature of the graphical content the collectibles were provided with. Despite the changes in virtual avatars, their graphics and optionality over the time, the core mechanics of the implementation remained the same. The implementation created allows any future developer continuing on the project to easily incorporate new collectibles over time.

Display of Collectibles

All the collectibles are part of the application and the display of the collectibles is implemented in different places of the application such as the application shop, user's profile section or the main "home" section. The implementation provides the user with all the currently available collectibles in the shop section of the application together with the requirements for obtaining the collectibles such as the price. The user can browse and purchase the collectibles for in-app currency or to see which collectibles in the shop are already owned by the user. In the profile section of the application, the user can browse all the owned collectibles and use them to customise the virtual avatar. The customised avatar is then displayed in the profile section as well as in the home section where the user is always directed when opening the application or after each successful login or registration.

Limited Time Collectibles

The implementation of the virtual collectibles concept and design provides great optionality for the future development as new collectibles can be frequently added within the application. The implementation also allows for features such as limited time (exclusive) collectibles which can be introduced by the stakeholders in the future. Exclusive collectibles can be then introduced in the application and available, for example, only during a special events held by the stakeholders, they can be inspired by different season of the year or by different relevant topics happening in the world. The advantage of this implementation is that it brings a vast flexibility into the application in terms of adding a new relevant content frequently over time. This feature can be also used to increase interest in the application and the user traffic in specific time when offering any exclusive collectible.

Cross Platform

Considering the targeted group and the nature of the research, it only makes sense that the one of the main requirements of the key stakeholders was for the final product to be a cross platform smartphone application, meaning it would be capable of running on both Android and iOS devices. The implementation of this feature enables the application for the both major smartphone platforms, but it also takes into consideration the nature of the application, which is related to the video game industry by using virtual collectibles and gamification and the targeted audience of this research.

Development Technology

Environment called Unity [13] was use as the development technology for the project as it is gaming engine and is capable of releasing application for most of the major platforms including Android and iOS. It does not only fulfil the need for the application to be cross platform, but it also makes the development of such application much easier in terms of the gaming element. The Unity environment also includes a service called Asset Store [3] offering vast number of resources, whether paid or for free, ready to be used in any kinds of projects. This implementation made the development process much easier and faster, especially on the graphic part of the project. All the virtual collectibles and graphic elements such as buttons, backgrounds fonts etc. were outsourced from the Asset store as there was no graphic designer involved on the project at the first stage. This allowed to test number of different graphic iterations and styles and to improve the visual design of the application swiftly without any previous experience.

Regardless the development technology implementation, as the project works with two different platforms, there was always a need for slightly different approach when releasing the testing versions and some features more complex required different implementation e.g. step counting.

System Architecture

The system architecture was created in a simplistic straightforward way to allow for easier interaction for the upcoming developer as well as to simplify the following implementations. The system consists of a Graphic User Interface that allows the user to interact with the application and was developed in a user-friendly manner, the smartphone device then hosts the application's logic which communicates with the Windows server through web requests. The server hosts different folders which contain specific PHP scripts that are responsible for all the query requests send to the database and for transferring all the query results which are then displayed via the GUI in form of, for example, number of coins, currently active avatar or name of the avatar. The system architecture is simply described in the architecture diagram (*Figure 11*).

Figure 11

Physical Activity

Tracking an incorporating physical activity in the application was one of the most important requirements for the design and implementation. As the title says, this research aims to encourage increase on healthier physical activity and therefore the design requires the application to work track such activities. There are different features implemented in the application that focus on physical activity.

Step Counting

Step counting is one of the core features implemented in the application. Steps represent the main passive and also active income of the in-app currency for the user. The implementation allows the application to count and display number of steps that the user has done since the last

opening of the application (*figure 12*). In the development process, step counting was one of the first features implemented and tested as it represents the most basic physical activity that can be recorded without the need of the application running in the real time. The user is rewarded for every hundred steps taken every time the application is opened creating a passive income of the in-app currency. It can be used in many different ways such as to measure progression of different goals and achievements that involve steps or as an objective of a previously mentioned competitions.

The implementation of this feature was one of the biggest challenges of development, mainly because of the cross-platform requirement. Each platform required slightly different approach and many tests to make sure the feature is reliable and user friendly, which can be especially challenging task considering how many different manufacturers of Android device there are on the market each with slightly different system.

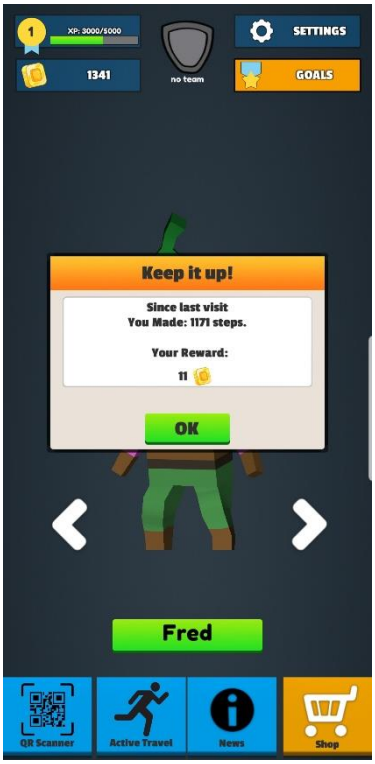

Figure 12

Active Travel

Active travel feature was introduced to the development process as the last core feature in response to the additional requirement from the key stakeholders. The requirement was to implement a feature in the application that could determine whether the user achieved an active travelling during a physical activity such as walking.

The idea of active travelling encourages the user to change the way of transportation and to either walk or cycle instead of using a car while, for example, travelling to work. Research by Public Health England suggests that over a week, the activity should add up to at least 150 minutes of moderate intensity activity, such as active travelling, in bouts of 10 minutes or more [2].

In the case of this project, walking is considered as an active travelling and the user is encouraged to perform active travelling. This is achieved by the user, recording an activity in the application (*Figure* 13) while performing an active travelling for which, in this case, the requirement

is to keep a pace of at least 100 steps per minute over the period of at least 10 minutes or more. Upon completion, the user is provided with the result of the activity. There are 3 possible results, achieving the active travelling by keeping the pace of 100 steps per minute for at least 10 minutes, not achieving the active travelling due to the time of the activity being less than 10 minutes or not achieving the required pace for active travel and being less than 100 steps per minute.

The user is rewarded for each hundred steps as usually and if the requirements for active travelling are fulfilled, the progress is added towards any active travel related goals or achievements. The active travel can be considered as an active way of generating income of the in-app currency.

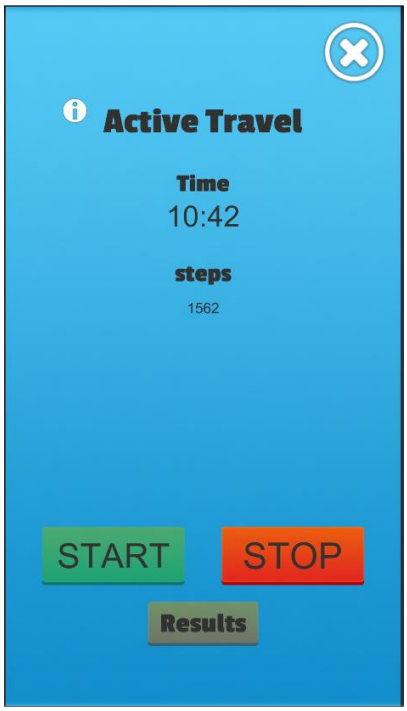

Figure 13

QR Scanner

In order to connect the application with real places such as gyms, youth centres or leisure centres owned by the key stakeholder or with open green spaces such as parks and playgrounds, the QR scanning (*figure 14*) feature was implemented into the application. The implementation works with simple QR codes that can be easily produced and placed in anywhere relevant to the stakeholders. The main idea is that by using the scanner and QR codes, the user can record, for example, a gym visits and by simply scanning the code and get rewards for the activity.

This implementation allows to track and record any complex physical activities without the need of sophisticated systems by just providing QR codes to scan at gyms, parks or different classes or events. The QR codes can be easily generated and produced and because of the versatility of this technology and its implementation, this feature can be used for number of different activities or needs of the stakeholders. This feature does not have to only be used to help promote physical activity, connect the application with real places but for other needs such as claiming an exclusive virtual collectible at events, or any other feature that might benefit from this implementation.

This feature was mostly tested by the internal group at Middlesex university to ensure its reliable functionality and for the external testing, this feature is completely dependent on the

stakeholders placing the QR codes in the facilities and promoting the application once publicly released. However, from the questionnaires collected and from the discussions during the testing sessions, it was indicated that the users would be more interested in visiting such facilities as gyms if it was a part of a goal within the application accompanied by a reward in form of in-app currency.

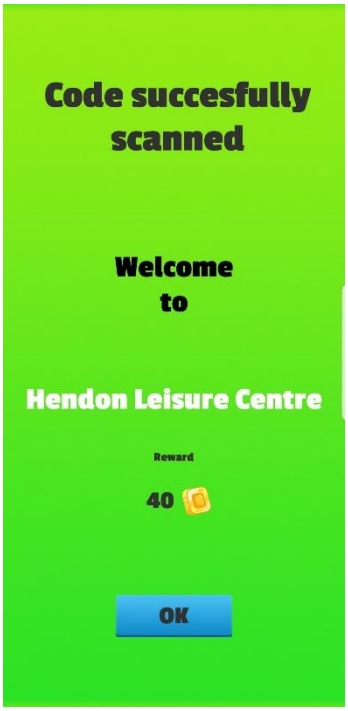

Figure 14

Evaluation and Analysis

Before any distribution and external testing, each feature and its implementation were first tested internally with the smaller closed group at Middlesex university. The aim of the internal testing was to test the functionality of each feature and to make sure that each tested feature is reliable enough to be added to the distribution version.

Internal Testing

As the requirement was for the application to be cross-platform and working both on Android and iOS devices, one of the goals of the internal testing was to make sure that each feature is performing reliably and producing same or very similar results on each platform. To achieve the desired performance and reliability, each feature was tested on various types of iOS and Android devices consisting of older models as well as the latest models, range of different version of operating systems of each platform and in case of the Android platform, different mobile manufacturers.

The internal testing helped to discover different errors or limitations in each tested feature allowing for adjustments to be done accordingly before any external distribution. After each successful testing of any feature, that feature would be then implemented into the version of application prepared for the distribution among external testers. Once all the features necessary for the external testing were implemented into the distribution version, that version was always tested, again internally, as a whole to reassure the reliability and good performance of each feature.

External Testing Design

The external testing was always designed in close cooperation with the key stakeholders. A date for each testing would be set according to the progress of development making sure there is a reliable iteration of the application ready for each testing. As the research targets younger users, the external testing was done in form of sessions and focus groups in youth centres interacting with groups of younger audience in age of, approximately, 12 -17 in the presence of the teachers or coaches to oversee the experiment.

Before each session, a simple guide and presentation, both digital and printed version, on how to use the application would be created and presented to the youth centres. An online questionnaire was created for the external testing and all the participant were encouraged to fill up the questionnaire and offered additional in-app points for competition. The goal of the questionnaire was to determine, whether the target audience is familiar with the concept of virtual collectibles, what they think about, how much active they are, etc.

Each Testing would then consist of a presentation of the application or any updates during the later sessions, explanation on how to use the application and why, assisting with the installation to each participant and followed by focus group where the participants could share their feedback or ideas. Every session where the project was presented was then followed by a period of time, when the users were instructed to use the application on daily basis to ensure all the functionality is reliable on wider selection of devices. During such periods, step competitions were held and the, activity of all the users would be recorded in order to see the activity of user within the application and the participant were encouraged to provide feedback via the application.

Distribution

Before each external testing, a reliable ways of distribution for each platform would be established to make sure on the day of the testing, the application is available to all the participants.

As for this part of the continuous project, the application was not to be released publicly and therefore, the application could not yet be distributed publicly via any available application stores for each platform and alternative ways of distribution were created.

For the iOS platform, the application TestFlight [1] was used to distribute the application. The TestFlight allows to create an external testing group and invite any number of testers via invitation link. To make things easier, the link was always encoded into a QR code, that could be simply scanned by any iOS device redirecting the user directly to the TestFlight application where the current testing version could be downloaded. The QR code would be than included in the printed presentation and guide on how to use the application provided to the youth centres allowing additional users, who could not attend the session, to participate in the experiment. The TestFlight application was also used for distribution of any further updates and the users would be notified any time a new update was successfully released.

In case of the Android platform, an installation file would be created for each final iteration of the application created for external testing. Such installation file would be then placed to a secured, shared cloud storage and the access link to the storage would be produced. The access link for the cloud storage would be then encoded into a QR code and included in the presentation and guide, the exact same way as for iOS distribution. The application has a feature implemented that controls the currently live version for each platform. This feature would then notify, upon opening the application, the user about any available updates and redirect them to cloud storage to download and update the application.

External Testing

There were, in total, four different session on three different days through the year were the application was presented and tested as described in the external testing design.

The first two sessions happened on the same day at two different places with two different groups of participants and it was held in June of 2019. As for the first two sessions, the application was in early development and a very first iteration was presented to the external texting groups. Due to the early stage of development, the application offered basic core features and limited graphical design which affected the interest of the participants. Despite the numbers and activity, which were significantly lower than in case of the later session, the first experiment was crucial as it mainly helped to discover the limitations of the experiment design and improvements were done accordingly to the feedback.

The third session was held in August of 2019 and the result for the session was much more successful in terms of the participant number and the usage of the application. The experiment was again held as described in the external testing design. For the third session, the iteration offered improved functionalities, graphical design, and options of virtual collectibles. After the session, the activity was recorded in the database so it could be later compared with the last external testing which eventually took place in January of 2020.

The fourth and last session, as already mentioned, took place in January of 2020 and the last iteration, for this part of the project, was presented. Alongside with the improved graphical design and functionalities based on the feedback, the real tangible rewards in form of voucher to the youth centre cafeteria were introduced in the application shop where the users could purchase such voucher with the in-app currency. The session was also followed by a step competition to increase the interest of the users in the project.

Validation

As a validation of the testing sessions, two time periods after the third and fourth sessions were compared in order to see the actual activity during each testing. Data were collected consisting of the:

- Records of successful registration
- Records of successful login
- Frequency of opening of the application
- Records of QR code scans
- Records of reward purchases

For the first time period, (August 2019 – 9th of January 2020) which took place after the third session, ending with fourth session, the total numbers including both external and internal testers are:

- 5,042,841 steps recorded
- 578 legitimate activities recorded
- 27 QR code scans recorded
- 8 virtual collectibles purchased

For the second time period, activity recorded during the last testing period (10th of January – 31st of January), which took place after the fourth session, the total numbers including both external and internal testers are:

- 5,044,266 steps recorded
- 1000 legitimate activities recorded
- 2 QR code scans recorded
- 0 virtual collectible purchased
- 28 real rewards (canteen vouchers) purchased

By comparing both time periods and the data collected, it is visible that during the second time period, significantly more activities were recorded in total as well as number of steps is slightly higher than in the first period. It is important to say, that the second time period is significantly shorter than the first time period, yet the number of activities (*figure 16*) and steps (*figure 15*) recorded are higher. This indicates that the introduction of a real rewards in form of material rewards increases the interest in the use of the application and leads to more frequent traffic. From the number of recorded activities, it is clear that the users were using the application more often and were using more features of the application in the second time period, except for the QR code scanning. The difference in number of QR scanning is, most likely, related to the time difference of each period as during the first period, testers were reminded over the whole period to scan QR codes as well as more QR codes were provided at the testing session and the feature was, perhaps, better promoted by the testing group teachers and coaches.

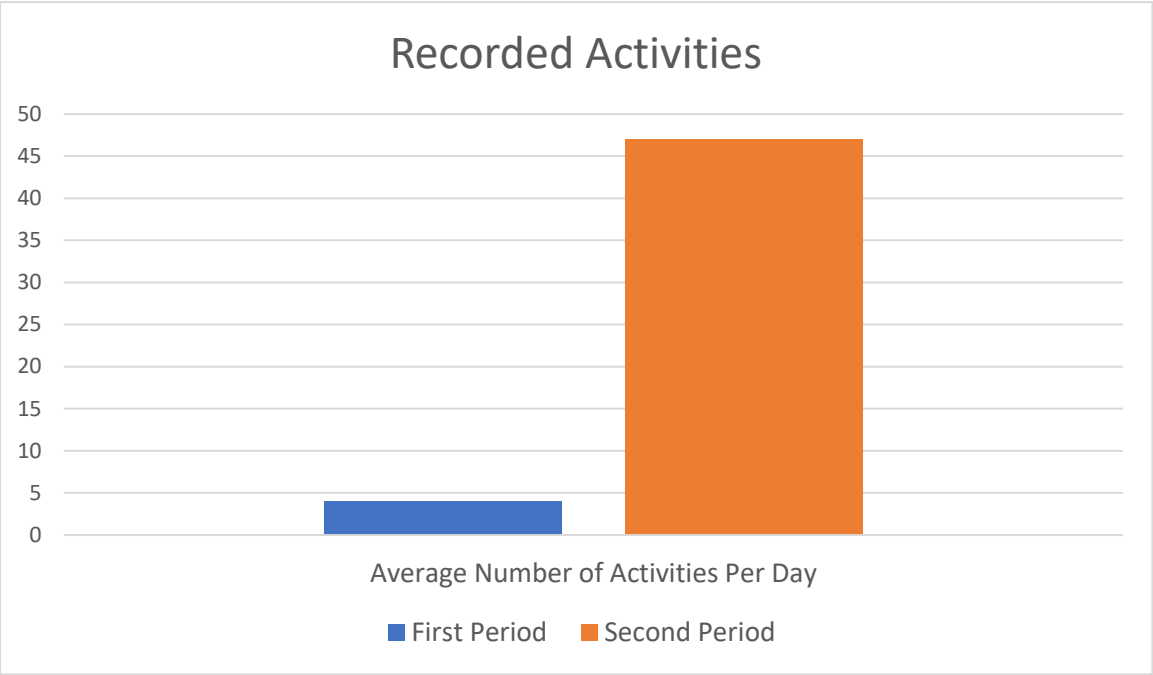

Figure 16

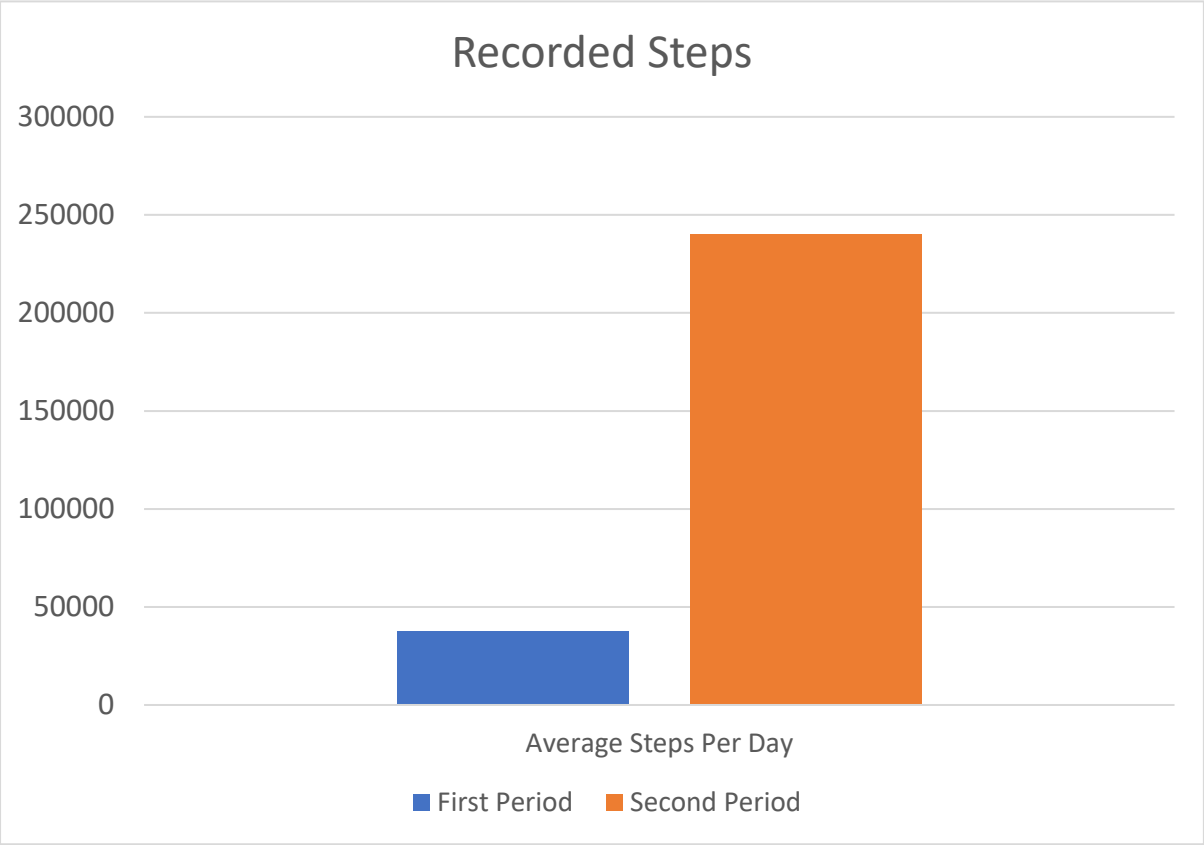

Figure 15

We can also see differences in terms of the number of virtual rewards and real rewards at each time period where virtual rewards were more popular at the first period and real rewards were more popular in the second period. This indicates that the lack of real rewards increased interest in virtual rewards in the first period and decreased the interest in the second period due to the introduction of real rewards.

Questionnaires

During the validation process, it is apparent from the data collected, that the real rewards seem to be more popular over the virtual rewards and can attract more people to use the application. This could be however caused by significant limitation over the graphical design of the virtual collectibles as the graphics were outsourced from the previously mentioned Unity Asset store thus making them less relevant to the topic and to the stakeholders. This is also supported by the questionnaire where:

- Almost 80% of respondents are familiar with virtual collectibles and from different video games
- All of the respondents who fit the research target group responded in a positive way about this concept such as “fun”, “great” or “good to push myself to reach some aims”

It is also apparent that the QR scanning feature which was implemented in order to connect the application with real places was not as popular as originally expected as there were not many successful scans recorded. The questionnaire where the respondents were asked about the facilities and their visiting, however, indicates that the they would be interested in this feature (*figure 15*). The low scan records are, most likely, caused by the lack of promotion of that feature at the youth centres or simply by the early stage of the application and once publicly released, the facilities or green open spaces can be easily included and promoted within the application encouraging the users to visit such places.

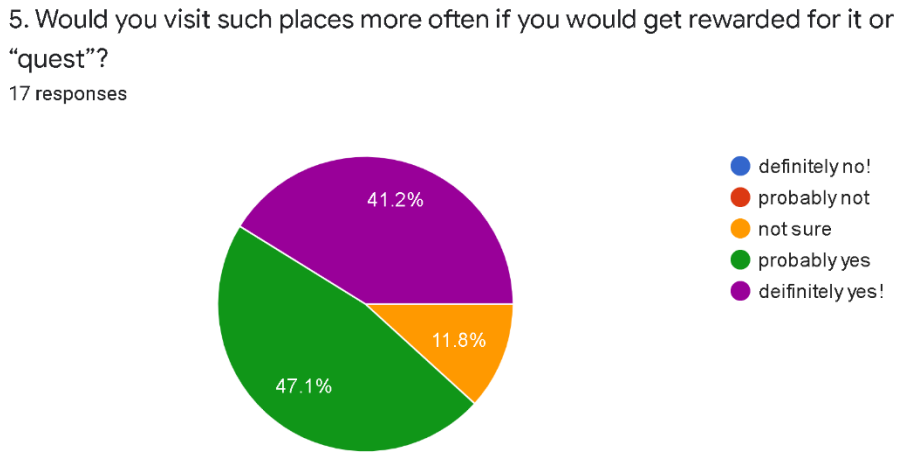

Figure 17

Conclusion

The original aim of this research was to create a solution that would encourage increase on healthier physical activity in younger users, using gamification and some relevant behavioural change techniques. The solution would need to fit different, often changing, requirements as number of stakeholders were involved in this project, trying to justify their ideas and expectations. It would also need to be created in a way that allows for future extension as this particular project is only the first part of a continuous research which aims to encourage increase on healthier physical activity in different groups of population, not only younger users.

As the solution, a cross-platform application that would use concept, appropriate for the target group, of virtual collectibles was proposed to the key stakeholders with the presentation of a simple demo application. The solution was agreed upon by all the key stakeholder and it is also apparent, from the questionnaire, that the concept is popular as **almost 80%** of the respondents already have experience with this concept from different video games and most of the respondents described this feature in a positive way. The solution was developed using the Unity engine due to its nature and tools which made the development easier, especially the graphical look of the application.

The gamification is one of the main features of this research so the application implements some of its elements. The user gets to create a virtual avatar and is provided with different types of content within the application which allows for the progress and modification of the avatar. The application rewards the user for being physically active, offers different type of goals to achieve, social element and competitions. The overall feedback about the gamification elements was really positive and it offers versatility for the future development as new goals, rewards, competitions etc. can be easily introduced in the future.

The development of the application was very difficult as there were many requirements from the key stakeholders, requirements which were often changing. The number of requirements was sometimes overwhelming and new requirements were introduced during the development process. Another aspect which affected the development was the number of different stakeholders, changing of management in some cases or the misinterpretation of some ideas or requirements. One of the key original requirements was for the application to be available on both Android and iOS devices which required different implementation, for some features, in order to get the same results on both devices.

The testing of the application was always done internally and then externally once an iteration of required features for each deadline was created. The internal testing was always done in a closed group of students and colleagues from Middlesex University making it much easier. The external testing, on the other hand, was one of the biggest challenges of this research mainly because of the nature of the targeted group. Each external testing was always planned ahead, and material was prepared in order to test the application with relevant users. The reality of each testing was much harder than originally expected as vast number of people from different background were involved often not being interested in the project or its testing at all. As the testing group consisted mostly of teenagers, it was hard to keep their attention and interest just for the sake of the research. Almost everybody involved was using different types of devices, which was extremely helpful to discover additional errors caused on particular devices but made the experiment much harder. One of the advantages of the targeted group was that a completely honest feedback was guaranteed and with enough patience and understanding, the external testing was always a successful in some way, especially for gathering feedback during focus groups.

In conclusion, a solution in form of cross-platform application with gamification elements that uses the concept of virtual collectibles was developed. Despite the difficulties of the research, the application and its concept received extremely positive feedback from most of the people involved. Regarding the features, the target users seemed to be more interested when the actual real tangible rewards were introduced but also provided positive feedback about the virtual collectibles. The main issue why tangible rewards were more popular over virtual rewards probably is in the design of the collectibles which were outsourced from the previously mentioned Unity asset store. It is important to say that the graphical part of the application was done without any previous experience in the field and therefore making it less relevant to the theme. In the next part of the continuous project, the graphical part of the application should be done by a professional who can create relevant design making the collectibles more interesting reward that offers number of options of additional content to be added frequently. In terms of the physical activity and the ways to encourage it, the application offers variety of features that can support this and can be also extended in the future development. And the answer to the question, whether the people involved became more physically active can be answered by the number of steps and activities taken during the testing, especially the last one, or perhaps by questionnaire, where most of the people answered that they definitely think they improved their physical activity and none of the respondents answered negatively to this question. This also indicates that the people involved changed their behaviour about physical activity which means that the behavioural change techniques were useful and worked with the users.

References

[1] Apple Developer. (2020). TestFlight - Apple Developer. [online] Available at: https://developer.apple.com/testflight/ [Accessed 20 Jan. 2020].

[2] Assets.publishing.service.gov.uk. (2020). [online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/353384/Everybody_Active__Every_Day_evidence_based_approach_CONSULTATION_VERSION.pdf [Accessed 25 Jan. 2020].

[3] Assetstore.unity.com. 2020. *Unity Asset Store - The Best Assets For Game Making*. [online] Available at: <https://assetstore.unity.com/> [Accessed 1 January 2020].

[4] Augusto, Juan Carlos and Kramer, Dean and Alegre, Unai and Covaci, Alexandra and Santokhee, Adityarajsingh (2018) The user-centred intelligent environments development process as a guide to co-create smart technology for people with special needs. Universal Access in the Information Society, 17 (1). pp. 115-130. ISSN 1615-5289

[5] Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From Game Design Elements to Gamefulness: Defining "Gamification". Paper presented at the 15th International Academic MindTrek Conference, Tampere. http://dx.doi.org/10.1145/ 2181037.2181040.

[6] Gonzalez, O., 2020. *Fortnite Made $1.8 Billion Last Year, But It's Still A Game In Decline*. [online] CNET. Available at: <https://www.cnet.com/news/fortnite-made-1-8-billion-last-year-but-its-still-a-game-in-decline/> [Accessed 1 January 2020].

[6] Howe, K.B., Suharlim, C., Ueda, P., Howe, D., Kawachi, I. and Rimm, E.B. (2016) 'Gotta catch'em all! Pokémon GO and physical activity among young adults: difference in differences study', The BMJ, 355, pp. i6270. doi: 10.1136/bmj.i6270

[7] Marczewski, A. (2013). Gamification: A simple introduction & a bit more - tips, advice and thoughts on gamification (2. ed.): self-published by Andrzej Marczewski.

[8] Matallaoui, A., Koivisto, J., Hamari, J. and Zarnekow, R., (2017). How Effective Is "Exergamification"? A Systematic Review On The Effectiveness Of Gamification Features In Exergames.

[9] Pokemongo.com. (2019). Catch Pokémon in the Real World with Pokémon GO!. [online] Available at: https://www.pokemongo.com/en-us/

[10] Rasche P, Schlomann A, Mertens A. Who Is Still Playing Pokémon Go? A Web-Based Survey. Eysenbach G, ed. JMIR Serious Games. 2017;5(2):e7. doi:10.2196/games.7197.

[11] Sailer, M., Hense, J., Mayr, S. and Mandl, H., 2017. How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction. *Computers in Human Behavior*, 69, pp.371-380.

[12] Susan Michie, DPhil, CPsychol, Michelle Richardson, PhD, Marie Johnston, PhD, CPsychol, Charles Abraham, DPhil, CPsychol, Jill Francis, PhD, CPsychol, Wendy Hardeman, PhD, Martin P. Eccles, MD, James Cane, PhD, Caroline E. Wood, PhD, The Behavior Change Technique Taxonomy (v1) of 93 Hierarchically Clustered Techniques: Building an International Consensus for the Reporting

of Behavior Change Interventions, Annals of Behavioral Medicine, Volume 46, Issue 1, August 2013, Pages 81–95, https://doi.org/10.1007/s12160-013-9486-6

[13] Technologies, U., n.d. *Unity - Unity*. [online] Unity. Available at: <https://unity.com/> [Accessed 1 January 2020].

[14] Yang, C. and Liu, D. (2017) 'Motives Matter: Motives for Playing Pokémon Go and Implications for Well-Being', Cyberpsychology, behavior and social networking, 20(1), pp. 52. doi: 10.1089/cyber.2016.0562