NFC Orienteering: Usability and User Experience Evaluation and Redesign

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Abstract

Recent technological advances offer new ways for encouraging people to participate in physical activities. The NFC Orienteering app is developed for the orienteering sport. Orienteering is an outdoor sport, in which orienteers compete to navigate from one point to another as fast as possible using a map and a compass. The aim of the app was to eliminate the need of physical equipment such as a physical compass, a printed paper map and an electronic control punch device that are required in conventional way of orienteering sport.

The primary goal of this thesis was to find the usability problems in the current prototype. In a usability test I organized a small orienteering track of 500 meters with the targeted end-users in its real context of use. Moreover, the study also involved measuring the essential user experience (UX) elements such as aesthetics, ergonomics, interest, frustration, motivation and effectiveness of the app. Classical usability testing method was used with some modifications to make it suitable for this study. The data was collected using different techniques such as think-aloud protocol, questionnaires, field observation, system logs and semi-structured interview. Usability testing identified many usability problems. Moreover, participants seemed to expect more complex and interesting features in the app. Despite the identified problems, all the participants were able to complete the orienteering track by visiting all 4 control points, which showed that the app fulfils its basic function. Most of the participants expressed their interest to use a better version of the app in the future. Finally, based on the test study I proposed a new design for the app.

Key words and terms: Usability, User Experience, Mobile Exergames.

Contents

1. Introduction

Traditional sports are becoming less popular among younger people. One of the biggest reasons is the excessive use of electronic devices such as laptops, smartphones and televisions in daily life [Capel et al., 2015]. Before this technological revolution people were more active in playing physical sports. Group of researchers believe that technology is making people's life sedentary [Salmon and Timerio, 2007]. Apart from this criticism there is no doubt that technology is also contributing to make sports better by adding fun, motivation and ease of use for athletes. However, the motivation of doing sports varies for each individual for example it depends on factors such as age, gender, skills and interests.

There has been a significant growth of interactive technologies that support different exertion activities [Mueller et al., 2014]. For example, around 10-15 years ago, devices like heart rate monitor watches, GPS devices, pedometers, and accelerometers were used in various exercise devices. These devices help users to track their performance and to do balanced workouts for maximum benefit. For example, pedometers help users to track the amount of footsteps to reach a specific target, such as 11,000 to 13,000 steps per day are recommended for weight loss [Rimmer, 2008]. Similarly, heart rate monitor watches help athletes to maintain a specific heart rate because some people prefer maintaining 90-150 bpm for burning calories. However, current generation of smartphones come with sensors such as magnetometer, gyroscope, pedometers, heart rate monitors and accelerometers. These smartphone sensors enabled developers to create mobile apps for exertion activities [Xu & Wei, 2013]. For example, activity tracker apps such as Nike+, RunKeeper, Endomondo, and Runtastic provide enthusiasts the ability to run and jog whenever and wherever they want while measuring the important information.

Video games are also playing a vital role to encourage people for physical activities. Games that make players exercise are called exergames. Exergaming is an old concept of doing physical exercise in a fun way. In 1982, Atari Joyboard a balance board controller for slalom skiing was created. The controller is operated by standing on it and leaning to different directions to emulate slalom skiing. Similarly, gaming sensor Kinect (2000) for Xbox and Eyetoy (2003) for PlayStation brought new revival in indoor exergames by allowing the user to control virtual characters in game with body gestures controller. The indoor exertion games are played by staying on one geographical location. However, the newer technologies such as GPS and Augmented Reality (AR) enabled games by allowing the player to move physically in the real world. The exergames which require the user to move physically in the real world are called mobile exergames. Mobile exergames are usually played by using just a

smartphone. Famous mobile exergames include Geocaching (2000), Ingress (2012), and Pokémon Go (2016). Developing a user interface that gives excellent user experience is an important aspect of mobile exergames. In this thesis, I report a study where I elicited usability problems and user experience elements of one such app called as “NFC Orienteering”.

The NFC Orienteering is based on an android app, and its first prototype was developed in February 2015 at University of Tampere, Finland. The NFC Orienteering app is a location based exergame for orienteering sports. Orienteering is a sport in which orienteers need navigation skills to find their way using a map and a compass by passing through the several control points of the track. The most popular and oldest orienteering is the foot orienteering but it also has other types such as Car orienteering, Mountain bike orienteering, Ski-orienteering, and Trail orienteering. NFC Orienteering is built to serve the purpose of orienteering by removing the need of expensive equipment. It intends to reduce the cost and effort of organizing orienteering events and participate in them. Organizers and participants need fewer pieces of equipment to accomplish their tasks with NFC Orienteering than with the conventional way. Mostly the mobile exergames use GPS for navigation, whereas in NFC Orienteering, player navigates from one point to another using a map and a compass. Thus, the common thing between mobile exergames (for example, pokémon go, ingress, and geocaching etc) and NFC Orienteering is that they encourage player to move around physically while playing.

It is important to test the usability and user experience of product as early as possible [Holzinger, 2005]. This reduces the need of making big changes in the end stages of the development process. If problems are found in the later stages of development, making changes can be very expensive and time consuming. The primary goal of this thesis was to inspect whether the app meets the basic user requirements or not. Furthermore, when developing the exergames, it is not only about how efficiently the user completes the task but it is also important that they experience fun and other positive things so that they want to play it again. Keeping this in mind, I investigated the user experience factors which are considered essential for good user experience of mobile exergaming apps. The data collected from the evaluation will then help to identify problematic parts, user expectations, and satisfaction towards the app. The study will also help to improve the app by presenting solutions to the identified problems.

The first research question was: What are the user experience issues in the existing system? Then, once they are identified, what are the possible improvements related to the issues? Moreover, what is the acceptance rate of an app, if it replaces the traditional

physical equipment? And lastly, does the NFC Orienteering app motivate people for physical sports?

The thesis begins by describing the orienteering sport. Chapter 2 presents the literature review on implementation of technology for exertion activities, the NFC Orienteering, the motivation behind the app and the prototype. Chapter 3 describes the available methods to evaluate the app and the chosen approach. The results of the test are presented in chapter 4. In chapter 5, the redesign methodologies and wireframe are presented. Chapter 6 contains the conclusion and discussion which summarizes the research.

2. Influential and related research work

Around 31% of the world's population do not perform enough physical exercise for good health [WHO, 2009]. There are many reasons, why the current generation spends more time in sitting than the previous generations. Sitting has increased due to excessive use of electronics devices and less physically demanding work. Experts describe sitting as the new smoking because it gradually harms the overall health and causes negative effects on health [Salmon and Timerio, 2007].

The motivation of doing physical activities varies among individuals depending on the factors such as age, gender, and interest. Maitland and Siek [2009] argued that young people like to do physical activities for fun, whereas, adults mostly do it for health and fitness. Touré-Tillery and Fishbach [2014] measured motivation in terms of observable, effective, behavioural and psychological responses. Moreover, Capel et al. [2015] presented factors that generally effect the motivation, and they categorized them into external and internal factors. External factors are related to social aspect such as social interaction and competition, whereas internal factors involve personal motives such as fun, relaxation, interest, health and fitness.

It is worthwhile to look at the hindrances that prevent people from doing exertion activities, because knowing them would help to minimize them. According to Maitland and Siek [2009] the biggest hindrance people face is the lack of leisure time. However, Morris and Choi [2005] argued that those who acknowledge the importance of exertion activities are more likely to make time for it. In a study by Capel et al. [2015], people indentified other barriers as lack of resources, tiredness, prioritizing other activities, weather and scheduling outdoor activities. People reported tiredness as a second major factor [Capel et al., 2015], that after school, university or work they feel less active to do any type of exertion activity. Furthermore, Capel et al. [2015] investigated that people have other important activities on to-do list that they prioritize over exertion activities. In addition, weather is another barrier in some countries, for example, winter in Scandinavian countries is longer, darker and extremely cold. Thus, sometimes due to weather it becomes challenging to schedule outdoor activities and stick to the plan [Capel et al., 2015]. Undoubtedly, life has become very busy in 21st century. So, I think the biggest hindrance could be the lack of leisure time, which stops people from doing exertion activities on regular basis. In my opinion, all the other factors mentioned above also influence people's behaviour for choosing specific exertion activity. For example cycling, running, and jogging are the most frequently performed exertion activities as they require less resources, skills and time to arrange.

2.1. Technological impact on exertion activities

This section contemplates the impact of technology on exertion activities. On one side it is believed that technological devices such as laptop, smartphone, and television contribute a lot in making life sedentary. On the other hand, it cannot be denied that there are technology devices that motivate people for doing exertion activities. For example, gym equipment now comes with various embedded technologies such as pedometer, accelerometer, and heart rate monitor to track athlete's performance which encourages them to perform better and more often. Generally, modern treadmill is the one of frequently used equipment in gym, it provides runners the information of their speed, heart rate, time spent, distance covered and estimated calories burnt.

2.1.1 Impact of technology on sports

Most of the research in sports technology seemed more focused on improving the athlete's performance in training and competition. For example, speed skating [Stienstra et al., 2011], swimming [Bächlin et al., 2009], jogging [Mueller et al., 2014], and martial arts [Hämäläinen et al., 2005] are sports in which researchers applied technology to improve the performance of athletes. Stienstra et al. [2011] presented the concept of Augmented Speed-skate Experience (ASE) to improve the speed-skater performance by giving informative, non-coercive, motivational, robust and easy to learn feedback through auditory information mapping during skating. ASE system used sonification (non speech audio to convey information) movement, which provides direct feedback to skater through sound [Stienstra et al., 2011]. ASE produces the auditory informative feedback through different technique for example pressure on foot that makes the pressure audible for athlete. The study showed significant results, when any speed-skater used ASE system for 7-8 times, it gave speed-skaters confidence to use it unconsciously, which then helped athlete to give better performance.

Similarly, Bächlin et al. [2009] tried to improve the skills of swimmers with SwimMaster. SwimMaster is a wearable swimming assistance based on acceleration sensors with micro-controllers and feedback interface module. These sensors helped to monitor and evaluate the different factors that affect swimming performance. These factors include time per lane, velocity and number of strokes per lane. Along with these, it also assists swim styles such as body balance and body rotation analysis and measurement [Bächlin et al., 2009]. The study showed that tracking performance with technology in swimming leads to improved performance.

Moreover, in one study of interactive technology in sports, the researcher developed concept of Interactive Video Mirrors for Sports Training [Hämäläinen, 2004]. The Interactive video mirror (Figure 1.a) helps athletes see performance and

moves repeatedly, which was not possible with a regular mirror. The results of the study showed that interactive mirror positively affected the athlete's and acrobat's performance in training for competition. Moreover, in their later studies, they developed the "Kick Ass Kung-Fu" for improving martial arts performance through playful entertainment training [Hämäläinen et al., 2005]. Kick Ass Kung-Fu is a video game, developed for martial arts, in which the player fights with virtual enemies with punches, kicks and acrobatic moves. In the real time image processing and computer vision, the player's own video image was embedded in 3D graphic interface (Figure 1.b), where player fights with virtual opponent. 46 participants took part in the study, and found that their idea is fun and entertaining. They discovered that Kick Ass Kung-Fu has the ability to augment and motivate martial artists and acrobats at least in the beginning and with moderate level of training.

Figure 1. Martial Arts in Artificial Reality (a) Athlete performing moves on stage and (b) game interface. [Hämäläinen et al., 2005]

Mueller et al. [2007] conducted a study on jogging over a distance. The system was designed to support the social contact between joggers who are geographically apart. In the study joggers put on the head phones and wore a prototype in a small backpack. Headphones were used as a communication tool, when one jogger spoke the other could hear his voice and could detect weather his partner was going faster, same pace, or slower and thus joggers decided the moving speed in order to keep his partner pace [Mueller et al., 2007]. The purpose of this study was to provide socialization, motivation to run faster, fun and encourage others to participate. This can help joggers communicate with each other and feel the presence of other joggers around for motivating each other to keep pace and discussing routes. The positive results of these studies showed that implementing technology in sports activities enhances player performance.

Apart from these serious sport games, there are many smartphone apps of fitness and sports for android, IOS and windows platform. Different apps support athletes in different activities and bring motivation to do exercise better and more often. For example, Nike+ [2010] and RunKeeper [2008] are popular apps for walking and jogging. Nike+ is an activity tracker app, which uses the pedometer, accelerometer and GPS of smartphone to measure and record the distance, speed and calories burned by the user. Runtastic is another app for running and jogging. Similar to Nike+, Runtastic also measure running distance, pace, elevation and speed of the runner and store the data on a cloud so that the user can access the achievements, progress and improvements from anywhere using any device. Similarly, Fitbit (2011) is an activity tracker to measure walk steps, distance covered, calories burned, sleeping hours, and weight lost. The app is developed by fitbit inc which is an American company famous for health and fitness wearable gadgets such as fitbit Flex (wristband), fitbit Surge (smartwatch) and fitbit Ultra (altimeter). These wearable devices are used to measure number of steps walked/climbed, sleep time, heart rate, and other personal metrics. The Nike + and Fitbit app dashboard is given in Figure 2 (a.b).

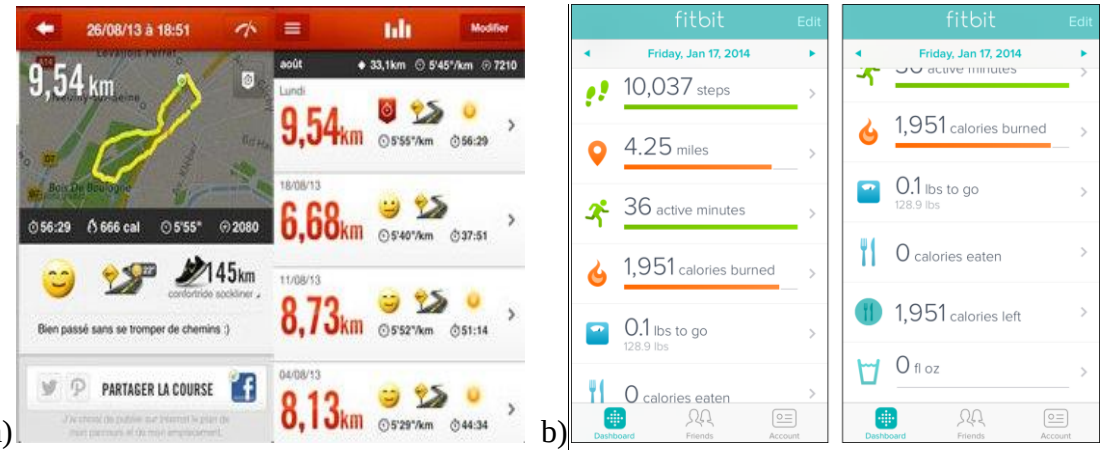

Figure 2. Dashboard of sport tracking apps: (a) Nike+ [Nike+, 2010] and (b) Fitbit. [Fitbit, 2011]

2.2. Exergames

The video games that involve its player in any kind of exertion activity are called exergames. Exergames are playing vital role in promoting exertion activities. Exergames mostly rely on technology as they need body movement tracking. The prime purpose of exergames is to promote an active lifestyle. Exergames is a fun way of doing exertion activities that someone otherwise finds boring [Dutz et al., 2014]. Exergames can be divided into two types, indoor and mobile exergames. Indoor exergames are generally played by staying at one geographical location such as player's own room,

whereas mobile exergames played outside and it usually runs on player's own smart device. Most people prefer outdoor activities when it comes to exercise. For example, running on a run track is considered more fun and satisfactory then running on the treadmill. [Dutz et al., 2014]

2.2.1. Indoor exergames

Indoor exergames are usually played by standing in front of PC monitor or TV screen; these games require the player to move different body parts. For example, Wii Sports (2006) developed by Nintendo, in which the players use the wii remote to imitate movements with their arms and upper body parts as a controller for playing 5 games including tennis, bowling, baseball, golf, and boxing. As the movement was tracked by accelerometer sensor of wii remote device in player's hand, thus it was questionable whether the game is full exergame or not, because the movement is not very extensive and even a player can play games with little effort while sitting on a couch.

Indoor exergames became popular when Konami Dance Dance Revolution (DDR) launched in 1998 and was a big hit. The DDR is a video game for dancing in which the players stand on a floor pad controller and hit their feet on colored arrows to musical and visual cues. The DDR aimed for improving the dance skills and physical exercise. The success of DDR brought new revival in dance world and lots of versions and similar dance games came in market [Höysniemi, 2006]. Nintendo's Wii fit is another exergame by Nintendo, released in 2007. It is a video game that used wii balance board accessory on which user stands and performs different exercises such as yoga, strength training, aerobics, and balance games [Dutz et al., 2014]. The DDR, Wii Sports and Wii Fit rely on sensors on floor mats which forced user to stand fairly while playing the game. The positive responses of Wii Fit makes it implemented in many fitness centers, hospitals, and physical therapy centres for exercise and rehabilitation.

Furthermore, Kinect (2010) brought new advancement in the motion sensing input devices. It enabled players to interact with games through body gestures and speech inputs. Popular kinect games include dance central, FIFA soccer, kinect adventures and zumba fitness. Eyetoy (2003) is a color digital camera device used for motion sensing for PlayStation 2 games. It was an earlier sensing device that allowed players to interact with a game using motion, color and sound detection. In later release of Eyetoy-kinetic (2005), it brought first multi-function hardware which allowed player to give game controller input with physical movements.

2.2.2. Mobile exergames

The technologies such as GPS and Augmented Reality (AR) brought a new dimension in exergames by allowing the player to move around in real environment. Undoubtedly, use of these technologies in sports enables vast range of opportunities for athletes. For example; GPS makes it easier for a runner or a cyclist to run on any track and can measure the speed, time and distance, GPS tracking has turned every track into a racing track because with GPS logger athlete can compare his own performance with other athletes [Krantz et al., 2013]. Zombies Run (2012), Ingress (2013), and Pokémon GO (2016) are the most popular examples of this game category. These games brought players out from their home and encouraged them to interact with real world instead of virtual world. Contrary to indoor exergames, mobile exergames are generally played on a smartphone and thus can be played whenever and wherever the player wants to play.

The Zombies run (2012) is an immersive running gaming app. In the game, player himself acts as a character in a game, as player needs to run physically for surviving zombie apocalypse. The player listens to the scary zombie's sounds chasing him, so he needs to run faster for survival and collect virtual items to survive. The player does not need to follow any specific path and rules as the main aim is to just run. However, game encourages player to run at a specific pace in order to complete different missions. The game is hands free playing which means player does not need to hold or interact with the game physically while running. Users can judge the chasing zombies position by listening to various audio narrations on the headphones. At the end of the game users can measure distance, time, pace and calories burned during game play.

The Geocaching is an outdoor exertion activity worldwide. Geocaching is a GPS based app, which allows geocachers to use GPS-enabled device to navigate to specific location on map and find geocaches. Geocaches are the items which geocachers need to hide and seek, it contains log book with pen so that when geocachers find it they sign the log with name and date and hide it back on the same place. The first GPS geocaching was played in May 3, 2000. The user interface of geocaching app is shown in Figure 3.

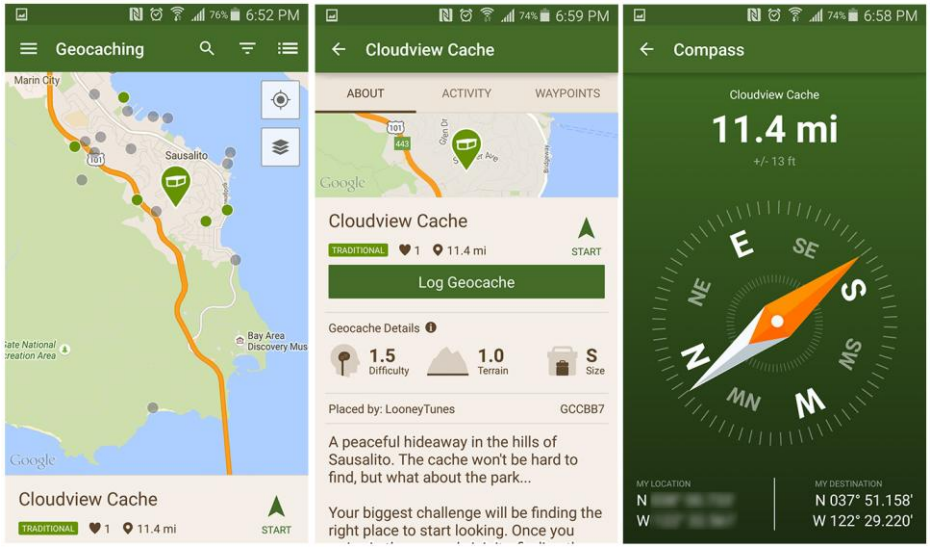

Figure 3. Geocaching application user interface (www.geocaching.com)

Similarly, Ingress (2012) is a popular GPS and augmented reality based exergaming app developed by Niantic. Ingress also encourages players to go out and explore the area around by interacting with portals located in the real world by visiting them physically. The game play consists of capturing portals of real world places such as public arts, landmarks, and monuments etc and linking them in a triangular shape on a geographical map. Ingress is a team play game; the team which covers more area by collecting more portals in a triangular field becomes the winner. The Niantic development team developed another game called Pokémon Go (2016). The Pokémon Go (2016) is also a GPS based augmented reality game. The motive of Pokémon Go is same as of ingress to make player move physically in real world. In the game, the player uses GPS enabled smartphone to navigate different points in the real world to capture different characters named pokémon. The player can find pokémon anywhere in the selected geographical area such as backyards, parks or on the sides of road as directed by the app. The Figure 4 given below shows the ingress and pokémon go app's user interface.

Figure 4. Augmented reality mobile exergames: (a) Ingress and (b) pokémon Go (https://www.nianticlabs.com/)

In the same way, SpecTreck (2010) an augmented reality exergame is based on searching for virtual ghosts and catching them by scanning them with a smartphone camera. In this game, players need to visit various locations in real world using the map in either a predetermined or player's defined area. The fun in this game is that the user needs to walk or run to the ghost location in order to catch them in specific time limit otherwise ghost could fly to some other place. The player can see the ghosts in augmented reality by using the phone camera and the player can catch them within the specific range of distance. The PacStudent is another mobile exergame created by students of Technical University of Darmstadt, Germany. It is based on popular game Pac-man. In PacStudent, players move in real world of predefined geographical area to collect virtual coins in path while trying to run away from virtual ghosts. The game uses GPS to track the location of player and map it with game's virtual map.

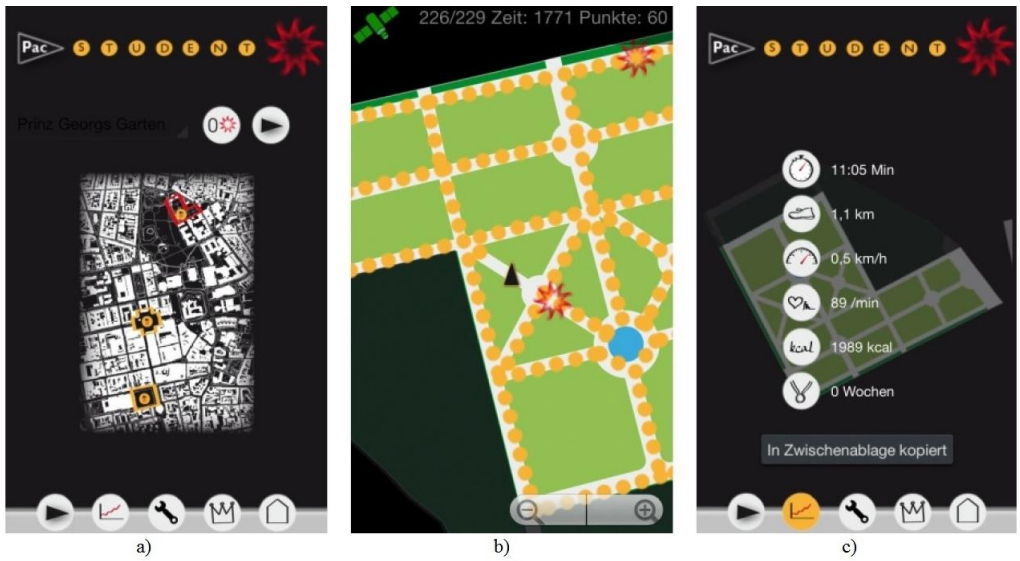

Figure 5. PacStudent [PacStudent, 2014].

Figure 5.a shows the selected area of game, Figure 5.b is the game interface which is a virtual demonstration of a real map and shows the player's location with a black rectangular arrow, virtual coins with golden circles and virtual ghosts with yellow stars. Moreover, Figure 5.c is displaying the game statistics. The game concept seemed to be simple; however when the game prototype was tested in real context of use, the developers faced many challenges. For instance, as the game included running that produced lot of shaking which forced player to stop running and then reorient his GPS position in the virtual world. According to Sinclair et al. [2007], this type of games require players to concentrate on the surrounding environment and at the same time on game interface which increases the risk of accident and reduces the entertainment level.

2.3. NFC Orienteering

NFC stands for Near-field communication, and the NFC Orienteering is based on an android app developed for orienteering sport using NFC technology. NFC Orienteering intends to reduce the effort of organizing the orienteering events and participating in them. First, in next section I will discuss the conventional way of orienteering sport that NFC Orienteering intends to replace, and then I will discuss app prototype and technical implementation of NFC Orienteering in Section 2.3.3.

2.3.1. Orienteering sports

Orienteering is an outdoor sport, in which participants compete in navigational skills using a map and a compass to find points in the landscape. There are different types of orienteering such as foot, mountain bike, skiing and car orienteering. The most common and popular is foot orienteering. [IOF, 2016]

Orienteering originated in Sweden in the end of 19th century, originally meant for crossing unknown land using a map and a compass. Later, it became part of the military training in many countries and was then adopted by common people as a competitive sport. In 1887, Norway organized the first orienteering competition [IOF, 2016]. The International Orienteering Federation (IOF) is responsible for orienteering standards of four orienteering sports including foot, mountain bike, ski and trail orienteering. These standards are recognized worldwide and thus make the guidelines of the sport, understandable for every orienteer regardless of their background, language and country. [IOF, 2016]

Orienteers require three pieces of equipment, a map, a compass and a control punch card (paper or electronic) for participating in orienteering sports. Firstly, a map used for orienteering is a specially designed topographical map [Ake et al., 2004],

which contains detailed and accurate graphical information and natural features of ground such as contour lines, forest density, wells, pits, roads, buildings, borders, fences, rocks, hills, water features, plain land and other necessary features as shown in Figure 6.

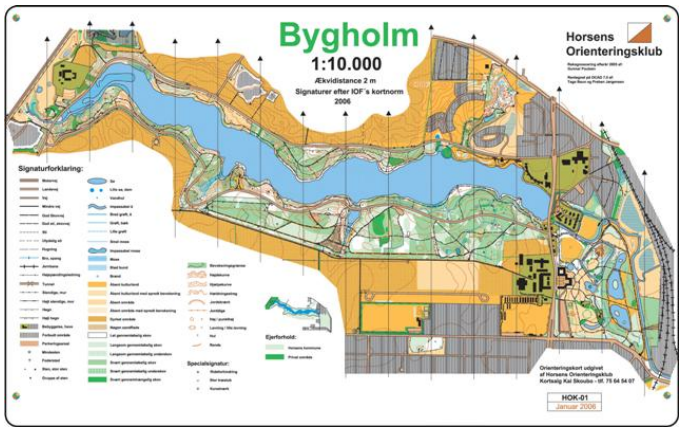

Figure 6. Orienteering map [Horsens, 2005].

Secondly, a compass is needed in order to orient the path. There are two types of compasses used by orienteers, one is the thumb compass and the other is the baseplate compass (Figure 7). The thumb compass is mostly preferred by orienteers as it can be fixed on the thumb which makes it easier to carry while running [Orienteering ca, 2016]. Generally, it is made up of a transparent material so that a map can be visible through it. Baseplate compass, also called as protractor compass, contains magnetized needle encapsulates in a circular rotating capsule, an orienting box for aligning the needle with magnetic north, a transparent baseplate with orienting lines and an outer dial (bezel) marked in degrees. It also contains magnifying glass for zooming into the map (Figure 7.b).

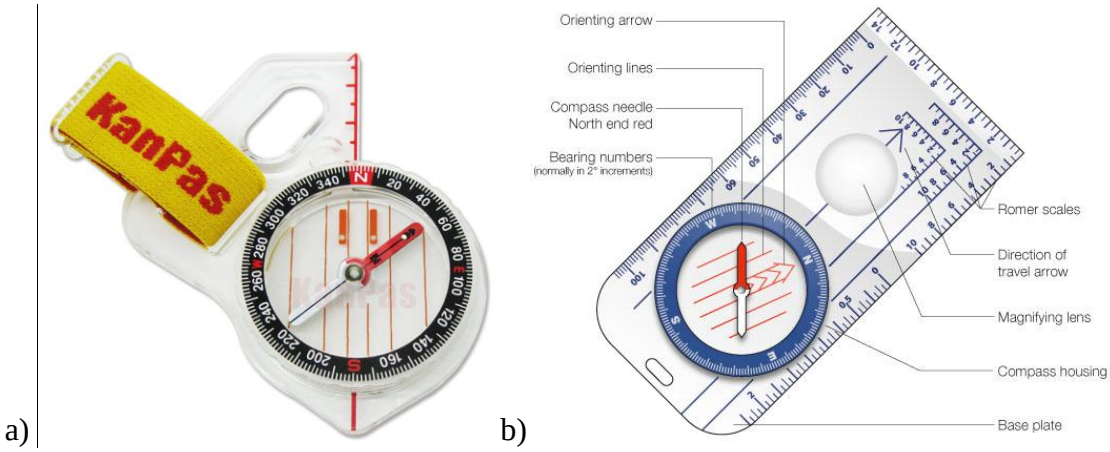

Figure 7. Orienteering compasses: (a) Thumb compass and (b) baseplate or protractor compass (http://everythingoutdoors.co.uk/how_to/navigation-tips/)

Thirdly, orienteers need a control card in order to punch at each control point [Orienteering ca, 2016]. In the past, paper control card (Figure 8.a) was used for a long time but nowadays it has been replaced by electronic control system such as SPORTIdent (Figure 8.b) and Electronic timing system (EMIT) (Figure 8.c). The paper control card system is now outdated but it is still used in some orienteering events because of lower cost. Orienteers are required to punch paper control card at each control point and the card gets different impressions at different control points which helps organizers know which control points the orienteer has visited. In contrast, an electronic control system makes this process much faster and reliable as organizer do not need to collect paper control cards and compare the punch marks in order to verify the result. [Suunnistusliitto, 2016]

a)  b)  c) 

Figure 8. Control punch system: (a) paper punch control card, (b) SPORTIdent and (c) EMIT punching control [IOF, 2016]

2.3.2. Motivation behind the NFC Orienteering app

The primary goal behind the NFC Orienteering system was to reduce the effort of organizing small orienteering events. The NFC Orienteering android app intends to eliminate the cost of printing maps, equipment rental and man power (one person could be able to organize the whole event and they do not have to be present at the place of event after placing NFC tags for control points). The list given below describes some of the intended benefits of the application.

1. The app would eliminate the need of printing physical maps. Printing maps is a time consuming process because sometimes organizer need to place a printing order weeks before the event in order to have delivery on time. Moreover, the cost of printing maps is significantly higher in European countries and as it is difficult to predict the exact number of prints for event, this leads to waste of time, money and resources.
2. Moreover, the app would eliminate need of expensive control gadgets. The emit control point gadget cost around €85 in Europe. However, NFC tag costs only around €1 or even less.
3. The app would eliminate the need of expensive electronic punching cards. The emit punch card costs around €65 in Europe. For NFC Orienteering, the

orienteers do not need to carry punching gadget. Instead they would just need to have an NFC capable mobile phone which most people already own.

4. Many orienteers feel discomfort when carrying a physical map, a compass, and a control card during walking or running. The app reduces this discomfort by replacing all these piece of equipment with one smartphone.
5. In big orienteering events hundreds of participants take part, which cause the formation of long queues at different points. For instance, orienteers are required to wait for their turns to collect the copy of map. Similarly, orienteer need to submit the result to organizer after finishing the track. Considering NFC Orienteering app can be the best solution from long queues prevention. The reason is that the downloading map and uploading the result is faster than conventional way.

Besides the above listed benefits, perhaps there could be some intangible benefits that this app can bring in this sport. Specifically, like the other mobile exergaming apps it can enhance the fun, motivation, playability, affordability and flexibility for the player.

2.3.3. The Prototype of NFC Orienteering

The first prototype of NFC Orienteering app was developed in 2015, by the team of 7 students in the course "TIEA4 Project work" at University of Tampere, Finland. The NFC Orienteering consists of two independent components. One is a website (for organizer use) and other is an android app (for orienteer use). This thesis will focus mainly on the android app. The prototype app will be discussed in detail in this section.

The landing page of an app contains basic instructions to provide help to naive users (Figure 9.a). In addition, the user can either start a new game or check the history of previous tracks completed using that device. If the user starts a new game then a screen (Figure 9.b) appears which requires the user to go to the starting point of an event and read the "RFID-tag" of the track (read the tag means, tapping the back side of smartphone on the tag) in order to load/download the track's map.

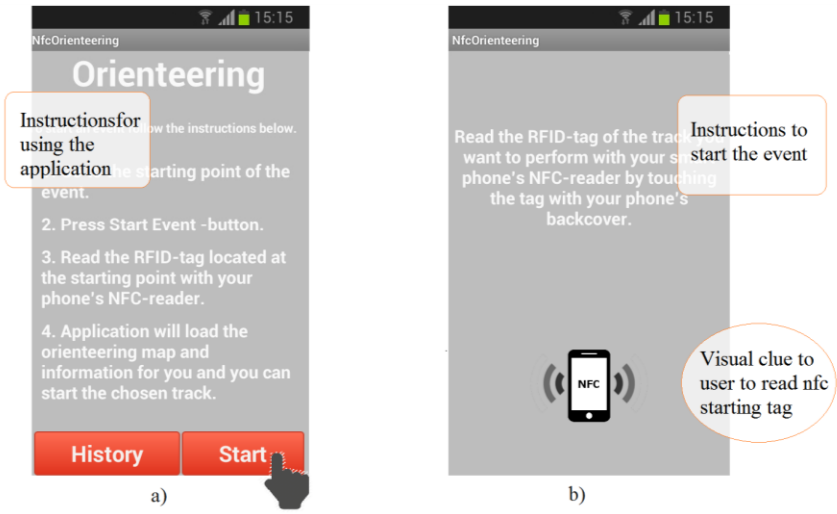

Figure 9. Starting the NFC Orienteering event: (a) Landing page and (b) loading the track map page.

Eventually, when user reads the starting tag, then user gets the track details. This process needs an internet connection as the app retrieves data from a website. The track detail includes the information of track length, difficulty level, time, date of track availability and the map image (Figure 10.a). From that point, the user could decide either to perform the selected track or choose some other track with 'other' button. An orienteering map with marked control points and a compass interface appears, once user starts the track. User can hide, show and change the size of the compass if he wants and also zoom in the map for better visibility (Figure 10.b).

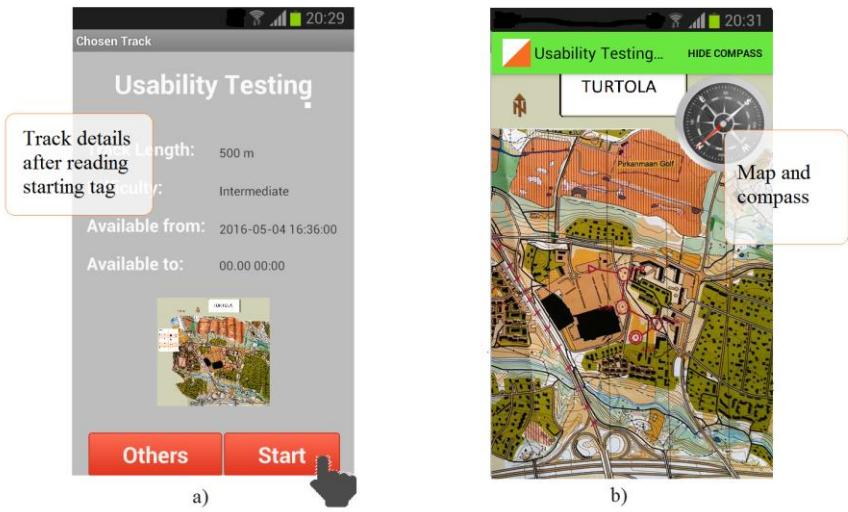

Figure 10. Event track information: (a) Track details screen, (b) control points on map and compass.

When the user reads the control point tag with the smartphone, the app notifies him with a visual message "control point tag x read successfully" along with vibrotactile feedback. Similarly, the app notifies the user for reading the incorrect

control point as “invalid tag read” (Figure 11.a). In the same way, the user receives a message “track finished successfully” when he or she reads the last control. Then the app immediately displays the ‘track results’ where the user can choose to “upload” and “not upload” the track results to the website (Figure 11.b).

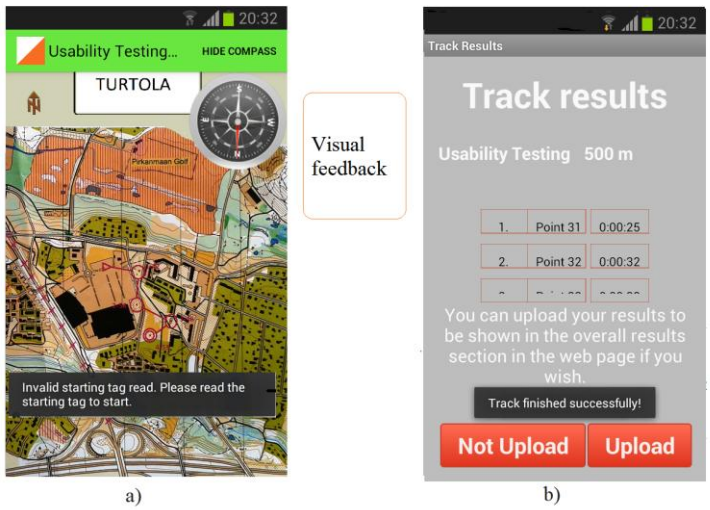

Figure 11. Notifications: (a) invalid tag read and (b) track finished successfully.

The user can upload track results to the website using nickname (Figure 12.a). The user can see the track’s leaderboard by visiting the website (http://nfc-orienteering.sis.uta.fi/) to compare his performance with other participants. However, the app only provides a user’s total time and split times for recently performed tracks. Locally, Figure 12.c and Figure 12.d are the screen interface for viewing the track results of a user.

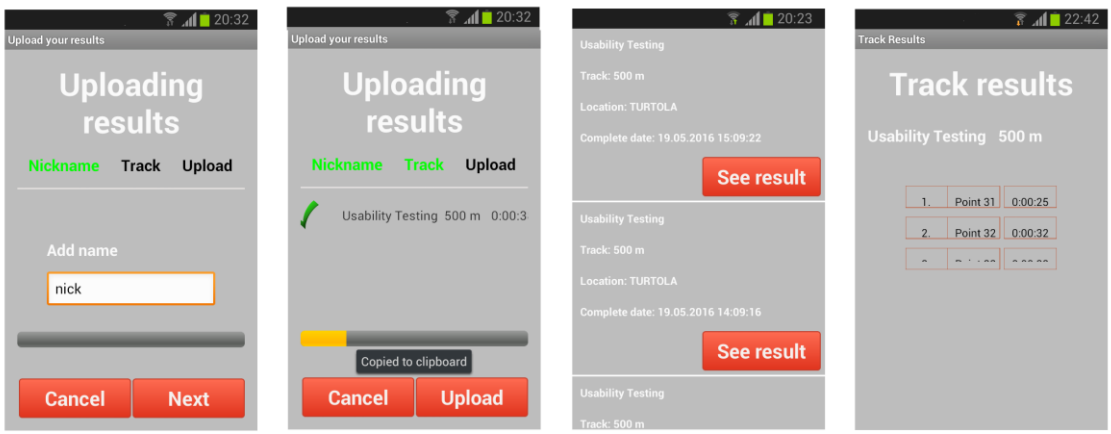

Figure 12. Upload the results: (a) adding nick name, (b) results uploaded successfully, (c) history of performed tracks and (d) track result.

2.3.4. Competitive analysis

In this section I will discuss the other existing apps for orienteering. The most similar with 'NFC Orienteering' is the "MOBO" app [2012] developed in Estonia by Tak-Soft. Currently, MOBO app has 166 courses or tracks in 15 different countries, majority of which are in Estonia and Finland [Mobo, 2016]. Like NFC Orienteering, the MOBO app also provides a compass, a map and a punching control point feature within the app.

However, the operating principles are different in the apps. For example, in NFC Orienteering the track map is available only at the starting point of the event whereas the MOBO app allows its user to search the track and get the map with marked control points from anywhere. Moreover, MOBO uses Quick Response Code (QR codes) to punch at control points for the majority of tracks, but for some tracks it is also using NFC technology. Most of the smartphones have internal QR reader which works fine for the MOBO app but in some phones users need to install external QR reader. The correct match of QR codes at each control point is accepted by the app and uploaded to the MOBO website [MOBO, 2016].

Another mobile app for orienteering is 'iOrienteering' for orienteering sport [iOrienteering, 2016]. Like MOBO, in iOrienteering the user also needs to scan a QR code to start a track, to punch at each control point and to finish the track. The user can upload the result on website. In contrast, user uses a physical compass and a printed map for iOrienteering. The iOrienteering app stores the user location with GPS tracker when he or she scans the QR codes, which helps in making the game fair.

In contrast to the above mentioned apps, Virtual Orienteering (VO) is a mobile exergame for orienteering which is played outside. The VO worked totally with GPS technology, by removing the need of a compass and a control punch system. The GPS tracks player location, when player reaches the marked check point. Therefore, the check point is automatically passed without the need to punch anything. Similarly, another mobile exergame O-Mopsi also uses GPS technology [Tabarcea et al., 2013]. It consists of targets (geo-tagged photos with location information) that a player needs to visit in free order. This gives players an extra challenge to create the best route to complete the game as fast as possible. The player needs to get closer than 20 meters to the targeted location to successfully pass the specific target. The game provides fun of visiting nice places that other players have visited and posted as geo-tagged photos. This concept is interesting and different in the way that any player can create new targets for the other players (Figure 13). [Tabarcea et al., 2013]

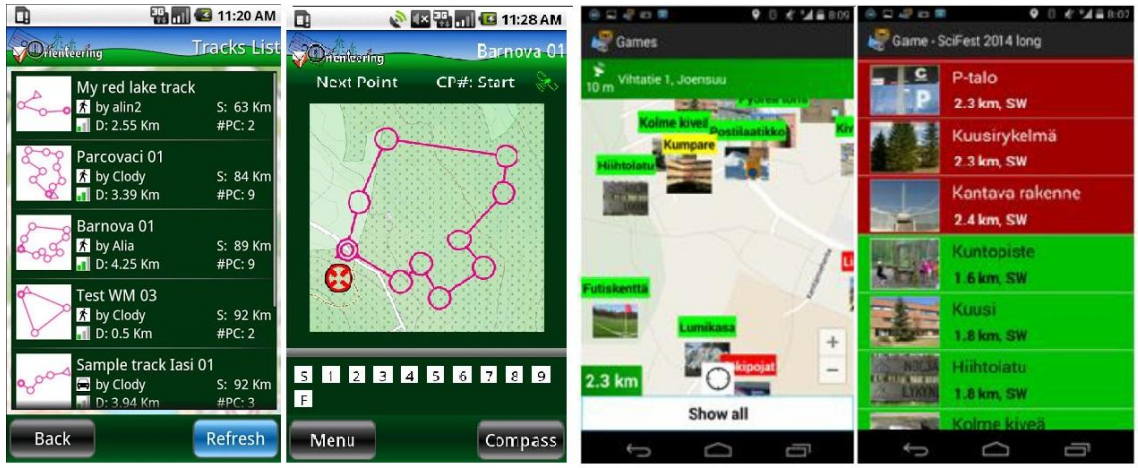

Figure 13. Apps for orienteering: a) Virtual Orienteering (VO) and b) O-Mopsi [Tabarcea et al., 2013]

2.3.5. Technical implementation of NFC Orienteering

Near-field communication (NFC) technology was utilized to develop the idea of NFC Orienteering. NFC finds its roots back to the radio-frequency identification (RFID). The RFID was invented during the World War 2 and it uses an electromagnetic field to retrieve the information stored in RFID tag [Coskun et al., 2011]. NFC works in a similar communication protocol to the RFID. The NFC allows communication between two NFC enabled devices by bringing them close to each other (5cm) [Al-Ofeishat and Al-Rababah, 2012]. NFC is based on two independent components, one is a reader and the other is a responder. The reader is a device that sends radio signals to read or write the data on the responder device/tag.

The NFC tag contains an antenna (Figure 14) which uses power received from the transmission to generate enough power for the NFC tag to perform specific command and send reply in response [Coskun et al., 2011]. The responders transmit response to the sender either by using power received from transmission or by its own power source. The communication is called passive if the responder uses power it receives from transmission, and it is called active if the responder uses its own power from another power source [Lehpamer, 2012]. NFC is used in many applications such as for tracking goods, machine readable travel documents and store medical information of patients and many others.

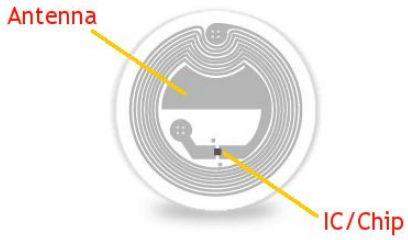

Figure 14. NFC tag: chip and antenna of the tag.

NFC is considered to be secured connectivity, because it needs very close contact between devices. Since the NFC technology emerged it has been used in various applications. For example, NFC enabled smartphones can act as credit cards, keys to open car doors and download information from an advertisement.

The NFC devices work in three different modes of operations [Jeffrey, 2009].

- NFC card emulation: The NFC-enabled devices such as smartphones act as the NFC smart cards. The external reader allows to access NFC card (smartphone) to perform payment transactions or ticketing.
- NFC reader/writer: It allows the NFC-enabled devices to read the information stored in the NFC tag. If the tag is programmable it also allows writing data on the NFC tag.
- NFC peer-to-peer: It allows two NFC-enabled devices (such as smartphones) to build a temporary connection for exchanging information.

In NFC Orienteering, the NFC enabled smartphone acts as tag writer as well as tag reader. The organizer needs to install an external app such as NFC Tools in an NFC enabled smartphone, which provides interface to write the NFC tags for control points and the starting tag. The organizer can configure tags to make them read-only for orienteers in order to prevent them from sabotaging. Similarly, orienteer uses a NFC enabled smartphone to read the NFC tags. There are four types of NFC tags which vary in speed, memory and cost. NFC Orienteering app is compatible with all the 4 tag types.

3. Research methods

When developing software products such as NFC Orienteering, ensuring good user experience is important. Human-technology interaction (HTI) researchers have recognized long ago the importance of considering the user perspective in designing a user satisfied product. In 1969, Nickerson summarized his research by stating that "the need for the future is not so much computer oriented people as for people oriented computers" [Nickerson 1969, p. 178]. In other words, he stated that a system should be designed from the perspective of its targeted users so that a user needs less training to perform basic operations. Moreover, Nickerson also concluded that the user oriented computer leads to fewer user errors. In the 1980s, most of the human-computer interaction (HCI) researches seemed to be more focused on how people interacted with computer programs such as word processing, databases and statistics software [Lazar, 2010].

According to Lazar [2010], a major shift in the HCl research field occurred during the beginning and mid 1990s when the internet and World Wide Web gained acceptance. This brought the need to research new types of interfaces [Lazar 2010, p.3]. Since then a number of fields such as user centered system design (UCSD/HCSD), user experience (UX), user-centered design (UCD), interaction design (IxD), and human-technology interaction (HTI) have emerged. These fields focus on designing technology products that are more useful to their users. Although, these research areas have a slightly different focus and scope from each other, the common factor is user involvement throughout the development process. Don Norman has made significant contributions to early research in the field of HTI. The Norman design principles [1983] are well recognized and considered as the standard for good design. Norman presented revised and extended version of his 6 design principles in his book "Design of Everyday Things, 2013", for good products design. These principles are listed below [Norman, 2013].

Discoverability: This refers to the possible actions a user can imagine performing in the current state of the system.

Feedback: This gives back information to the user on what has been done, what is going on and what is next. It makes communication better between the user and the product. For example, progress bar in Windows gives information on the progress of a process or task.

Conceptual model: The conceptual model explains, in a highly simplified way, how the product works. For example: icons of documents, folders and files in Windows give the conceptual model of the things they represent.

Affordance: Affordance is the relationship between the user and the product. It gives a clue about how to use the product. For example, a door affords to open and button affords to press

Signifier: It is any mark, symbol, sign or sound on the product which helps the user to understand what action should take place. For example push/pull sign on a door.

Mapping: Mapping represents the relation between controls and their outcomes in the real world. For example: arrows on keyboard buttons, up arrow is used for upward motion and down arrow for downward motion.

Constraints: Constraints are the restrictions in the system, which help to prevent wrong entries and actions by users. For example, in MS word disabling the "Copy" and "Cut" commands when no text is currently selected.

In this chapter, I will first introduce general concepts of usability and user experience (UX), and the methods to evaluate them in the section 3.1. Then in the section 3.2, I will discuss how I applied these methods in this work.

3.1. Usability and User Experience

Usability refers to the ease of use and learnability of the product. The ISO standard [ISO, 9241-11:1998] (clause 3.1) defines usability as "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [Jokela et al., 2003]. In 1993, Nielsen presented 5 factors, given below to evaluate the usability issues in any product [Nielsen, 1993].

Learnability: This refers to the ease of use and understanding a system, and how well user performed basic tasks while using the system for the first time.

Efficiency: Once the user learns how to operate the system, how efficiently can the user complete the tasks?

Memorability: After a long time of not using the system, if the user tries to use the system again, how easily can he remember the basic operations of the system?

Errors: Number of errors a user makes while using the system, the quantity and severity of errors and how easily a user can recover from these errors.

Satisfaction: This refers to how pleasant the user felt after interacting with the system.

In the mid-1990s, Norman presented the concept of "user experience (UX)" when he observed that the usability alone is not sufficient for making good product design. According to his definition of UX, it is the extended version of usability to include holistic perspective of the system instead of just task oriented perspective. The international standards [ISO, 9241-210:2010] (clause 2.15), defines UX as a "person's

perceptions and responses that result from the use or anticipated use of a product, system or service." Besides the user and the system, ISO also gave importance to the context of use. Thus, According to the definition, user experience includes all the user's emotions, beliefs, preferences, perceptions, physical and psychological responses, behaviors and accomplishments that occur before, during and after use the product in specific context of use.

User experience talks about the positive sense of human-technology interaction rather than just preventing the usability problems [Hassenzahl and Tractinsky, 2006]. UX is a broad term as it refers to the entire experience of the user that includes user feeling of before, during and after using the system, product or service. This makes UX difficult to understand, many researchers interpret UX differently and presents different definitions according to their understandings [Roto et al., 2011]. According to Hassenzahl and Tractinsky [2006] UX is usually viewed from different perspectives. They grouped these perspectives into three categories and named them as beyond the instrumental, emotion, effects and the experiental (Figure 15). They said that combination of these perspectives better explains the UX. First perspective, beyond the instrumental deals with the non-task based features of a system such as aesthetics, ergonomics and beauty of the system. Second perspective, the emotion and effects, deals with the internal state and emotions of user before and after using the system. Third perspective is the experiental, which relates to the fact that experience is temporary, unique and complex caused by the user, system and the context. Hassenzahl and Tractinsky [2006] argued that overlapping of these three perspectives defines the UX.

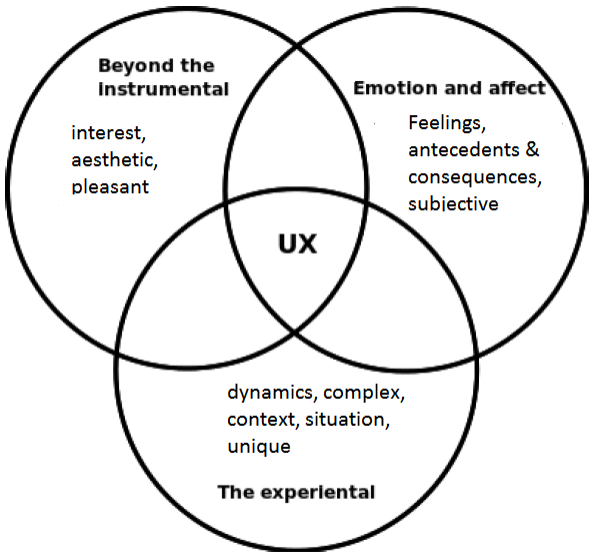

Figure 15. UX elaboration by Hassenzahl and Tractinsky [2006]

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Good user experience is now essential for the success of any product. Arhippainen and Tähti [2003] described that for investigating the interaction between user and system, there is a need to identify the nature of the product, user and the surrounding environment in which the product is intended to be used. The Figure 16 given below illustrates some examples of the attributes of user, system and context of use. These attributes vary for different types of products, for example evaluation of web application product needs a focus on visual issues such as, navigation, appearance, and text content, whereas for mobile application focus goes to screen size, device weight and OS capabilities. [Arhippainen and Tähti, 2003]

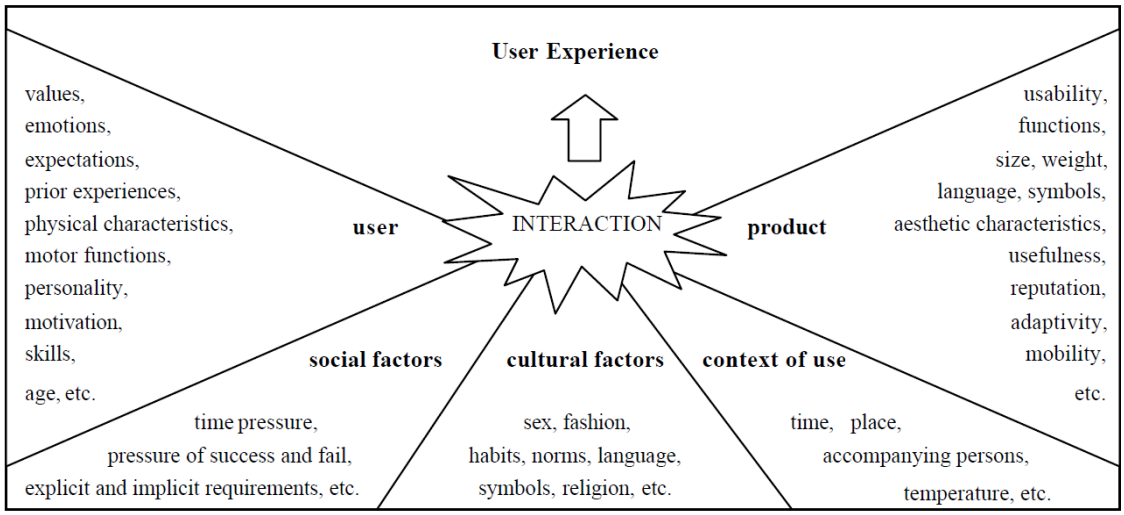

Figure 16. User experience factors in interaction with user and product in the particular context including social and cultural aspects [Arhippainen and Tähti, 2003].

Undoubtedly, it is difficult to measure each aspects of user's experience of a product. UX refers to the user's emotions, perception, psychological responses and satisfaction level that occur before, during and after the use of the product. It is important to know which factors of the product are worth measuring before starting the evaluation process. For example, in exergames excellent task efficiency, functionalities, aesthetics, ergonomics, engaging motivation, fun/interest and wanting to use it again are considered to be the most important elements.

The relationship between usability and UX is intertwined. UX is subjective [McCarthy and Wright, 2004] as it focuses on lived experiences. UX talks about how a user feels about the product. Whereas, usability is mostly objective, it focuses on task performances such as completion time and number of errors. However, usability components can be taken as a UX component. UX rather includes range of other subjective qualities such as user motivation and expectation. [Vermeeran et al., 2010]

Different authors define user experience differently and thus there are several definitions of UX [Roto et al., 2011]. Regardless of these differences, three things are common in all descriptions:

User: Every human possesses a unique nature, thoughts, behavior and attitude. Along with these natural differences external and temporary factors such as mood, culture and knowledge also affect the person's behavior towards the product. Thus, one user can have one set of expectations for the product and another user has completely different expectations.
System: Good system design ultimately enhances the user experience which leads to a successful product. The system includes all its characteristics such as color, appearance and functions.
Context of use: Context of use is the actual conditions in which the system is intended to be used. It involves all environmental factors which have direct or indirect impact on the use of the product such as light, temperature, sound, and geographical location.

The paramount requirement for a good UX is that the user can perform basic operations of the product without any trouble or inconvenience. In order to achieve that, the user should be provided with all the instructions for the product's use, necessary actions for basic operations, best suited interaction techniques and the user should be aware of what is going on during the usage time.

3.2. User experience evaluation

Only a product with superior user experience can be successful in the market. [Albert and Tullis, 2013]. Measuring the user experience of any product helps to improve it. Evaluation pin points the areas which a user feels confusing, inefficient and frustrating.

Usability and user experience are strongly related to the user perspective [Holzinger, 2005]. In order to obtain user satisfaction in the product there is a need to involve the user throughout the development process. As usability is an essential component of UX, it is hard to imagine a good UX product with large number of usability problems. On the other hand, UX is not all about usability; it is also possible that a product with almost no usability problems may not provide good UX. Therefore, in product evaluation, it is important to know how to measure usability and user experience of the product.

This thesis includes the evaluation of the usability issues in the NFC Orienteering app. Moreover, it also involves measuring some important UX factors, which I considered worth measuring for this type of sport app. These UX factors are derived

from the extensive literature review about ‘factors affecting the UX of mobile exergames’.

Hassenzahl [2008] argued that people perceive interactive products with two dimensions, pragmatic quality and hedonic quality. Pragmatic quality of a product relates to its qualities to support users’ task related needs, for example, utility and usability. Whereas, hedonic quality relates to user’s desire of pleasure and avoidance of discomfort and boredom such as fun, beauty, innovativeness, interesting and engaging [Hassenzahl et al., 2000], for example, “why does someone own and use a particular product” [Hassenzahl, 2010]. Moreover, according to technology acceptance model [Venkatesh and Davis, 2000], effectiveness and ease of use are the two most important factors for system acceptance.

In a study by Vermeeran et al. [2010], 96 UX evaluation methods were collected. These methods can be used to measure UX depending on the scenario and requirement. Some of these methods can only be feasible for lab testing and some are for field testing. However, half of these methods can be used flexibly in any situation. List of these methods are available on the web source [UXEM, 2016]. UX researchers often combine these methods according to their need in order to collect the data. Some researchers believe that a large amount of data needs to be collected in order to get better result. On the other hand, some believe that gathering a huge volume of data could lead to the waste of time, resources and skills and may cause large amount of redundant data [Vermeeran et al., 2010].

How to collect data

There are different methods to measure the UX of a product and can be implemented at different developmental stages. However, it is more beneficial to test it in early stages of development when the working prototype is ready, with the help of targeted user in a real environment.

First of all the questionnaire is an important tool to collect data for UX evaluation [Roto et al., 2009]. The user can be asked to fill one or more questionnaires. Generally, a background questionnaire is given before the test begins, which includes questions related to user education, knowledge and skills. In some cases, participants are asked to fill user expectations questionnaire, which helps to know what user expects from the product. The post test questionnaire is given after the participant has used the product. Post test questionnaires include questions about how user felt after using the product. Interview is another tool to easily retrieve information about the user’s thoughts on the product [Roto et al., 2009]. Perhaps, a semi-structured interview is the best way to

conduct an interview to measure UX [Arhippainen and Tähti, 2003]. Semi-structured interviews are conducted with an open framework, not all the questions are pre designed and most of the questions are created during the interview which makes the interview a two-way conversation between the interviewer and the participant. Field observation is another important tool to measure UX factors. Field observation involves observing the participant behaviour while the participant performs tasks using the product [Roto et al., 2009]. Field observation requires close attention to interpret correctly the participant's facial expressions, body movements and comments while using the product. According to Arhippainen and Tähti [2003], the best way to observe the participants' behaviour is to record a video with their permission. Watching the video repeatedly helps the moderator to analyze participants' reactions more clearly.

All these different techniques could be used in an UX evaluation. However, different techniques can give conflicting outcomes, for example, a participant could say that a specific function of product is easy to use but in field observation, participant was observed struggling in performing that specific task. All these techniques have equal importance. For instance, it is not possible for a moderator to correctly interpret all the behavior of participants so it is better to ask a participant in an interview about how the participant felt when performing the specific task [Arhippainen and Tähti, 2003]. Usability evaluation methods can be used to test the UX factors [Koeffel et al., 2010]. These methods are divided into two categories: usability inspection methods and usability testing [Holzinger, 2005].

3.2.1 Usability testing

Usability testing is a method used in user centered design process to evaluate the system with the help of its targeted end users. Testing with end users is the most fundamental usability method, because it provides direct information about user's feelings about the system. Usability testing is used to measure a product's capacity to meet its intended purpose. In addition, Koeffel et al. [2010] argued that usability testing can be modified and used to measure the UX factors of a product. Usability testing is a good evaluation method for mobile exergames as it is strongly linked with the user, product and context of use. [Holzinger, 2005]

How to conduct a usability test

Setting up the usability test involves a well arranged test plan. The test moderator should have a good understanding of what factors he/she needs to evaluate. This should be kept in mind while designing the questionnaires, test tasks and interview statements. The first thing in the usability test is to make a test plan according to the requirements. When the test plan is ready, a pilot test is generally conducted in order to check the

efficiency of the plan. The pilot test helps in identifying the practical issues in the test plan and also in improving the quality of questions being asked in the test.

Nielsen argued that five participants are enough for finding around 80% of usability problems. He suggested that it is not beneficial to make more people suffer through the same flawed design. Instead it is better to conduct several small usability tests in various developmental stages with a small number of participants [Nielsen, 2000].

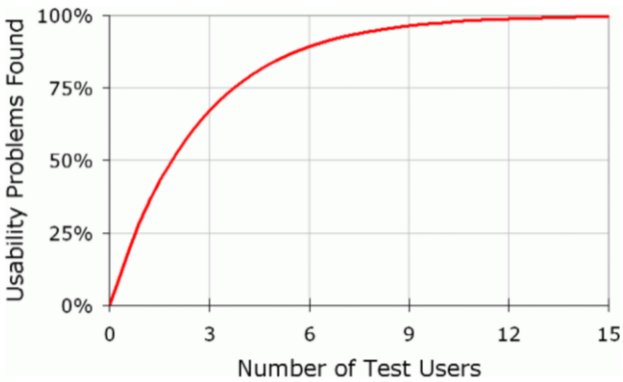

Figure 17. Number of test user and usability problems found. (source: https://www.nngroup.com/articles/why-you-only-need-to-test-with-5-users/)

3.2.2. Usability inspection method

In contrast to usability testing, the usability inspection method involves expert evaluation in which an expert tests the system without user involvement. Experts can use different methods such as heuristic evaluation and cognitive walk through. Usability testing is the best way to measure the usability and user experience of the NFC Orienteering app. However, knowing alternative methods could help in viewing the app from a different perspective during evaluation phase.

Heuristics evaluation is an expert evaluation method used to identify problems in the user interface of system. Heuristics evaluation can be used together with other usability testing methodologies. The evaluation is made on the basis of Jakob Nielsen's heuristics. These heuristics are listed below. [Nielsen, 1994]

Visibility of system status	The system should inform the user about what is going on with appropriate feedback.
Match between system and the real world	The system must present information in a language that is understandable for the user and not use system-oriented term

	or phrases. The system should follow real world protocols and present information in a natural and logical way.
User control and freedom	The system should provide redo and undo support as user often chooses wrong option by mistake. The mistake should be resolve in simple way.
Consistency and standards	The user should not have any confusion about the meaning of different words. Thus the product should follow standards.
Error prevention	Error prevention is better than error handling. For example, confirmation message before deleting something is an excellent example of error prevention.
Recognition rather than recall	The system should be designed to minimize the memory load of user by making things visible.
Flexibility and efficiency of use	The system should support fast interaction for both experienced and inexperienced users. Quick interaction provides user flexibility and efficiency.
Aesthetic and minimalist design	Extra information which is not needed should not be displayed. Unwanted information affects the visibility of wanted information.
Help users recognize, diagnose, and recover from errors	Error messages should be presented in simple words which indicates the issues and briefly suggests a solution.
Help and documentation	It is better if the user can operate the system without any help. However, a proper help document should be provided so that user can learn how to operate the system.

Table 1: Nielsen heuristics design principles. [Nielsen, 1994]

Cognitive walk through is a task oriented method. In this method the developer team analyses the system functionalities by stimulating the user's action step by step to accomplish the task.

3.3. Test protocols and execution

Section 3.2 discussed the methods that could have been used to evaluate the NFC Orienteering app. In this section, the chosen methods and the way they were implemented to test the system will be discussed. By analyzing the available UX and usability evaluation methods, I decided to choose usability testing. It is hard to imagine

good UX without the good usability in this app. Therefore, usability testing is suitable tool to measure usability and UX factors of an app.

In this section, the usability testing procedure will be discussed. This section will begin with describing some useful background information of the participants. Next, the hardware and software used in the test will be described. Then, I will discuss the test settings and environmental conditions. Last, but not the least, the procedures used for conducting the test will be explained.

3.3.1. Participants

The participants were recruited according to their expertise in orienteering so that the test covers all types of target users. Table 2 given below shows the background information of the participants. The table is derived from the background questionnaire form (Appendix 2)

Serial number	Gender	Age	Computer skills	Orienteering skills	Use of GPS tracker	Participation in any sport
P1	Male	29	Excellent	Beginner	Frequently	Occasionally
P2	Male	29	Good	Beginner	Frequently	Rarely
P3	Male	27	Excellent	Beginner	Rarely	Frequently
P4	Male	26	Basics	Beginner	Rarely	Rarely
P5	Female	44	Good	Advanced	Frequently	Frequently
P6	Male	54	Good	Advanced	Frequently	Frequently
P7	Male	40	Excellent	Advanced	Frequently	Frequently
P8	Male	29	Excellent	Beginner	Frequently	Rarely

Table 2: Background information of participants

There were eight participants in the usability tests, and one in the pilot test. They all hold at least a graduate degree and their age ranged from 26-54 years. Moreover, all the participants were familiar with location navigation and used GPS trackers such as Google maps for tracking their location. Only P5, P6 and P7 had previous orienteering sport experience. P5 had competed in more than 100 orienting events, whereas P6 and P7 said that they participated in more than 50 orienteering events. All the other participants had no experience in orienteering sport.

The participants reported that they used mobile apps on a daily basis, except P4 who used them occasionally (few times in a week). Besides that P1 and P8 participated

occasionally (1-2 times in a month) in any sport activities, P2 and P4 participated rarely and the others participated more frequently (2-5 times a week).

3.3.2. Hardware and software

NFC Orienteering is based on 2 hardware components, one is the smartphone and other is NFC tag. The app was already installed in the smartphone that was given to the participants. The important and relevant specifications of the smartphone are given in the table 3 below.

Smartphone name	Samsung I8190N Galaxy S III mini
Dimensions	121.55 x 63 x 9.9mm (HxWxD)
Weight	111.5 g (3.92 oz)
Display type	Super AMOLED capacitive touch screen, 16M colors
Display size	4.0 inches (~59.4% screen-to-body ratio)
Resolution	480 x 800 pixels (~233 ppi pixel density)
Multi-touch	Yes
NFC Connectivity	Yes
Operating system	Android OS, v4.1 (Jelly Bean)

Table 3: Specification of Samsung galaxy S3 mini

Additionally, an NFC tag type 2 was used for the control points. The tag type 2 has memory capacity of 48 bytes, which was more than enough to store the control point ID. Tag type 2 supports read, write, rewrite and read-only functions, while in this case the tags were configured as read only so that the participants could not rewrite them accidentally. An android app ‘NFC Tools’ was used to write the NFC tags. 5 NFC tags were placed at different locations of a 500 meter track. The participants were required to search for the tags using the NFC Orienteering app.

3.4. Usability test conditions

The app is intended to be used outdoors, hence the environmental conditions such as weather, light, temperature and sound would have a significant effect on the app usage. Therefore, the usability tests were conducted in a park located in Turtola, Tampere Finland. The test aimed to evaluate the NFC Orienteering app in its real context of use with the help of its end users. The usability tests were conducted on three random days, due to the availability of participants. It was around +16 °C outside in the Finnish

spring season. The first two days were bright with sun shining and on the third day it was raining.

In the test, participants were asked to perform small orienteering track of 500 meters using the NFC Orienteering app. This section will elaborate the techniques and tools used in usability tests.

Figure 18. Photos from the setting for the usability testing: (a) NFC enabled starting check point and (b) punch in control point.

3.5. Test procedure

Each participant was provided the same test instructions via email and all went through the same test procedure. The procedure is listed below.

1. Participants were recruited according to their orienteering skills.
2. Participants were given test instructions via email to avoid unclear communication so that test could start immediately at the test site.
3. Each participant was first welcomed at the test site and then asked to sign the consent form (Appendix 1).
4. Participants were asked to fill in the background questionnaire (Appendix 2).
5. After that, the smartphone was handed over to the participant, in which NFC Orienteering app was already installed. Then, the test tasks were given one by one.
    - Only one participant took part in the usability test at one time.
    - Participants were asked to think aloud while performing each test task.
6. Participants were asked to fill in the post test questionnaire.
7. Last part was a semi-structured interview, which included 5 themes and multiple follow up questions.

3.5.1. Pilot study

A pilot test was conducted before the actual usability tests. The pilot test helped in evaluating the efficiency and feasibility of the test plan. The data gathered from the pilot test was used to improve the test plan. For example, the pilot test participant identified that it is difficult to understand some of the instruction as we both were speaking English in foreign accent. Moreover, verbal instructions are usually difficult to understand and remember, so it was not efficient to provide test instructions on the test location. In order to avoid this problem, I decided to send test instructions (Appendix 5) via email to every participant. Besides this big change, other changes included the removal and addition of questions from the background form, interview and post-test questionnaire.

3.5.2. Test tasks

The test tasks were designed in a way that the user interacted with every feature of the app. In task 0 the participants were asked to open the NFC Orienteering app and download the track's map by reading the info NFC tag. Next, task 1 was intended to measure the effectivity of the app, it required user to perform an orienteering track of 500 meters by passing through four control points. Measuring the app's effectiveness was important, because if participants were unable to finish the track it would be a serious problem that needed to be fixed. Test task 1 required minimum time of 4 minutes to finish, and it was longest than the other tasks. Task 2 included the uploading of test results and in task 3 participants were asked to view the history of their track result. A list of the test tasks is given in table 4.

Task 0	Open the NFC Orienteering app and start the new event. Then, load/download the track map by reading the NFC info tag. Note: Read the NFC tag by tapping the back cover of the smartphone on the NFC tag.
Task 1	Perform orienteering track of 500 meters by passing through the 4 control points. Read the NFC tag at each control point Note: Time will start after reading 1st checkpoint and finish with reading the 4th checkpoint.
Task 2	Upload your track result with the nick name.
Task 3	Check the history of your track results.

Table 4: Test tasks used for usability testing

3.5.3. Questionnaires

Participants were asked to fill in two questionnaires in the test. The background questionnaire was given before the test begun. It included questions about their computer, orienteering sport skills etc (Appendix 2). Second, a post-test questionnaire was filled after the participants had interacted with the app (Appendix 3). The design of the post-test questionnaire was inspired by AttrakDiff questionnaire [Hassenzahl et al., 2003], and it was designed to measure different UX elements of the app. The AttrakDiff is a UX evaluation method used to study both hedonic and pragmatic dimensions of UX with semantic differentials. Hedonic qualities relate to the user's feelings and opinions. Pragmatic qualities relate to the product properties such as learnability, playability and ease to use [Hassenzahl, 2003]. Some of the questions included in the post test questionnaire are listed in the table 5 below. Refer the post-test questionnaire for more details (Appendix 3)

Statements	**Attribute evaluated**
Do you think this app is useful? Yes/no	Effectiveness of an app
Would you like to install and use this application in the future? Yes/no	Wanting to use it again
How well the compass worked? Good/worst	Perceived the efficiency of the compass which is an important feature of the app
How good was the visibility of map? Good/worst	Perceived map visibility, which is an important feature of the app
How was your overall interaction with the app? Good/worst	Ease of use
Did you feel any physical discomfort while using the app? If yes please specify.	The ergonomics of the app

Table 5: List of statements in the questionnaire to measure UX attributes

3.5.4. Field observation

Field observation is commonly used by researchers to record participant's behaviour such as expressions, responses and comments, while the participants interact with the system [Holzinger, 2005]. This method is used in usability tests from beginning to the end of the test, in order to make notes of user expectations, interaction and thoughts for the app. I acted as the moderator in order to observe the participants' behaviour and made notes.

Think aloud Think aloud is the most valuable tactic used in usability test. This mechanism asks the participant to verbalize their thoughts and actions while doing the test tasks in the usability test [Holzinger, 2005]. The tests were conducted in an open environment and participants needed to move during the test, therefore it was difficult to see or record the participant's interaction with the app. Thus, think aloud helped in knowing the user's interaction with the app.

3.5.5. Interview

A semi-structured interview allows the moderator to ask prepared questions but also provides freedom to ask additional follow up questions to encourage the participants to elaborate more on how they feel about the product [Mason, 2002]. Semi-structured interview was used in the test to learn about the participant's thoughts about the app.

Interview was conducted after participants had performed all test tasks. The interview design was based on five themes (Appendix 4). Theme 1 included questions of participant's overall view about the app. Theme 2 included questions about app features such as compass, map and reading the NFC tagged control points. Theme 3 contained questions to measure the appearance and interaction of the app, questions were phrased as: Did you find any difficulty in interacting with the app? And did you like the appearance of the app for instance the color combination, button position and content of the app? Theme 4 included questions related to participant's emotions after using the app, questions were designed to investigate factors such as fun, interest and frustration that directly or indirectly affected participant's experience. Lastly, theme 5 included a question about the participant's suggestions for improvements and additional features they want to see in future versions of the app.

The interview was audio recorded with a written permission from the participants. The recording allowed me to focus on the interview rather than on writing down the answers. This was important because the follow-up questions needed to be invented during the interview. After the test, the recorded material was then transcribed into text on paper for better understanding and analysis.

4. Results

This chapter addresses the findings from the usability test. The test was conducted according to the plan with the help of 8 participants. The details of the participants are listed in section 3.3.1.

4.1. Usability Problems

The system log was used to measure the effectiveness of the app. The system log contained data collected from the NFC Orienteering web server. It stored split times and total time for the finishing track. These data are important because they helped in identifying how many participants successfully finished the track and in what amount of time. The NFC Orienteering app saves the data from a track only until the upload phase. If not uploaded, the data are lost. This is why test task protocol included uploading all track data.

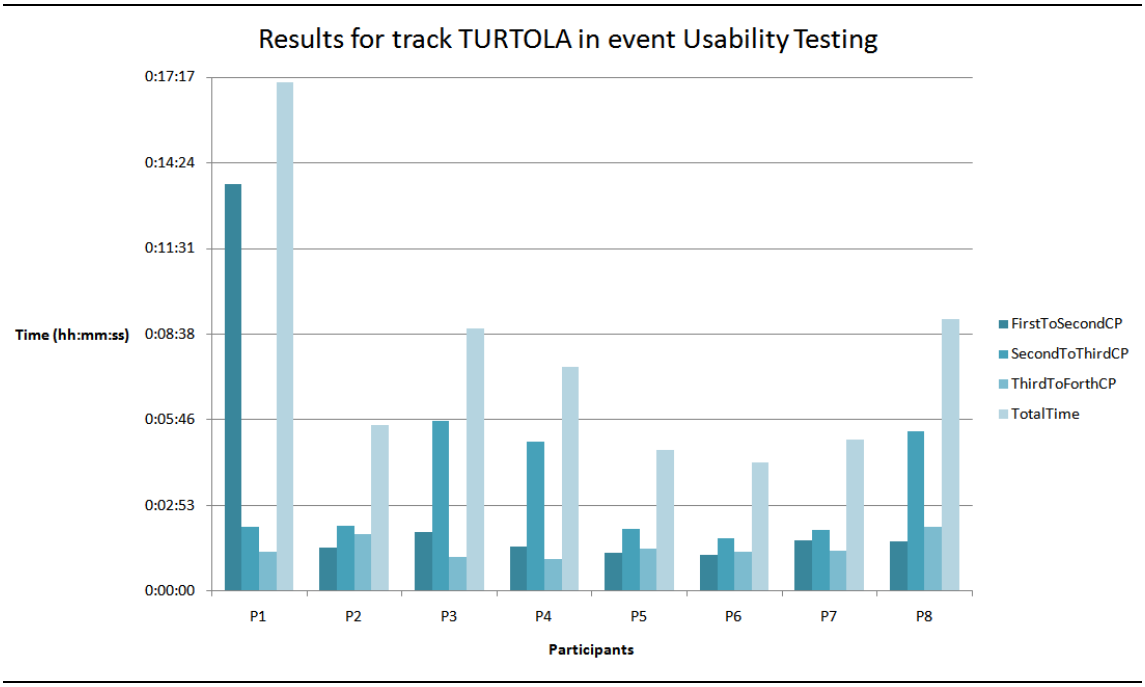

Figure 19. Bar chart with the total time and the split times for all participants.

The graph (Figure 19) shows the time taken by each participant in the usability test to finish the track. The orienteering event was named “Usability Testing” and track name was “Turtola”. The horizontal axis of the graph shows the participant id and the vertical axis represents the time. The minimum time required to complete the track by walking was approximately 4 minutes. The graph illustrates that the fastest completion took 04:17 (mm:ss) time and the slowest took 17:06 (mm:ss). The graph shows that all the participants succeeded in finishing the track and in uploading their results to web server. Detail analysis showed that those participants who had previous orienteering sport experience finished faster than those who had not competed in any orienteering

events. The graph demonstrates that P1 took three times more time than the estimated completion time, perhaps, it happens because he misunderstood the app's instructions (see Figure 9.a for app instructions).

4.1.1. Functionalities

Functionality is the tools and features in a product that provides users the ability to accomplish the goal and achieve their tasks [Cerejo, 2012]. What functions can a product do? It is usually the first thing, users look in a product [Ritter et al., 2014]. All the participants were able to finish the orienteering track and uploaded their results to the web server which shows that the app fulfils the purpose for which it was intended.

Compass: Two out of eight participants reported that the needle of the compass fluctuated a lot, which was confusing for them. Perhaps, it was because the android compass was not calibrated before on that smartphone. Additionally, P6 and P7 mentioned that they prefer other design for the compass (i.e. baseplate compass), which they are used to using for orienteering.

Get started: The landing page of the app contained instructions on how to get started. It was observed that these instructions were not enough for participant to understand completely how to use the app. One participant suggested that a more detailed, separate guide for beginners would serve the new users better. The same participant suggested that instead of only instructions in text, the guide could include images, animation and a video tutorial along with the text.

Currently, the instructions need more explanation. For example

- First instruction, "Go to the starting point of the event", all eight participants seemed confused because the app provided no clue to where the starting point was located. So all participants needed moderator help to reach the starting point. If the user does not know the starting point the user will be stuck on the second screen (Figure 9.b) which could lead to closing the app.
- Third instruction, "Read the RFID-tag located at the starting point with your phone's NFC reader". Two participants expressed that they do not know "what the RFID-tag and the NFC reader were, and how to read the RFID-tag".

Overall, there were many problems occurred due to improper instructions, and the findings helped in knowing those areas in which participants needed detailed guidance for using the app.

Load/download track's map: It has been observed that most participants liked this method of getting the map at the location of the event. The reason is that it makes the game fair and challenging. Seven out of eight participants loaded the track map without any error. Only one participant faced difficulty due to a bad internet connection.

Besides this, few participants seemed confused about how to interact with the app at this screen (Figure 10.a). P4 tried to view the map image on a bigger screen but it was not an option. Similarly, two participants used "others" button in order to choose another track, but one said "it acts more like a back button" and other said "where are the other tracks?"

Map visibility: Participants seemed to like the virtual map, because it was easier to carry than a physical map. One participant said that he liked the zooming feature better than using a magnifier on a physical map.

None of participants reported any problems in viewing the map. However, in the field observation I noticed some minor adversities: such as it is difficult for the participants to look at the control description sheet on the map as it was positioned in the left corner of the map.

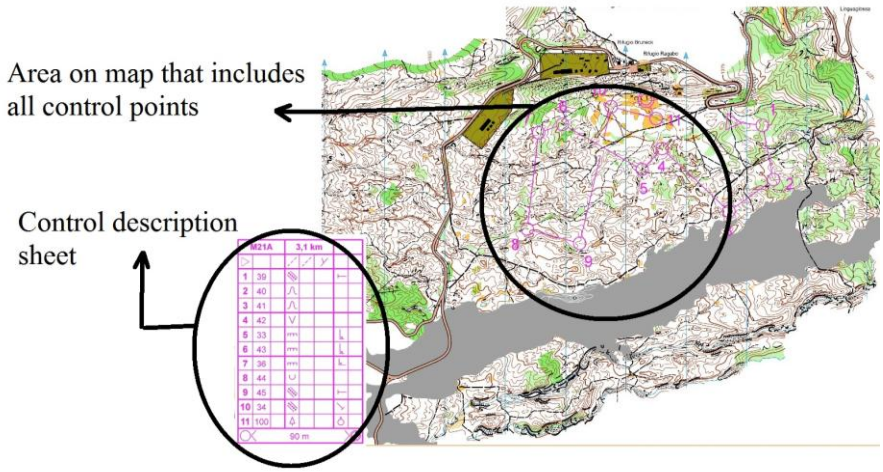

Figure 20. An orienteering map with the control description sheet.

Figure 20 shows that, participants usually focused on the area where there the control markers were, thus the control description sheet stayed unseen due to the small screen size of the smartphone. Moreover, two participants elaborated that the sun light was affecting the visibility of control markers. Perhaps, it happens because the dull color that was used to mark the control points. Moreover, the app appeared to have other usability issues, such as it was annoying for the users to turn on the screen light/lock again and again while performing the orienteering. Overall, no major problems were found in map visibility.

Punch in control: The participants found punching in at the control point to be fun and easy and enjoyed the visual and vibrotactile feedback. However, when I asked about the visual feedback in the interview, then I came to knew that three out of eight participants did not notice the visual feedback. The reason could be the small text size of the message (Figure 11.a) which appeared for very short time. Consequently, P2 recommended that instead of small text, there should be a big animation or image that appears to confirm a punch at the control.

Uploading results: All the participants successfully uploaded their results on the NFC Orienteering web server. This shows that this feature works absolutely fine. However, a minor issue was observed in the progress bar (Figure 12.b). The upload process takes four steps/screens to complete and the purpose of the progress bar is to show completion of each step. However, I observed that four participants waited for a while, because they assumed that the progress bar indicates to wait for the upload. One of them said "its (progress bar) not moving, is it an error".

View the history: A major problem was found in viewing the track history. All the eight participants reported that they were unable to view the full track record (Figure 12.d). This problem occurred due to bad user interface design. Next, three out of eight participants expressed their desire to see the leaderboard of the track which they performed. Perhaps, this is worth considering as orienteering is a multiplayer competitive sport. Majority of the participants expected to see the leaderboard instead of only their own result. P2 said "I cannot see my name in the list…where is my name?" In the same way, P8 said "what is my position?" So I replied that you need to visit this website (http://nfc-orienteering.sis.uta.fi/) to see the leaderboard of the track. Moreover, P8 informed back after visiting the website that on the website the total time was 02:17:06, whereas, he actually completed the track in 17 minutes 06 seconds.

4.2. User experience

The data derived from the post-test questionnaire helped in measuring UX factors such as effectiveness, interest, compass, map visibility and overall interaction. Participants were asked to rate each of these factors on scale 1 to 7. 1 showed worst feedback and 7 showed the maximum positive feedback whereas 4 was the neutral response.

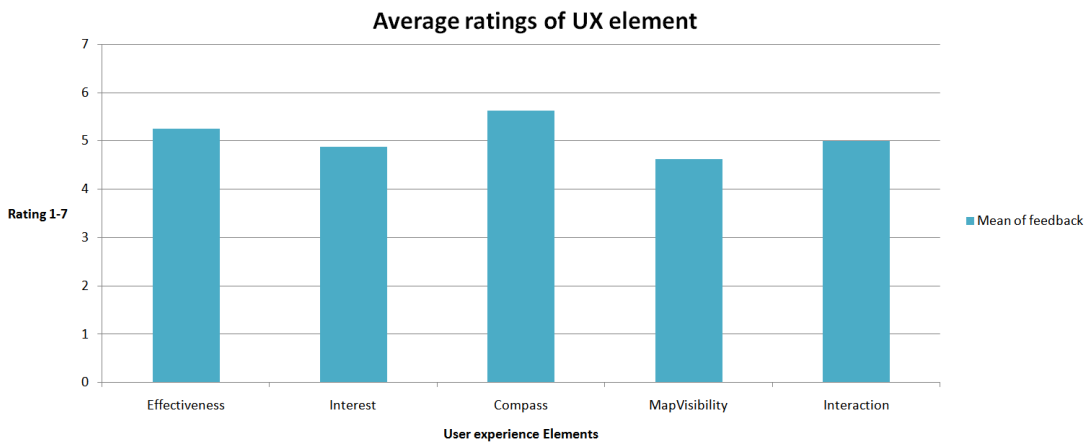

Figure 21. UX factors mean, derived from participants' feedback.

Figure 21 presents the average scales of responses for different UX factors of the app. The average rating of each element is above 4 which suggest that each participant had a positive attitude towards the app. However, because the mean of every factor is not rated close to 7, there seems to be room for improvement.

4.2.1. Effectiveness

Effectiveness refers to accuracy and completeness, error free completion of tasks is important for any product's success [Bevan, 2008]. If the product is not useful for someone then there is no purpose to bring it in the market. For that reason, there was one direct question in the post test questionnaire about the effectiveness of an app. The average response is calculated as 5 (Figure 21) which suggests that the app is considerably effective. Apart from the questionnaire, effectiveness was also measured through field observation. P5 suggested that the app could be used in schools, colleges for training beginner orienteers. Similarly, P6 expressed the opinion that the app could work fine for small orienteering events. P4 articulated that this app is effective as it removes the need of any other equipment for orienteering.

4.2.2. Fun and interest

Any exergaming app must be fun and interesting for the user. Orienteering is already a fun activity, which made measuring this factor more challenging. When the participants were asked: "do you think the app has a fun or playful factor itself?" Three participants expressed that the app is simple, and they enjoyed doing orienteering with the app. Specifically, P2 identified that viewing the track history is the interesting thing for him. Moreover, participants eagerly suggested improvements to enhance this factor. For example, P5 and P7 recommended that if the app highlighted the path they took and

allowed them to compare it to the most efficient route, this would add to the fun factor. P1, P3, P6 and P8 expressed their wish to connect the app with social media so that they could invite their friends to events and share their track records on social media. Moreover, P4 stated that he would prefer a video tutorial for instructions instead of a lot of written text.

4.2.3. Motivation

One of the purposes of this study was to evaluate, how this app can be used to motivate people to perform the orienteering sport. Participants P2, P6 and P7 acknowledged that the app could be used to attract people to orienteering because it would remove the need of any other physical equipment and thus it would make it easy for beginner orienteers to join. However, three out of eight participants mentioned that the app could have more interesting features which would increase the motivation for users. For example, participant P3 said that the app would motivate him to participate if he received notifications/alerts of upcoming events or if his track record is broken. Similarly, P4 expressed that he might do orienteering more often, if his friends participated with him in the event.

Moreover, four out of eight participants expressed the wish to search for nearby tracks in the app. It is worth considering because searching nearby tracks could save the user time by reducing the need to go far to participate in specific event. Additionally, P1, P2, P3, and P8 suggested that if the app could allow inviting friends and sharing results on social media, then this would be motivating for them and for their friends. Surely, inviting friends could help to attract more users to the application. Thus, competing with friends in this sport could enhance the user interest and motivation.

4.2.4. Frustration

The type of frustration which is being discussed in this section is the hindrances in user interface of the app that caused negative effect on user experience. It was observed that all the participants felt troubled at some stage in the test, despite of the fact that no one directly mentioned it. Most of the participants had difficulty in getting and understanding the instructions to get started. For example P4 said “I don’t know what to do next” when he was supposed to read the NFC tag in front of him. P5 and P7 reported that the screen turned off again and again during the test, which was frustrating. Overall, the participant who had orienteering skills did not report many difficulties as they knew the basics of orienteering rules and standards. On the other hand, participants with no orienteering experience struggled a lot with understanding the orienteering map, the descriptive symbols and orienting the compass.

4.2.5. Aesthetics and Ergonomics

Participants reported that the design looks fine and none of them suggested major changes. However, some participants expressed that the layout can be improved to look more appealing. Additionally, one participant said that the color combination is not appropriate as it is difficult to read the text on a bright sunny day.

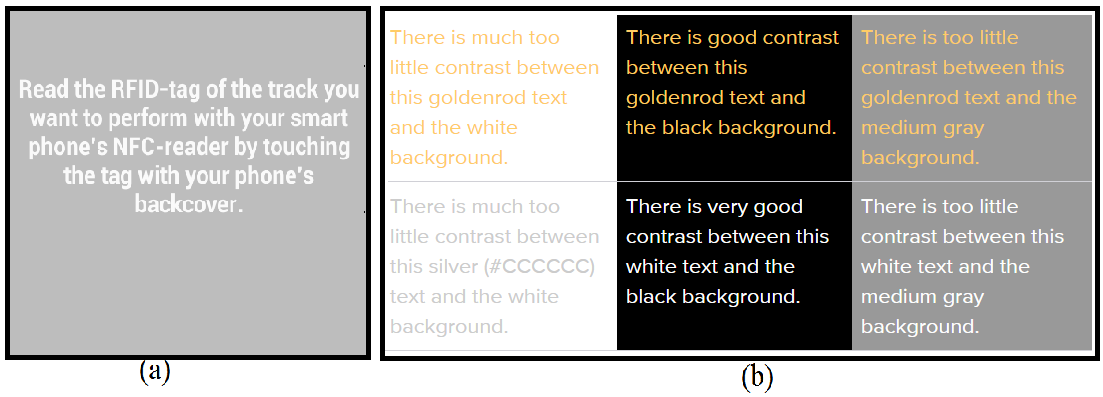

Figure 22. Contrast of best color combination (a) Color combinations of NFC Orienteering and (b) color combination for better visibility [Pabini, 2007].

Use of an appropriate color combination is very important for the app that is built to be used outdoors. Black text on a white background is shown to be the best color combination for user interfaces that are mostly used in sunlight [Pabini, 2007].

5. Redesign

The evaluation helped to pinpoint problematic areas of the app. The results showed that the user expectations from the orienteering app are somewhat higher than just doing basic operations that are required for orienteering. Moreover, testing of the app with real users refines the true user needs of NFC Orienteering.

5.1. Analysis and modeling of user data

The collected data was interpreted immediately after all the usability tests were conducted (i.e. within 1 week). For redesign, I followed the user centred design approach. In the analysis phase I drew a consolidation of sequence model, interaction model and data flow diagram derived from user evaluation data. This helped me to understand the user needs and the flow of the activities in the app.

5.2. Redesign approach

The purpose of redesigning is to remove the flaws and usability problems from the former design and to improve UX. In this section, the proposed changes will be discussed. The app gave satisfactory results for basic operations; therefore, the whole app does not need to be redesigned. Only the problematic part is going to be redesigned, whereas other things are kept the same as they were in the previous design. Moreover, the interfaces for most demanded features by the participants will be designed according to user expectations. The android design principles and guidelines [Android, 2016] were followed in the design process to enhance the user experience of the app.

5.2.1. How to get started

In the former design, the landing page was mainly covered with the text instructions along with two buttons at the bottom, which were not visible without scrolling in small screen devices. However, in the new design, position of buttons is changed to centre and the text instructions are replaced with an additional “guide” button. It has been analysed that the instructions in previous version were not sufficient for novice user to start the orienteering track. The things listed below need to be explained in “guide” section.

- How to start the event using an app.
- Video tutorial simulating the whole process.
- Explanation of map descriptive symbols.
- How to calibrate an android compass.

- Explanation of an orienteering map and a compass usage.

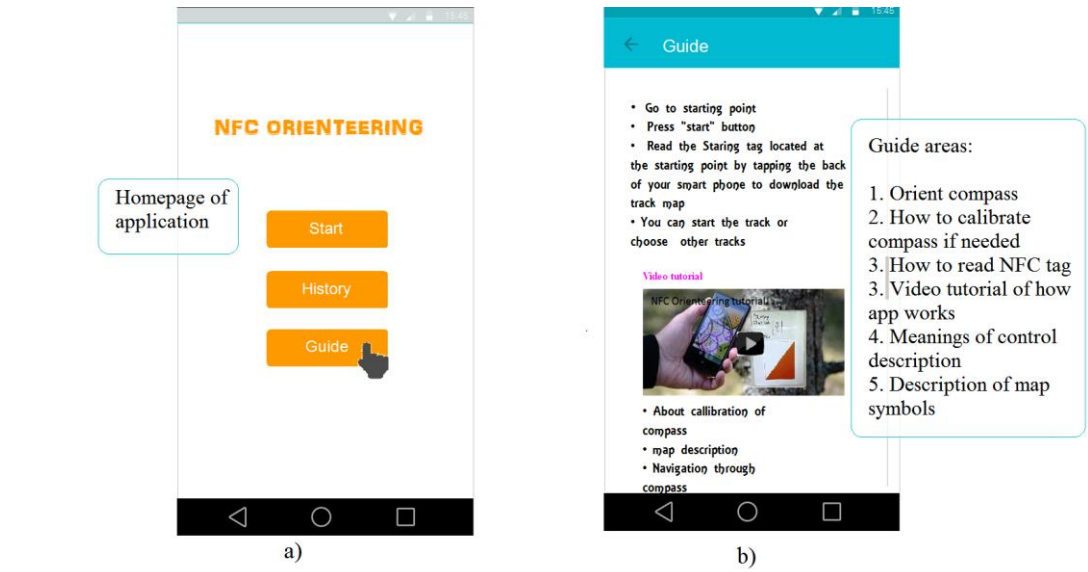

Figure 23. How to get started: (a) landing page of an app and (b) user guide.

5.2.2. Search tracks

Participants reported a major problem in getting the track data. There was no option in the previous version where the user could be notified about upcoming events or available tracks. Moreover, the user was not even able to search for the nearby tracks. Therefore, in the new design this problem has been resolved by providing interfaces for a database of available tracks and upcoming events. The interface for the track database has been designed in such a way that the user can search for nearby tracks and upcoming events. This would allow the users to see the track information from anywhere and choose to do a specific track even without leaving their homes.

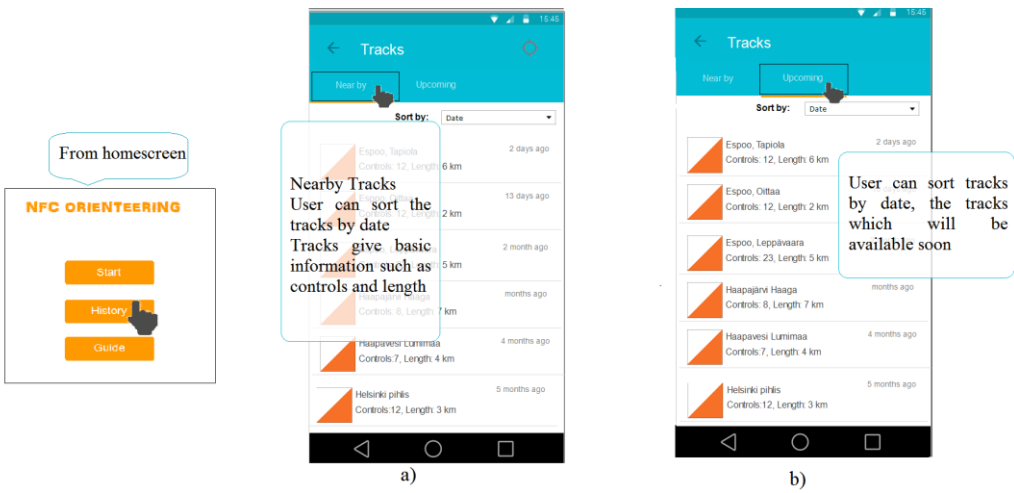

Figure 24. Search Track: (a) Nearby tracks and (b) upcoming events.

Implementation: Searching for tracks could be implemented in two ways. One is that the user selects his city or town and the app would show tracks that match the search filter. On the other hand, the app could show nearby tracks based on user location. Moreover, for upcoming event/tracks the app needs to display all tracks that have an availability date greater than the current date.

5.2.3. Getting a map of orienteering track

In the above section, it was explained that in the new design users can search the tracks from anywhere using the app. However, in order to make the competition fair the user would be able to access the map in full screen with control markers only at the starting point of the event. Thus, this feature would work similarly to previous version, except that the track detail would be accessible from anywhere. Moreover, due to participants wish to invite friends for events an additional feature of friend invitation interface is introduced in the new design.

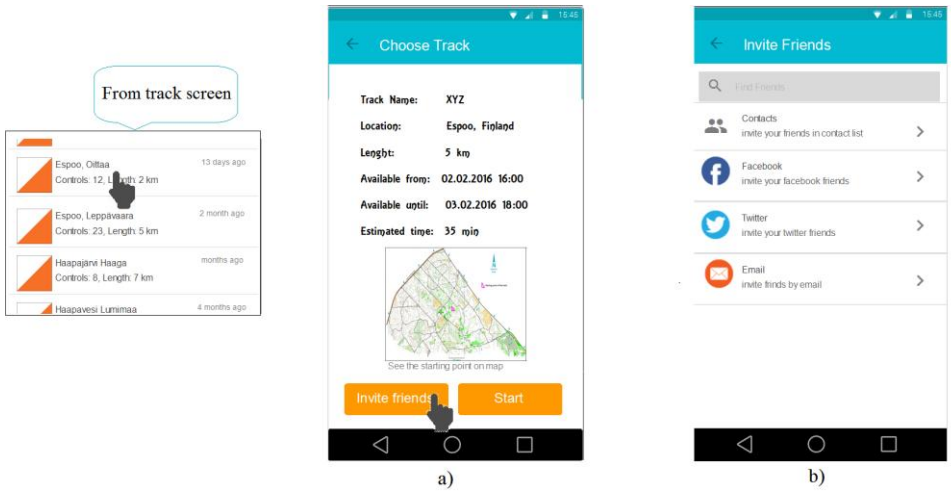

Figure 25. Getting a map of an orienteering track: (a) Track details and (b) to inviting friends to an event

Implementation: For the track detail screen (Figure 25.a), first I thought to add map image with no control markers but only the starting point of event so that the participant could reach it easily. However, an alternative would be that the organizer would give the GPS coordinates of the starting point so that the participants can use any navigation app they happen to have to navigate to the starting point (this can happen e.g. through a URL into Google maps).

Moreover, Facebook SDK for android allows other apps to login to the app through facebook credentials. This allows other apps to automatically receive a user's basic

information such as name, location and friends list. Thus, Facebook SDK for android could be used to login to the app and to send invitations to facebook friends. [Facebook SDK, 2016]

5.2.4. Starting the track

In former app design, the control description sheet was located in left bottom corner of the map (table in Figure 26.b placed on map is called ‘control description sheet’). It was observed that the users faced trouble seeing the control description sheet. Therefore, in the new design a small button on the upper right corner has been proposed for easier access of control description sheet. Actually, this idea was derived from MOBO app that uses the same techn1ique.

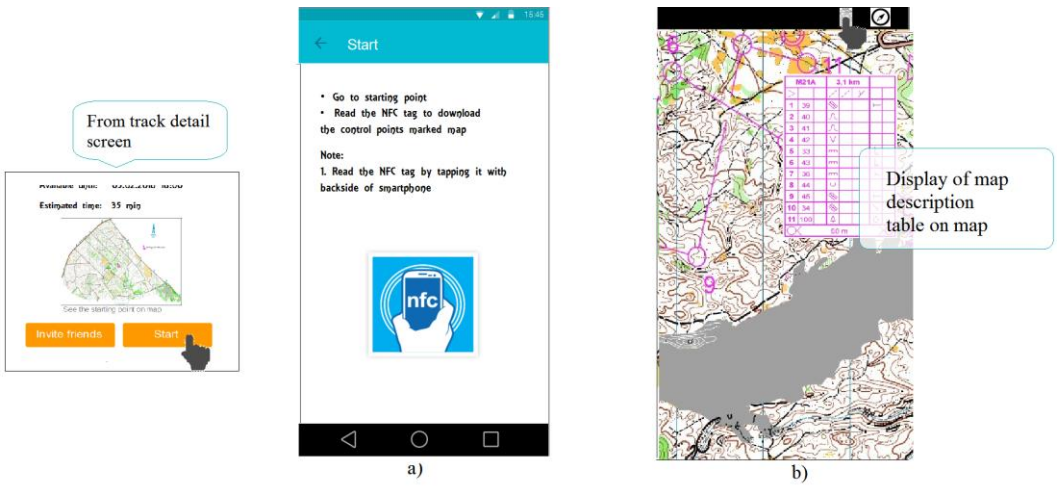

Figure 26. Starting the orienteering track: (a) Read the info tag to load the map and (b) button for control description sheet

Implementation: For displaying the control description sheet separately, there would be a need of separate entity in track database. This would increase the work of organizer because organizer would need to upload the control description sheet of map separately.

5.2.5. Orient the compass

A simple compass design was used in the former app design (Figure 11.a). It worked fine for the short track of 500 meters in the usability test. However, in the orienteering sport, orienteer need the compass only to estimate the direction, with the help of magnetize needle that points toward north. Then, orienteers use the map and the terrain to follow the correct path. Orienteers have their own preferences of compass type. Two participants expressed their wish to use a baseplate compass design which they are used to using.

The important difference between a baseplate compass and a simple compass is that, the baseplate compass contains a rotating bezel with orienting lines. The rotating bezel allows orienteers to set a guide of arrow to keep an exact angle in relation to north.

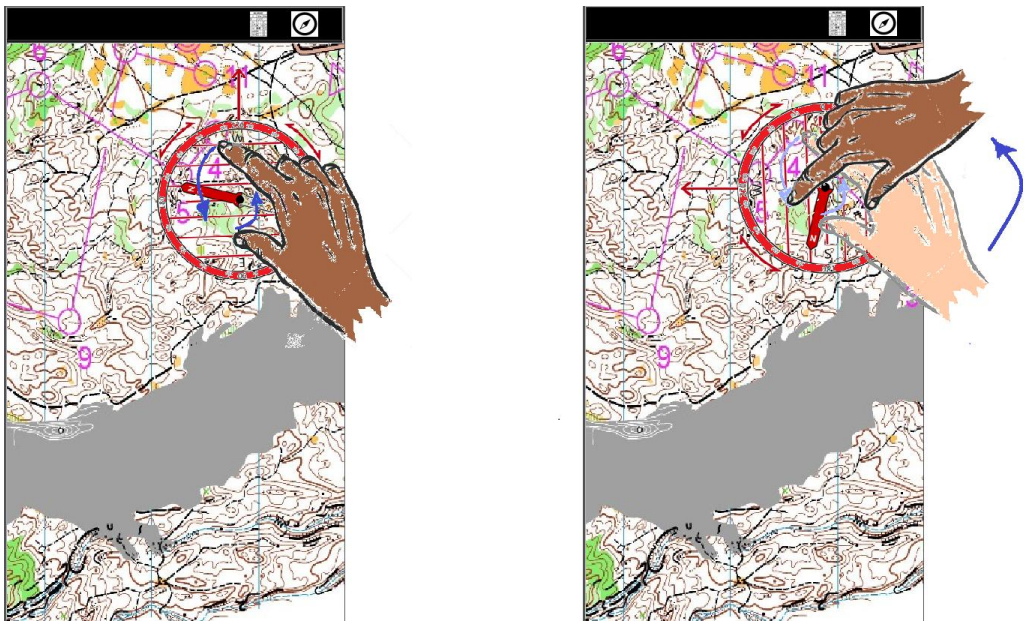

Figure 27. Orient the compass: (a) Android baseplate compass design and (b) adjusting the direction of rotating bezel in relation to north

Implementation: First of all, in the new compass design one goal was to block less of the map. Secondly, I tried to make the compass design similar to a baseplate compass. Fortunately, android has several types of orienteering compass designs available. The VO compass (virtual orienteering compass) is an example of android orienteering compass. The VO compass design can be used in the app, as a substitute of the simple compass design.

5.2.6. Upload Result

In the upload process, a few minor changes have been proposed in the new design. Overall, the upload process remained the same. The participants wished to see the leaderboard of the track instead of just their own the results. Thus, in the new design when the users upload the track result they can view the leaderboard of the track. In addition, a victory image is added along with the text “track completed successfully” to create the feeling of success and accomplishment for user.

Moreover, the progress bar for upload has been removed in the new design because it confused participants. Additionally, a new feature for sharing results on social network has been suggested in the new design (Figure 28.a). Other minor changes include changing the content and labels of buttons to create more sense of signifier.

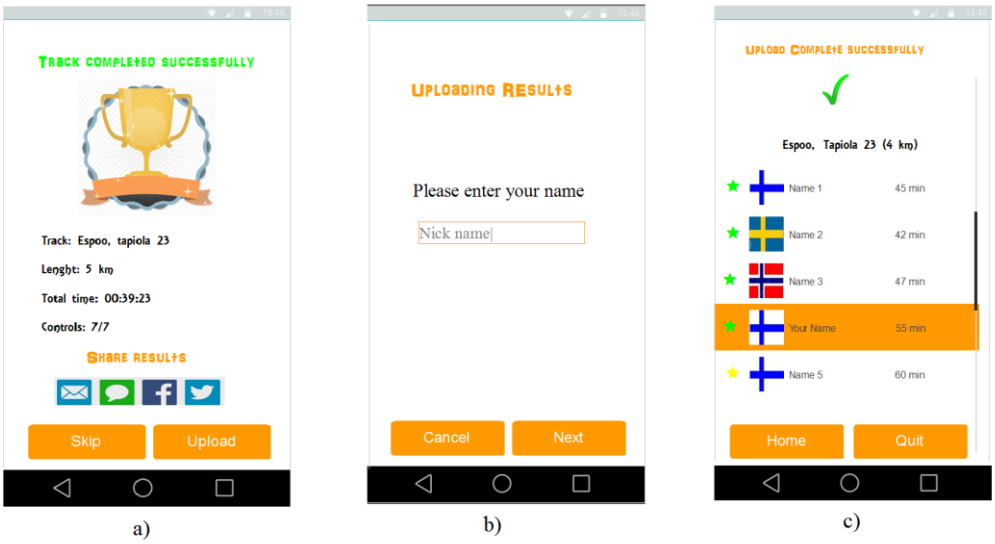

Figure 28. Uploading of the results: (a) The track completion screen, (b) add a name for upload and (c) upload completed with leaderboard of track.

5.2.7. View the result

In the previous design, the user was only able to view own track record in the app and in order to view the leaderboard the user needed to visit the website. In the usability test, the participants expressed their wish to view the comparative results of the track instead of just their own result. Moreover, there was a visibility problem in viewing the results.

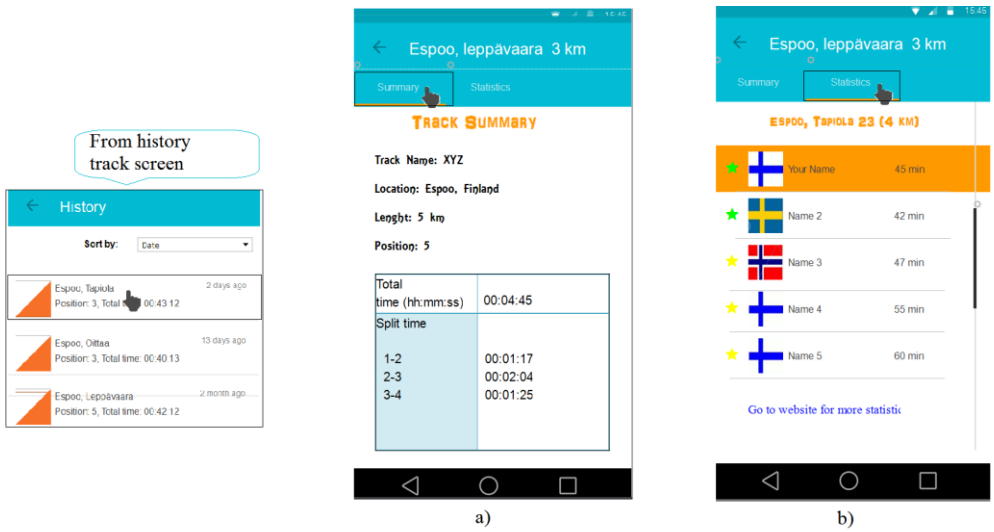

Figure 29. Viewing the history: (a) Summary of completed track and (b) full statistics showing leaderboard.

Implementation: The error in viewing the record occurred due to bad user interface code. Perhaps, the user interface code has the table with fixed number of rows and columns. If the code includes a ‘while loop’ then this problem can easily be solved. While loop is a control flow statement that allows code to be executed repeatedly based on condition.

Moreover, there are two solutions for showing leaderboard of the track to user. First is to display the leaderboard in the app as shown in Figure 29.b. For implementing this method, the app needs to retrieve the track results from web server to display an up-to-date result. However, the issue is that the leaderboard may not be completed when the user finishes his or her track. Therefore, they may want to return to the leaderboard later and update it to see how their position in the “race” develops as more people complete the track.

An alternative implementation for the leaderboard in the app would be to have a link that would open the server-generated result list in a web browser. This method is easy to implement and the other benefit is that it would prevent the app from using more memory on the smartphone. Hence I would recommend this implementation rather than showing the result within the app.

6. Discussion

The mobile app use for various purposes has increased rapidly during the last few years [Xu & Wei, 2013]. This trend raised the user expectations for doing this kind of sport with mobile apps. The test results showed that the majority of participants liked the app and found it useful. The participants liked it because it reduced their expenses for buying other pieces of equipment to participate in orienteering. Moreover, the participants eagerly provided suggestions for improvement and the other features they wanted to see in future version of the app. This showed their interest in the app.

As mentioned earlier this thesis is a part of the developmental process of the NFC Orienteering system. The application was not tested before with its targeted users. Therefore, first of all I decided to test the app with its targeted users in real context of use by organizing a short orienteering track of 500 meters. The primary goal of the test was to check the effectiveness of the app: "how effective the app fulfils the orienteers' need?" Moreover, the test also involved measuring some UX elements of the app. All the participants were able to finish the track using the app. This showed that the app fulfils the basic operation required for orienteering. Apart from the participants' interest and positive attitude towards the app, the test results helped in identifying many usability problems.

The results revealed that the app is too simple in its working and participants suggested the need of more complex and interesting features. Perhaps, these users' expectations come from previous experiences of using the various mobile apps. For example, a few participants suggested the facebook account connectivity, so that they can invite facebook friends for orienteering and share the achievements on their facebook profile. Facebook grants permission to other apps to user facebook credentials for retrieving user's profile information and use it to login in to those apps.

Moreover, the test results revealed that the former design had some severe usability problems that occurred due to the restricted accessibility of tracks. The app provided no means to get the track details unless user was present at the event location and loaded it by reading the 'track info (NFC tag)' placed at starting point of the track. In other words, the users were unable to search the tracks by themselves or receive any notification of available/upcoming events through the app. Most likely, this would make it hard for user to reach the event location without any external source of information. User from home can do nothing with the app except to check the history of his performed tracks. Therefore, I concluded that the app needs to be redesigned according to true app user requirements rather than following the conventional way of doing orienteering. As far as the solution is concerned, I tried to remove those limitations by allowing user to search the track details from anywhere.

Some other problems occurred due to the lack of proper instructions provided by the app. First of all, four out of eight participants seemed to be struggling with reading the NFC tag. This happened because those participants had no previous experience of NFC technology in this way. Secondly, participants with no previous orienteering sports experience faced problems in using the compass and also in understanding the orienteering map. Obviously, these problems usually occur with beginner users, but the study helped in identifying the areas in which beginner orienteers need training. Undoubtedly, one purpose of the app is to attract the beginner orienteers and to provide them the basic training of orienteering sport through the app. Fortunately, orienteering is easy to learn for beginners, all they need is to learn a few techniques to begin orienteering. This can be done by using the app. However, a user can refer to the NFC Orienteering website for more extensive training. Moreover, it was observed that there is a need of separate section for user guide in the app.

My results indicated that some things were misleading for the participants, for example reading 'RFID-tag' meant to be NFC tag (Figure 9.a), 'others' button literally acted as a back button (Figure 10.a), progress bar while uploading the results confused the participant and the track result (history) shows only participant's own result and not the leaderboard of the track. Moreover, the history of the track was not clearly visible due to the bad UI design. It seems that these problems need minor fixing in the coding, which would then lead to good user experience. Despite these user experience problems, overall participants liked the app and expressed their wish to use a better version of it in future. Therefore, it would be worthwhile to develop this app further and address the existing problems. This research finding could also be useful for other similar sports applications and specifically for the other orienteering apps.

6.1 Limitations

This study had some limitations. The tests were conducted outdoors and they included the physical movement of the participant. Therefore, it was difficult for me (moderator) to record or even see the user interaction with the app. Thus, the study assumes that participants were honest in their feedback. Moreover, this study cannot guarantee that all problems have been identified or that fixing the problems according to redesign proposed in chapter 5 will make the app ready for launch. However, the study clearly identified major problems that will definitely be useful to consider for app's further development.

A thing worth mentioning here is that this thesis did not measure the whole user experience of the app, but only few user experience factors. However, in future work

the test plan could be designed to measure the whole user experience of the app. However, this requires further development or at least fixing the most severe problems.

Another limitation of the study is that it did not focus on the evaluation of methods for generating income through the app. However, there are different ways listed below, the owner of this app can consider.

- The app can generate recourses by asking user to pay for each track map or subscribe for monthly packages.
- The app can be used by different orienteering clubs and thus they would be responsible for providing services and generating recourses to organize the events.
- Additional income can be generated by In-app advertisements. Wide range of apps relies on third party advertisement service for income.
- Paywalls (Subscriptions): this method allows users to view and use some content for free and then app ask for subscription to get paid content. For example, this app can offer some tracks of longer availability (15-30 days) for free and charge for participating in specific events.
- App sponsor: Sponsors can help to generate a bit of revenue. This works in a way that company would be willing to sponsor the app in return of the marketing of their brand name in the app.
- Third party involvement: In this method, the app developers get paid by third party for minutes of use. Most of the mobile gaming app relies on this method to generate resources. This approach requires a third party with a revenue stream from the app.

6.2. Conclusion

This thesis measured the user experience when technology is implemented for traditional sport. The focus was on measuring the user experience of one such app. This study is part of the developmental phase of the NFC Orienteering app. The app would allow user to perform orienteering without the need of any physical equipment (i.e. a compass, a map and an electronic control punch device). Moreover, the app intends to reduce the organizers effort, time and resources they spend in organizing the orienteering event. In this thesis, I conducted a usability test with the app’s target users in real context of use. The test helped in finding the problematic part, which helped me to redesign the poorly working parts for improvement and discuss the future work and user expectations from the app.

Positive responses of participants showed that the app has large acceptance rate. The participants with no previous orienteering experience seemed interested in the app and reported that it is easy to use as there was no other physical equipment required. On the other hand, participants who had previous experience in orienteering seemed more exited and interested in the app and discussed eagerly about future improvements and suggestions.

Majority of the participants showed interest in using the app again. However, one out of eight participants said that he is sure that he would not download and use it in future, because he said that he is not really a technology person and does not like to download such apps. Moreover, the participants described different reasons for their motivation to use the app such as P2 said “I would use it more often if my friends would participate with me”, P3 said that “I would like to use it to explore places near me”, P3 expressed that he would prefer to perform the tracks only if they are near to his location.

Overall the study showed that the app can be used to replace the conventional way of doing orienteering. Undoubtedly, it has capability to reduce the effort and time for organizing the event. However, the current prototype is not good enough to provide complete user experience. This thesis helped in identifying the true user requirements and expectations for the NFC Orienteering. Thus, I recommend considering the problems and their solutions proposed in this thesis to help in enhancing the user experience and user satisfaction level.

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Appendix 1

CONSENT FORM

Date: ___ /__ / 2016 Participant number: _____

Description

You are invited to participate in a usability test, in which you will need to interact with the NFC Orienteering app, by performing small orienteering event of 100 meters. By participating in this test you will help us to evaluate the user experience of the NFC Orienteering app.

You will be asked to perform different test tasks using the app and to think out loud while doing the tasks. In addition, I will ask you to fill in post-test questionnaire and I will interview you about the use of the application. The interview part will be audio record to analyze the answers later on.

Duration

Conducting the test will take approximately 30-45 minutes.

Participant rights

All the data collected during this test study will be handled anonymously. The participation is voluntary, including that you have the right to withdraw your approval at any time without bearing consequences.

By signing this consent form I agreed to participate in the usability test and understood that there is no monetary compensation for participating. I also understood that my participation is voluntary and I am entitled to refuse to participation or stop the performance at any time without any consequences.

SIGNATURE _____

DATE AND PLACE _____

Appendix 2

BACKGROUND QUESTIONNAIRE

Date: ___ /__ / 2016 Participant number: _____

The purpose of this form is to collect some basic information about you and also some specific information about your familiarity with mobile application interaction. The information is stored anonymously so that it cannot be used to identify a specific participant.

1. **Age _____**
2. **Gender**

[ ] Male [ ] Female

3. How do you evaluate your computer skills?

[ ] Excellent, I understand how computer functions

[ ] Good, I use computer fluently

[ ] I can use basic functions such as email

[ ] I am a novice in computer use

[ ] I don't understand computer at all

4. How often you use mobile applications for different purposes?

(*For example: Netflix, Spotify, WhatsApp, Run Keeper, etc.)*

[ ] I do not use them

[ ] I use them rarely *(2-4 times in a month)*

[ ] I use them occasionally *(few times in a week)*

[ ] I use them frequently *(daily)*

[ ] I don't know

5. How often do you participate in physical sports?

(*For example: Football, ice hockey, skating etc.)*

[ ] I do not participate

[ ] I participate rarely

[ ] I participate occasionally *(1-2 times in a month)*

[ ] I participate frequently *(2-5 times a week)*

[ ] I don't know

6. How many orienteering tracks have you performed?

[ ] I never performed any orienteering track.

[ ] I performed few tracks (please specify ____)

[ ] I performed many tracks (please specify ____)

[ ] I don't know

7. Do you use GPS tracker to track location?

(*For example: google maps, GPS tracker, offline maps.)*

[ ] I never used

[ ] I use very rarely

[ ] I use very frequently

Appendix 3

POST TEST QUESTIONNAIRE

Date: ___ /__ / 2016 Participant number: _____

Answer the following questions on the basis of your previous experience with app.

1. Do you think this app is useful?

	1	**2**	**3**	**4**	**5**	**6**	**7**	
No	☐	☐	☐	☐	☐	☐	☐	Yes

2. Would you like to install and use this application in future?

	1	**2**	**3**	**4**	**5**	**6**	**7**	
No	☐	☐	☐	☐	☐	☐	☐	Yes

3. How well a compass worked?

	1	**2**	**3**	**4**	**5**	**6**	**7**	
Worst	☐	☐	☐	☐	☐	☐	☐	Good

4. How well was the visibility of map?

	1	**2**	**3**	**4**	**5**	**6**	**7**	
Worst	☐	☐	☐	☐	☐	☐	☐	Good

5. How was youroverall interaction with app?

	1	**2**	**3**	**4**	**5**	**6**	**7**	
Worst	☐	☐	☐	☐	☐	☐	☐	Good

6. Did you feel any physical discomfort while using the app?

[ ] No
[ ] Yes, please specify

_____

7. What did you like most about the app?

_____

_____

8. What did you like least about this app?

9. If you want to add something in this app what it could be?

10. Any general comments?

Appendix 4

INTERVIEW STRUCTURE

Date: ___ /__ / 2016 Participant number: _____

Theme 1: General question about application

1. What are your thoughts about NFC Orienteering application in general?
2. Any suggestion to improve the application

Theme 2: Application feature

1. What was the difficult level of orienteering, by using map and compass of an app?

2. Did you feel the application acted as you expected? (Wait for participant response before asking "If not, please explain.")

3. What difficulties you faced when oriented between one check points to another?

Theme 3: Appearance and interaction

1. Did you find any difficulty in interacting with application?
2. Do you like the overall appearance of application for example color, buttons, text etc?

Theme 4: Emotions

3. Do you think this application can motivate people to participate in orienteering event?
4. Is there anything which made you feel frustrated while using the app?
5. Do you think application has a fun and playful factor?

Theme 5: suggestions

6. Any suggestions or additional features you want to add for improvement?

Appendix 5

USER STUDY SCRIPT

1. INTRODUCTION

Thank you for your willingness to participate in the usability test. My name is ____. If possible, kindly read the test instruction given below before the test, so that on the test day we will start the test right away. Please ask me if you will have any questions.

Location of test: Martinpojankatu 3, Tampere

2. PURPOSE OF THE TEST

The usability test is part of my master thesis of Human-Technology Interaction. In the test, you will need to interact with NFC Orienteering app by performing small orienteering event of 500 meters. App is already installed in the smartphone which will be given to you.
The purpose of the usability test is to evaluate the user experience of NFC Orienteering app. Usability test is a method to measure efficiency, effectiveness and user satisfaction of the product.
I need to point out one thing, that the usability test is not about testing you but the system. However, your role is important as you will come to help me to test the NFC Orienteering app. If you encounter some problems during the test you shouldn't get confused, because finding problematic parts in the system is just what the test is aiming at so your honest feedback is extremely important for the success of this study.

5. BACKGROUND QUESTIONNAIRE

I will need to collect some of your background information. However, the data will be kept anonymous, so that it cannot be used to identify any participant.

3. TEST PROCEDURE

In real scenario, you could use your own NFC enabled smart phone. However for the study we would use Samsung galaxy S3 mini mobile phone.

The application would be used to perform orienteering event, the app is aiming to remove expensive equipment used in orienteering event. This application includes a map and a compass which you can use to orient your path.

The test will involve three activities:

- Test Tasks, where you will be asked to do certain tasks using the app.
- Questionnaires, to let us know what you think about the system in general.
- Short Interview, so you can give your thoughts in more detail.

As the test is conducting in semi urban area, be aware of the traffic, bikes and pedestrians.
You can stop participating in the test at any time and for any reason and you do not have to explain the reasons why you quit.
Also if some task feels difficult and you no longer want to keep on doing it, please tell me and I might give a small help or maybe we can move on to the next task.

THINK-ALOUD

I want you to think-aloud during first part of the test, which will include few test tasks.
Think-Aloud means that you speak out what you are thinking when doing a specific task.
I can elaborate with an example on test day if you do not know how it works.

PERMISSION TO RECORD THE TEST

Only the interview part will be going to audio record, in order to analyze each answer in more detail.

The recorded material will be used only by me and it will be discarded after analysis.