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Developing Software for Motivating Individuals with Intellectual Disabilities to do Outdoor Physical Activity

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ABSTRACT

People with intellectual disabilities (IDs) often have a sedentary lifestyle that can lead to long-term issues like cardiovascular diseases, diabetes, obesity and depression. Few games and apps promoting physical activity for people with IDs exist, and they do not have a focus on the motivational aspect. This paper aims to find how to develop software that can motivate people with IDs to do physical activity outdoors. For this purpose, we have followed a design and creation research strategy using several qualitative methods such as semi-structured interviews with health care workers, special education experts and software engineers; a focus group with occupational therapists, physical therapists and software engineers; and a preliminary pilot user test with 3 users and 2 caregivers aiming to a test of the software on the field and at the refinement of its specifications. Having social interaction during the physical activity turned out to be a major motivational aspect of the system, whereas rewards systems did not attract much of the users' attention. Regarding the adapted navigational assistance, easy-to-read text, visual communication and street-level pictures were the key features to achieve successful and understandable guidance outdoors for people with intellectual disabilities.

CCS CONCEPTS

• **Social and professional topics** → **Cultural characteristics**; • **Human-centered computing** → *Empirical studies in interaction design*; • **Software and its engineering** → *Designing software*.

KEYWORDS

Intellectual Disability, Physical Activity, Outdoor navigation

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1 INTRODUCTION

The established methodologies and practices of Software Engineering have widely proved on the field their validity, utility and applicability, and are nowadays commonly used in software development [3] [4]. However, the emergence of the Internet of Things and mobile, cyber-physical technologies brought the software systems more integrated with the hardware and closer to the end users. This fact changes the perspective in software engineering, making it also dependant on several user-related aspects like acceptance, usability, ethics, common practices of the application domain, etc.

An interesting example is given by the development of e-health applications. These applications address a wide range of stakeholders ranging from medical specialists to insurance companies, public health systems or patients, relatives, etc. They may drastically change the established medical practices (and thus require a validation of the new practices and approval from ethical committees and/or follow existing laws and regulations), use cyber-physical devices (and thus include aspects of hardware design) and, on the software side, keep all the complexity of any other (complex) software system that thus require the application of the best software engineering methodologies.

In this context, we describe the experimental development of a software (an Android exergame) designed for people with Intellectual Disabilities (IDs), which aims at motivating their physical activity. This software is motivated by the fact that physical activity is, in general, associated to health benefits, while its lack can lead to different health issues, like cardiovascular disease, diabetes and cancer [13]. At the same time, many adults with IDs have a sedentary lifestyle, as concluded by several studies [11, 12]. In particular, [2] observed that only 9% of people with IDs reach the recommended amount of physical activity while Queralt et al.

[8] found that 50% of the physical activity for adolescents with IDs came from the time spent at school and that girls were less active than boys. The barriers that prevent people with IDs to have a proper physical activity include accessibility, cost of equipment, supervision, personal health, feeling lazy, the general preference for sedentary activities, but also social factors such as feeling that other people prevent them from doing it [11]. However, the same studies also highlighted that many people with IDs enjoy several activities like dancing, walking, bowling, training with weights etc. [11], and that is important to associate physical activity with fun, music or goal-oriented games [7]. At the same time, however, very few studies address the design of exergames for people with ID.

For this reason, and considering that walking is one of the activities mentioned as most enjoyable by people with IDs [11], we focused on the design of an Android-based exergame that is fun and easy to use to motivate users with IDs to go on hikes. The design of this experimental application led us through a software engineering process exposed to many of the above mentioned challenges, including the interaction with people with IDs and the other stakeholders for the requirement elicitation, the design within a framework determined by ethical constraints, and the design of a preliminary pilot study aimed at testing the exergame in a real condition to pave the way for a subsequent large scale experimental study for the general validation of the methodology.

Thus, the main contribution of this work is a working prototype of the exergame that helps motivate users with IDs to do hikes, and, from the software engineering perspective, an example of a practical engineering methodology that takes into account specific requirements and constraints of the e-health domain.

The main research question for this project is: *How can we develop game-inspired applications that motivate young adults with intellectual disabilities to do outdoor physical activity?*. The question has been specialized into *How can we design navigational assistance systems for young adults with intellectual disabilities?* and *What is important when designing games and applications for young adults with intellectual disabilities?*.

The paper is organised as follows: we present the research methodology including the design process and the pilot tests in Section 2 and the prototype as the main result in Section 3. Finally, Section 4 draws the conclusions and the future work.

2 RESEARCH METHODOLOGY

We follow a design and creation research strategy [5] with a strong multidisciplinary component that includes several data generation methods. At the center, there is the creation of an ‘artifact’ that is refined and improved after each phase. The ‘artifacts’ is a mobile app to motivate people with IDs to do physical activity. Our process includes (Figure 1): (a) a literature review and semi-structured interviews with domain experts to create the first version of the prototype, (b) a focus group to refine the working prototype and (c) a pilot user study and group interviews to further refine the prototype.

2.1 Participants

The “Outdoor Life Organization for the Disabled” arranges outdoors events all over Norway adapted for people with intellectual IDs

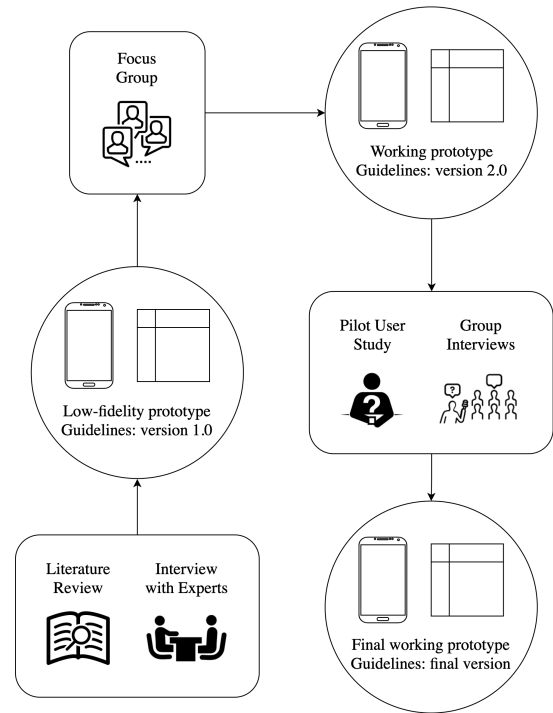


Figure 1: Design and Creation Research Strategy

and exploits an app developed by Smart Cognition to inform about these events. The nurse specialized on IDs was included due to her expertise in the organization of hiking trips for people with IDs and is currently part of a team hosting outdoor events for people with IDs in Trondheim through the “National Association for People with Intellectual Disabilities”. She was initially contacted about one of these outdoor events she was hosting and was later interviewed in one of the expert interviews. People from Smart Cognition and Trekking Association are experts in leisure activities platform for people with intellectual disabilities using artificial intelligence and machine learning. Experts from NTNU and UNN were included as experts in IDs and rehabilitation.

Concerning the composition of the focus group, the physical therapist was selected for her experience with people with IDs and her interest in physical activity and hiking. An occupational therapist was included as she works at a day center for people with IDs and has a lot of experience with the user group. Researchers from NTNU participated as experts in application development for people with IDs.

The Pilot User study on the prototype in the third step was carried out with 3 individuals with IDs aged 16 - 35 years and 2 caregivers. They mostly have moderate level of IDs, but many also have additional diagnoses like autism or related to mental health. The pilot test, which was aimed at a general test of the software, included two hiking events that were followed by group interviews. Both hikes and interviews were carried out by the same group of people with IDs and caregivers. The caregivers were included to mediate the interaction between the technologists developing the software and the users with IDs. In particular, they provided the

ability to interpret the answers and the users feelings better than an interviewer new to the user, and to make the users feel safe at new settings.

2.2 First step: Interviews with Experts

We performed five interviews with experts on IDs, physical activity and digital systems. They were semi-structured, in order to make it possible to ask follow up questions if something was unclear or the question was misunderstood. The questions were written to be as open ended as possible and to give the participants the opportunity to add their own opinions.

The interviews were also designed to shed light into how these types of outdoor events are organized. They asked for information about the life of people with IDs and the people around them, including both caregivers and families. The questions were divided into four main categories: General questions about games for people with IDs, questions about motivation for exercise for people with IDs, questions about navigation for people with IDs and questions about designing games for people with IDs.

2.3 Second step: Focus Group

A focus group session was carried out to quickly get some feedback from experts before testing the game on users. The goal was to find improvements for the app. We had 6 participants. They had different backgrounds, which led to a multidisciplinary discussion about the app. The event was scheduled for 1 hour: 15 minutes for introduction and 45 minutes for presentation of the current work and discussion.

2.4 Third step: Pilot User Test

As shown in Figure 1, the prototype was reworked in order to be tested with end users. This prototype was a working mobile app. This testing with end users was an empirical investigation including people with IDs, who used the proposed game. This investigation looked into what the users think about this type of game. In order to gather data from the users, observations and interviews were used. The players were observed when playing the game and interviewed after the trial session. Each interview was done with a caregiver accompanying the user. The caregivers that participated in the user tests were also interviewed afterwards to fetch their opinion on the test session, how they thought the app worked in practice and what they thought the user felt about the app.

The interviews done after the user test were unstructured and the questions were based on the earlier user test. The interviews that took place in Trondheim were done in person and audio-recorded, whereas the interviews with people not living in Trondheim were done over Skype for Business and recorded with the built-in recorder. All the interviews were transcribed in order to perform the later analysis.

3 RESULTS

The prototype has been developed to support the experimental pilot. In particular, its goal is to put guidelines into practice and be able to test them in real hiking activities.

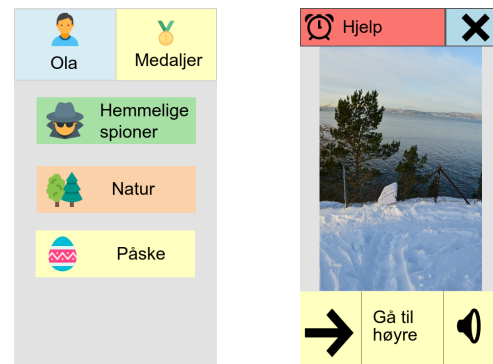


Figure 2: The application start screen (left). Navigation assistance screen. The text here says “walk to the right”(right).

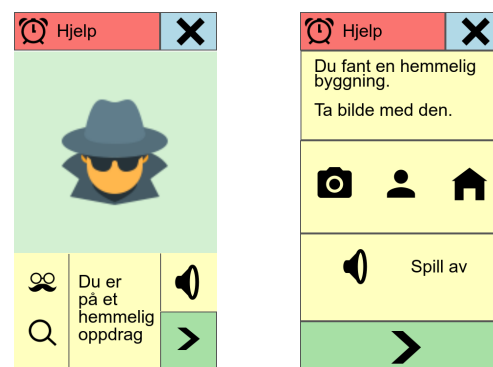


Figure 3: Two screenshots from story points of the spy story. “You are in a secret mission” (left) and “You found a secret building. Take a picture of it” (right)

The main idea is that the user joins a game built around a story during his/her walk on a given path. The physical activity of walking is enhanced with a gamified experience through the story and reward system. Along the path there are various places (the *story points*) in which parts of the story are told or quests are made to the user. The user has to walk between the story points, thus promoting physical activity. The app proposes different stories for the same path and the same story can vary in presentation, difficulty and type/number of story points. The current prototype proposes three stories: a spy story, a story on nature and an Easter story. The stories can be selected using the main menu in Fig. 2.*left*. A story point consists of one or more story screens that can provide part of the story, ask a question or to take a picture. Some screens include both pictures and images to make the request more clear. However, question screens include only text and at the moment they can only be used by people that are comfortable with reading easy-to-read text [6] (Fig. 3.*right*). Symbols used are those provided by ARASAAC [1]. In order to do that, the images used were straightforward and mostly objects, since this is the preferred images type for people with IDs [9].

The game-inspired app follows the magic circle model defined by Salen and Zimmerman [10]. This model is built around the idea

of a “magic circle” that separates the game from the real world. It creates its own rules that apply and make sense inside this magic circle. Once the route is set, the game has to be played at a set time and only the players playing with you are a part of the game. We chose not to make a pervasive game because of the users’ need for predictability of the route and the need to include caregivers when playing. This makes quite difficult to design something to be played anywhere and anytime. The app would be used when walking and sometimes around other people. The routes need to be manually inserted in the app for each location. So far this consists of manually adding the pictures, text, audio and coordinates of each point. This gives the caregivers some control over the areas the app will be used in and an opportunity to personalise the content. The story points should be divided throughout the route and put not too far away to help maintaining focus and motivation throughout the hike.

Since social interactions are motivational for most people with IDs the story can be played alone or in a small group. The types of interactions made are to be determined by the user and the stories created. The interactions can be: talking about the game, everyday things and where to go. There could be a caregiver or parent present to help with the navigation and other possible difficulties related to the app. The app makes possible to take pictures during the trip. Sharing pictures after a hiking trip is usual and can create opportunities for communicating and sharing making the activity more effective from the social perspective. Concerning rewards, in the current prototype, the user earns a medal after finishing a story. The medal consists of a medal icon, the icon for the story and the story name. All of the users medals can be viewed in the medal screen.

We took care of the navigational aspect of the prototype in order to increase the users’ independence, since that way they would get more freedom to visit more places in an autonomous way. The use of maps was found to be difficult due to being too abstract for people with IDs so we did not include them. Instead, street level pictures were used at every decision point or when there is a long distance between decision points. The use of street level pictures at decision points can be seen in Figure 2 right. A short directional description was also included, telling the user where to go next. This was presented both with easy-to-read text and spoken instructions. For people who struggled with the difference between right and left, an arrow was added to all navigational screens.

A notification in the form of a sound prompt and vibration was also added when the user is close to a decision/story point in the route. This would limit the time needed to look at the screen and give the users more time to watch their surroundings. This is especially important in more risky areas like those with traffic. Finally, an alarm button was included to be used when the user is lost and needs help. When the alarm button is clicked, a caregiver or parent would be contacted and the location of the user would be shared.

4 CONCLUSION

In this paper, we study the development of software that helps people with IDs get the motivation to do physical activity outdoors as an example of the preliminary stages of a software engineering

process in practice that involves multidisciplinary requirement elicitation and participatory design. It has been created following a design and creation research methodology, in which an ‘artifact’ is the main result of the research, and it is improved through several refinement steps that employ qualitative methods such as interviews with experts, focus groups, group interviews and a pilot user test, along with a literature review to assess some of the decisions taken. We split the research in three steps and present the final prototype obtained as result of the research.

We extracted some ideas of scientific interest for interface designers and software engineers who might want to develop software for this purpose. Fostering social interaction turned out to be the feature that motivated the users the most, but rewards through medals did not attract much of their attention in the pilot user test. The selection of communication method was very important for the end users, and their experience showed that the navigational assistance would not have been possible or feasible without the easy-to-read text, the audio descriptions or the street-level pictures. The role of caregivers and domain experts in the creation process of the software proved to be highly valuable, as they are the main actors in the research steps that cannot have the participation of the end users, as it includes activities that might be too cognitively demanding for people with IDs, such as the requirement elicitation sessions in the interviews with experts and the focus groups and giving opinions about the elements of the game interface.

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