HikePal: A Mobile Exergame to Motivate People with Intellectual Disabilities to do Outdoor Physical Activities

JC Torrado, L Jaccheri, S Pelagatti, I Wold

Abstract

People with intellectual disabilities often have a sedentary lifestyle that can lead to long-term issues like cardiovascular diseases, diabetes, obesity and depression. Although literature shows that the main reason for this is the lack of motivation to do physical activity, scarce research has been done in accessible apps to track and foster physical activities that address motivation. This paper presents HikePal, a game-inspired app to motivate individuals with intellectual disabilities to do physical activity outdoors. We have followed a design and creation research strategy using 1) semi-structured interviews with five experts (health care workers, special education experts and software engineers); 2) a focus group with an occupational therapist, a physical therapist and four software engineers; 3) a pilot user test with three individuals with intellectual disabilities and their caregivers. Having social interaction during the physical activity turned out to be a major motivational aspect of the system, whereas reward systems did not attract much of the users' attention. Regarding the adapted navigational assistance, we found out that 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. It proved useful to perform a test on the field and to refine the design guidelines in view of a forthcoming large-scale experimental test involving a larger number of persons with intellectual, sensory and motor disabilities.

Keywords: Intellectual Disabilities, Motivation, Mobile Applications, Outdoors Navigation, Physical Activity

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1. Introduction

People with disabilities tend to be less physically active than their non disabled peers. For this reason, they have shorter life expectancy and are at greater risk of developing secondary, comorbid and age-related health conditions, such as depression, cardiovascular problems, obesity and osteoporosis [1, 2]. This happens for intellectual, sensory and motor disability, and one of the main problems to be addressed is lack of motivation [3, 4, 5]. motivation is a complex psychological phenomenon that has been studied thoroughly in the particular case of physical activity of neurotypical adults [6, 7], being intrinsic motives such as enjoyment, challenge and emotional regulation the most found ones. However, those motives entail a degree of self-awareness, abstraction and executive skills that is usually hindered in the case of intellectual disabilities [8]. Therefore, new ways to motivate people with intellectual disabilities to do physical activities have to be investigated, such as game-inspired apps.

While there are many rather accessible apps which can help people with disabilities to keep track of their physical activity, to the best of our knowledge, none of them has a real focus on the motivational aspect. In this paper, we describe the experimental development of a piece of software (an Android game) designed for individuals with disabilities which aims at motivating their physical activity. The development starts from the deep analysis of the problems related to people with intellectual disabilities.

Many people with intellectual disabilities have a sedentary lifestyle, as concluded by several studies [5, 8]. In particular, Dairo et al. [9] observed that only 9% of people with intellectual disabilities reach the recommended amount of physical activity while Queralt et al. [10] found that 50% of the physical activity for individuals with intellectual disabilities came from the time spent at school and that girls were less active than boys. The barriers that prevent people with intellectual disabilities to have a proper physical activity include accessibility, cost of equipment, supervision or personal health, but also social factors such as feeling that other people prevent them from doing it [8]. However, the same studies also highlighted that many people with intellectual disabilities enjoy several activities like dancing, walking, bowling, training with weights etc. [8], and that is important to associate physical activity with fun, music or goal-oriented games [11]. At the same time, however, very few studies address the design of exergames (i.e.: games that address doing physical activity) for people with intellectual disabilities).

Considering that walking is one of the activities mentioned as most enjoyable by people with intellectual disabilities [8], we focused on the design of an Android-based game that is fun and easy to use to motivate users to go on hikes. The design of this game led us through a requirements elicitation process exposed to many of the above mentioned challenges, including the interaction with individuals with intellectual disabilities and the other stakeholders during the whole process, the design within a framework determined by ethical constraints, and the design of a preliminary pilot study aimed at testing the game in a real condition to pave the way for a subsequent large scale experimental study for the general validation of the software and design methodology. Undertaking research tasks related to intellectual disabilities entails some challenges that are similar to those of other disabilities like sensory [12] or motor disabilities [13]. Actually, they tend to be grouped some times, and their conclusions bridged, as in the studies cited before. Therefore, an additional aim of this paper is to shed light on how researchers and software designers can bridge information and communication technologies (ICTs) to disabilities in their many aspects. Specifically, this general contribution of the paper to assistive technologies for disabilities of any kind applies to the requirement elicitation and prototype design stages of the process, as well as the way we have involved stakeholders such as caregivers, nurses, designers, technicians and individuals with disabilities in the process. Therefore, we present this study as an example of how co-design and participatory approaches can be tailored to meet the needs of participants with disabilities, for whom traditional approaches might not be suitable.

The preliminary stage of requirement elicitation was conducted by experts' interviews first and then by organising a focus group. This preliminary stage led us to the definition of a first set of guidelines for the development of the exergames, which, however, needed to be validated with users in realistic conditions. The first prototype of the game was designed according to these guidelines and tested in a preliminary, small scale pilot study, aimed at testing the reliability and usability software and at validating the guidelines. The results of this first experimental study provided us with enough information to proceed with a revision of the guidelines, that in the revised form is one of the main results of this work.

Thus, the main contributions are (a) a set of guidelines for the design of exergames for users with intellectual disabilities motivating them for hikes, (b) a working prototype of the game, and, from the design research 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 paper is: *How can we develop game-inspired applications that motivate individuals with intellectual disabilities to do outdoor physical activity?*. The question has been specialized into *How can we design navigational assistance systems for individuals with intellectual disabilities?* and *What is important when designing games and applications for individuals with intellectual disabilities?*.

The paper is organised as follows: after the review of the state of the art in Section 2, we present the research methodology including the design process, the ethical issues and the pilot user test in Section 3, the main results including the guidelines and the prototype in Section 4, and we discuss the limits and potentiality of our approach in Section 5. Finally, Section 6 draws the conclusions and the future work.

2. Related work

Bondar et al. [14] have a systematic literature review on the effects of interventions on the behavioral change regarding physical activitiy of people with intellectual disabilities. Although there is no specific mention to the technological aspect of these interventions, the authors concluded that are two main aspects that must be kept in mind when designing such interventions: (a) integrate the support of the caregivers in the intervention mechanisms and (b) provide individualised instructions.

Apart from that general vision of the issue by Bondar et al., we did not find studies reporting on how to develop apps for promoting outdoor physical activity specifically for individuals with intellectual disabilities. The closest study was PuzzleWalk [15, 16], which is a mobile app to promote physical activity for people with autism spectrum disorders. The authors present exhaustively the design research process, with a requirement elicitation phase and an iterative research methodology that included interviews, observation and participatory design of the game. They included people with autism spectrum disorders, but the authors state that they fell more on the high-functioning area of the spectrum, which allowed them to participate in cognitively demanding activities such as cognitive walkthrough, thinking-aloud testing, usability inquiry and self-reports. Moreover, the app was designed with the goal of avoiding unnecessary social interaction, which is particularly challenging for their target population. However, one of the main findings of the study is that, despite their communicative difficulties, there is a significant desire for feeling part of a social community and to socialise when they use the game. Regarding the impact of the app on their motivation, the authors declared that they had reached a consensus in which they would seek motivation through challenge. However, they admit that this had a positive impact in their users because they had a sample of individuals in the spectrum that might be considered as high-functioning: they could understand the research process and the activities it included. Thus, PuzzleWalk lacks the focus on intellectual disabilities and cognitive accessibility that is represented in this paper.

Given the aforementioned lack of studies that directly address the issue describes in our research questions, we have looked for related literature by searching three kinds of studies: a) studies about apps or games promoting outdoors physical activity; b) studies about the issue of outdoors wayfinding for people with intellectual disabilities; and c) studies about advice on interface design for intellectual disabilities.

"Exergames" is a term used to describe apps or games promoting outdoors physical activity [17]. From the game theory point of view, exergames are considered a subgroup of serious games [18], that is to say, games with a clear purpose to instruct and educate at the same time as the player has fun [19]. There are a number of studies about exergames. However: (a) they do not address specific medical or psychopedagogical conditions and (b) they contain features that might entail cognitive challenges for people with intellectual disabilities. For instance, Tabarcea et al. propose O-Mopsi [20], a digital system for the wayfinding in urban areas. This game is different from other wayfinding systems because the targets are not marked with exact coordinates and the order of the targets is not fixed. The tasks in this game are first to find the shortest route, then go to the correct area and finally find the target based on a photo. This system measures the amount of physical activity using a simple step counter. In some games, the challenge was larger and taking steps towards the goal was the motivational factor. Stickers for Steps [21], is built around the the goal to collect all the stickers. The user gets new stickers after walking a specific number of steps, which increases throughout the day and resets at midnight. The research focuses largely on the social aspects of the system. The social interactions are face-to-face meetings with other users where they would exchange stickers. These interactions worked as icebreakers and resulted in conversations about the game, used routes and general topics often followed the exchanges. The social interactions of the game were enjoyed by the users and the game was more engaging when seeing other people like the game. Stanley et al. present Gemini Redux [22], a game where the challenge for physical activity is not part of the primary game play. It is created as a Massive(ly) Multiplayer Online Role-Playing Game (MMORPG). The physical activity is used to strengthen an animal companion that can be used in the gameplay. It is measured with a phone and includes an app for the user to keep track of its amount. The app also reminds the user to do physical activity through alerts on the phone. In their study, they do not declare a significant change in the motivation to do it, but they propose the implementation of exer-games with a stronger connection to the primary game in order to increase the motivation. Research on Pokémon Go is reported by Marquet et al. [23]. In this game the physical activity is performed while catching Pokémon, since the user needs to change location in the real world in order to find them. The amount of physical activity is measured using a step counter and calculating the walked distance. The authors used college students to study the motivational factor of Pokémon Go to do physical activity. They found out that motivation was more likely to increase in people who had a previous interest in the Pokémon fictional universe. According to the research done by Althoff et al. [24], Pokémon Go increased physical activity by 25% for engaged players. The researchers suggested that playing Pokémon Go had a positive effect for people who play a lot of games and had a sedentary lifestyle. We also wondered how much the phenomenon of motivation had been investigating as a psychological factor in the case of people with intellectual disabilities. The literature, however, investigates mostly the motivation applied to specific areas of the life of this population, mainly employment motivation [25, 26, 27]

Regarding studies that address the issue of outdoors wayfinding for people with intellectual disabilities, the app Poseidon [28] uses a map and simple text directions that are designed for people with Down's syndrome. At important steps in the route, the app shows street-level pictures, which turned out to be the most helpful feature. However, end users found the understanding of the map rather challenging. Garcia de Marina et al. report about the development of an app called WSI-GO [29] for people with intellectual disabilities. It has two modes: audio-based and visual-based. The former proved to be more useful for individuals with deeper cognitive limitations since it required less effort to interpret information from the screen. The latter contained street-level pictures in order to help the users identify landmarks and other details, and proved to be helpful for other users as well, though they reported some issues matching the real world to the pictures when some details were different. The system included several other features such as alerts and prompts to notify the user about changes in the interface and the progress. AssisT-Out by Gomez et al. [30] includes street-level pictures and some visual and haptic alerts to inform the users of their progress. It also includes navigational buttons in order to be able to go back to previous steps and text to speech functionality to help users with reading problems, a progress bar and also vibration alerts. AssisT-Out collects automatically the street level pictures from Google Street View. This reduces significantly the time needed to make a new route and makes it possible to include recalculation of the route if the user walks in an incorrect direction, whereas in WSI-GO [29] and Poseidon [28] routes have to be added manually by a caregiver. The study of AssisT-Out [30] compares the efficacy of the app compared to Google Maps, and the subjects have a higher chance of reaching their target destination by using AssisT-Out. In terms of safety of the outdoor navigation, the users of Poseidon [28] looked constantly at their screens, so the caregivers had to remind them to pay attention to the road when crossing the streets. The subjects belonging to the experiment of AssisT-Out [30] suggested to include a help button in the screen in order to be assisted when they got lost. Caregivers pointed out that getting the location of the individual through that feature would be also helpful.

We also reviewed some literature about advice on interface design for intellectual disabilities. Torrado et al. [31] provides an extensive set of recommendations that derive from the author's experience on developing digital solutions to address different issues concerning education, daily life or labor training. They highlight the value of co-design and adapting traditional software design techniques in order to include the final users in the process along with the rest of the stakeholders in transdisciplinary teams. The study by Tsikinas et al. [32] suggests that the user interface needs to be straightforward, clear and with minimal input required. A game should have large text, few distractions and high contrasting colors. They recommend customizable difficult levels that can be also increased gradually, always keeping a feasible learning curve. Finally, the study concludes that providing continuous and positive feedback is helpful for the users and in order to provide feedback, monitoring of the user activity is necessary. Regarding the use of textual indications, the study by Cano et al. [33] suggests that the size, color and reading speed of the text is significant and should be customized to match the user's needs. Downtown, proposed by Cano et al. [33], offers both written and spoken instructions, straightforward and clear language, and a video tutorial for each task. In order to attend the need for different difficulty levels, Downtown [33] uses three levels: “easy”, “medium” and “hard”. Some of the more difficult and stressful features, like the time limit, can be turned off. Both Downtown and the study of Tsikinas [32] employ and recommend the use of customizable avatars. The study by Wilson et al. [34] suggests that there should only be one stream of available actions in every interface to make the app intuitive and predictable for the user. The app is focused on the importance of communication for people with intellectual disabilities, specifically communicating the goals in a way that is adapted to the user. The study suggests that visual communication is important and that icon-based exclusive communication is feasible. However, actual pictures, as close to the user’s life as possible, are preferred. The study gives evidence to the assumption that collaboration and being social is important for individuals with intellectual disabilities. The picture of the user achieving their goal could be shared to their caregivers and parents via email. Sending the picture to their parents was appreciated by the users. The authors propose to include social media in the future as well. In addition to the studies found on the literature, the World Wide Web Consortium [35] added new guidelines concerning the cognitive accessibility of web pages, that is to say, suggested standards to follow when designing websites that are accessible for people with cognitive disabilities. Although these guidelines are meant for web design, general advice on readability, simplicity and customisation served as input as well for our prototype design.

The lessons learned in these literature overview, as well as the way we have used them, can be seen in a tabular version later in the paper when the guidelines are formulated. (see Table 4)

3. Research Methodology

We follow a design and creation research strategy [36] with a strong multidisciplinary component that includes several data collection methods. This research strategy consists of scaffolding the investigation steps around the development of an ‘artifact’, that can be a piece of software, a physical product or an idea. Thus, this ‘artifact’ is created, refined and improved after each phase of the research. The ‘artifacts’, in our case, are a game to motivate individuals with IDs to do physical activity (called HikePal) and, in parallel, a set of guidelines to inform the design of applications with this purpose. Our process (Figure 1) consists of: (a) a literature review and semi-structured interviews with domain experts to create the first version of the HikePal prototype and guidelines, (b) a focus group to assess the guidelines and refine the working prototype and (c) a pilot user test to further refine the prototype and the guidelines.

In order to ensure the ethical integrity of the study regarding individuals with IDs, an application to the [National] Centre for Research Data was filed and approved. This application addresses many of the ethical concerns including consent, what data is gathered, data storage, sharing and anonymisation of data. In this study the users' ability to consent was determined in cooperation with health care professionals working with them. This follows the advice given by The [National] Committee for Medical and Health Research Ethics [Anonymised for blind review] when it comes to determining the competence to give consent and consulting with someone independent to the research project on this matter. Detailed information about the study is available in [Anonymised for blind review]. The subjects were able to provide consent themselves, as evaluated by the [National] Committee for Medical and Health Research Ethics. Health care professionals that worked with them on a daily basis confirmed this fact.

3.1. Participants

The experts who participated in the interview of the first research step have a multidisciplinary background and are summarized in Table 1.

The "Outdoor Life Organization for the Disabled" arranges outdoors events all over [our country] adapted for individuals with IDs and exploits an app developed by [Company1] to inform about these events. The nurse specialized on intellectual disabilities was included due to her expertise in the organization of hiking trips for individuals with intellectual disabilities and is currently part of a team hosting outdoor events for people with IDs in [City1] 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 [Company1] and Trekking Association are experts in leisure activities platform for people with intellectual disabilities using artificial intelligence and machine learning. Experts from [University1] and [University2] were included as experts in intellectual disabilities and rehabilitation.

Concerning the composition of the focus group (Table 2), the physical therapist was selected for her experience with people with intellectual dis-

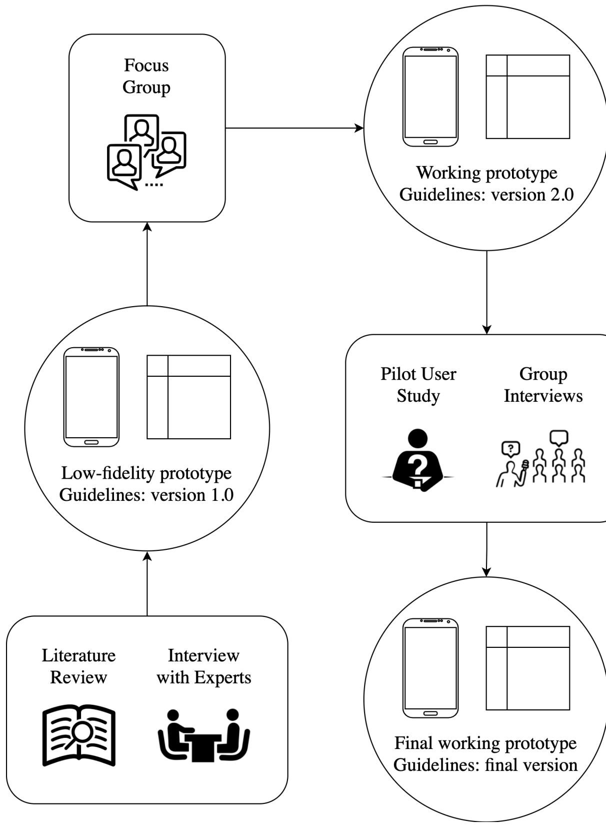

Figure 1: Design and Creation Research Strategy

abilities and her interest in physical activity and hiking. An occupational therapist was included as she works at a day center for people with intellectual disabilities and has experience with the user group. Researchers from [University1] participated as experts in application development for people with intellectual disabilities.

The pilot user study on the prototype in the third step was carried out with 3 individuals with intellectual disability aged 16 - 35 years and 2 caregivers (Table 3). Due to the current regulations in [Country], it was not possible to get other demographic information like ethnic background. The level of intellectual disability was not disclosed by the families or the participants. They mostly have moderate level of intellectual disability, but many also have additional diagnoses like autism or mental health issues. The pilot test, which was aimed at the refinement of the guidelines and at a general

Code	**Background**	**Place of Work / Affiliation**	**Contribution**
Name1	Intellectual Disability Nurse	[University1]	Organization of hiking trips for individuals with intellectual disabilities
Name2	Business	Trekking Association and [Company1]	Experience in leisure activities, platform for people with intellectual disabilities using artificial intelligence and machine learning.
Name3	Advisor PhD project	[University2]	experience in rehabilitation
Name4	Psychologist	[University1] Hospital and [University2]	Experience in intellectual disabilities
Name5	Computer Scientist	[Company1]	Experience in platform for people with intellectual disabilities using artificial intelligence and machine learning.

Table 1: Participants in the Interviews with Experts

test of HikePal, included two hiking events that were followed by group interviews. Both hikes and interviews were carried out by the same group of individuals with IDs and caregivers. The caregivers were included to mediate the interaction between the technicians developing the software and the users with intellectual disabilities. 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 when facing a new setting.

3.2. First step: Interviews with Experts

We performed five interviews with experts on intellectual disability, 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.

Code	Occupation	Place of Work
Name1	Physical Therapist	Intellectual Disabilities Day center
Name2	Occupational Therapist	Intellectual Disabilities Day center
Name3	Phd Candidate	[University1]
Name4	Postdoctoral Fellow	[University1]
Name5	Guest Researcher	[University1]
Name6	Postdoctoral Fellow	[University1]

Table 2: Participants in the focus group

Name	Description	User test
Participant 1	Female with intellectual disability	User test 1
Participant 2	Male with intellectual disability	User test 2
Participant 3	Female with intellectual disability	User test 2
Caregiver 1	Works at the day center	User test 1
Caregiver 2	Works at the day center	User test 2

Table 3: Participants in the user test

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 individuals 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 (e.g.: "How do you think a training phase for the game should be executed").
- Questions about motivation for exercise (e.g.: "How often do you believe people with intellectual disability need new motivation to continue with physical activity?")
- Questions about navigation (e.g.: "What do you think are the security issues for people with intellectual disability when walking and gaming in urban areas?")
- Questions about designing games for people (e.g.: "How should positive and negative feedback be given?").

3.3. Second step: Focus Group

A focus group session [37] was carried out to get some preliminary feedback from experts prior to the pilot user test. The goal was to find improvements to the guidelines and the game. We had 6 participants (Table 2). They had different backgrounds, which led to a multidisciplinary discussion about the game. The event was scheduled for 1 hour: 15 minutes for introduction and 45 minutes for presentation of the current work and discussion.

In the introduction part, all the participants introduced themselves. Then, a presentation on the characteristics of the project followed. The first part of presentation consisted of the current status of the project and the guidelines. This was followed by a short discussion about the guidelines, discussing which are important and if there were guidelines the participants disagreed with. The second part of the presentation consisted of a presentation of the HikePal and of its foundation on the guidelines. Further, a discussion on how the participants thought the game would be in regards to motivation to do physical activity, navigational assistance and the design was included. The discussion also touched on how HikePal would be used at day centers or housing for people with intellectual disability.

Examples of questions related to the guidelines were "What are the most important guidelines?"or "Is there any guidelines you disagree with?". An example of questions related to HikePal idea is "Is the navigation screen straightforward enough?".

3.4. Third step: Pilot User Test

As shown in Figure 1, the prototype was reworked in order to be tested with end users, since the first one was a low-fidelity mock-up, and for the pilot user test we needed a functional high-fidelity prototype. This prototype was a working mobile game. This testing with end users was an empirical investigation including people with intellectual disability, who used the proposed game. This investigation looked into what the users think about this type of game and suggested guidelines. 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. If the participants had difficulties communicating verbally, the caregivers would help interpreting their opinions and thoughts on HikePal and test session, which is a recommended practice when the user has communicative issues [38]. The caregivers that participated in the user tests were also interviewed afterwards immediately to fetch their opinion on the test session, how they though HikePal worked in practice and what they thought the user felt about HikePal.

The interviews done after the user test were unstructured and the questions were based on the earlier user test. Preparing questions in advance would have not allowed the participants to discuss the problems that might happen during the user test. The interviews were audio-recorded with previous consent from the interviewees. All the interviews were transcribed in order to perform the later analysis. The interviews were organized around topics, for example "How is the outdoor navigation in the game experienced?".

3.4.1. Group Interviews

Group interviews were used after the user test. This test involved two individuals with IDs and one or two caregivers, depending on how much assistance was believed to be needed. The interviews were unstructured and addressed issues that emerged during the test session related to the use of HikePal and physical activity. At the end, questions about the experience of HikePal and session as a whole were also asked. Important questions were written in advance to make sure the language was simple without complex sentences too much abstractions, in order to make sure the user understood the question and, thus, give the interview more credibility [39].

3.4.2. Observations

Naturalistic observation is often used when working with people with intellectual disabilities, because asking questions directly during trial sessions usually derives in biases, as many users will give the answer they think is desired and not the objective one (positive bias). Moreover, this method includes people that struggle to answer questions in an interview setting [40]. The observers took notes about the users' feelings about HikePal and where and why the user struggled or enjoyed the game. One researcher participated in hiking trips through the National Association for People with Intellectual Disabilities including people with intellectual disability and caregivers. This experience was used to see the difference between hiking trips without a game or an app and just walking. The observations were used in addition to the the interviews during the user test. The notes from the observations during the user test were analyzed altogether with the interviews.

3.5. Data Analysis

After all expert interviews in the first step were transcribed, a table for each interview was made. Following the advice given by Oates [41], each question got its own row, sorting the data into themes. The transcribed data was added to the left side of the table and long text was split into paragraphs. On the right side notes were added when re-reading the transcription. If the transcription was difficult to understand, we listened to the recording. A summary of each interview was created based on the notes from the table. This summary was then sent to the interviewed person and asked if they still meant the same or if they felt that something had been misinterpreted. The summary used in the rest of the analysis process included the changes from the comments of the participants. Categories were formed when similar pieces of information (codes) were merged to get a broader sense of the data. Categories were then gradually arranged in themes. Then, we made tables representing the different opinions, following the advice of [41]. These tables constantly changed, merging multiple opinions meaning the same and splitting up tables into multiple tables. They were used together with the summaries of the interviews to extract the results. The transcriptions were re-read in order to look for good quotes and to check again that the experts' opinion was analyzed correctly.

For the focus group much of the same method of analyzing the data from the experts interviews was used. The focus group included less data, so some steps were skipped. This included making tables of each participant's thoughts on different topics, since all the data came from one interview and few participants expressed an opinion on the same topics. To start with, the focus group discussion was transcribed. This transcription included the participant code for all of the comments, making it possible to link each quote to the participant that said it. Following the method mentioned by Oates [41], relevant data from the discussion in the focus group was extracted. This data was then added to a summary, which included both interpretations of the discussion and quotes. The transcription was re-read to make sure that all the important points from the focus group were included and to check the interpretation's trustworthiness. The data was then added to a table with three columns; themes, codes and comments. In this analysis an inductive approach was also used and the themes were found from the data. The second column included both interpretations and quotes and the third column were additional comments on the data collected on this theme. After the initial table was made, some smaller themes were merged together and larger once was split into two themes during the process.

The data analysis process for the user test was very similar to the expert interviews and the focus group. Firstly, all of the interviews were transcribed and the notes taken during the observation were added to the same document.

We extracted themes, codes and personal notes. We found six categories: motivation to physical activity, navigation, design, rewards, communication levels and other (see Fig. 2). The relevant data was then added to a summary sorted by the previously mentioned main six categories.

4. Results

4.1. Guidelines

After the three research steps (Fig. 1) and the analysis of the gathered data, we propose the following guidelines for a game promoting outdoor physical activity for individuals with IDs. These guidelines are based on the categories and ideas extracted from the interviews, which can be seen in Figure 2. Table 4 shows the guidelines divided by groups (physical activity motivation, visual interface design for people with intellectual disabilities and navigational assistance), as well as their rationale.

4.2. Prototype

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.

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. HikePal 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. 3.*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 [42] (Fig. 4.*right*). Symbols used are those provided by ARASAAC [43]. In order to do that, the images used were straightforward and mostly objects, since this is the preferred images type for people with IDs [44].

Gamification

According to [45] "Gamification refers to: a process of enhancing a service with affordances for gameful experiences in order to support user's overall value creation". Using this definition, Hikepal can be seen as gamification. The physical activity of walking is enhanced with a gameful experience through the story and reward system. The value created for the user by Hikepal is the physical activity the user does.

In [46], Deterding recommended looking at the winder system and the context when using gamification and not only gamification mechanisms. When developing the game idea the context was considered and specially the role of the caregivers. How the game fits into the users everyday life, a day center or housing for people with IDs.

Magic Circle and Pervasive Games

The game followed the magic circle first mentioned by Huizinga [47], but defined later by Salem and Zimmermann [48]. The magic circle separates the game from the real world. In basketball where the rules of basketball apply at the basketball court when playing a game, but when the games finishes the rules no longer apply. The game creates its own rules that apply and make sense inside this magic circle.

Hikepal was not an pervasive game which was the original idea, because it does not expand the magic circle [49]. The route was set, the game has to be played at a set time and only the players playing with you are a part of the game. The choice to not make a pervasive game was made because of the users need for predictability of route and the need to include caregivers when playing. This makes it difficult to design something to be played anywhere and anytime.

Hikepal will be used when walking and sometime around other people, many people use alibis to justify playing [50]. For this game, alibis like playing to increase physical activity could be used. For the caregivers it is also possible to use the alibi of doing their job. This way playing the game will be less embarrassing for the player.

Creating the Routes and Stories

A route in Trondheim was created for the testing and a few more will hopefully be added in the future. For each new city Hikepal is going to be used in, a couple of routes has to be added. So far this consist of manually adding the pictures, text, audio and coordinates of each point.

For now the available route exist in Hikepal, but in the future one option is that caregivers or parents can create their own stories and routes. This gives the caregivers some control over the areas the game will be used in and an opportunity to personalize the content.

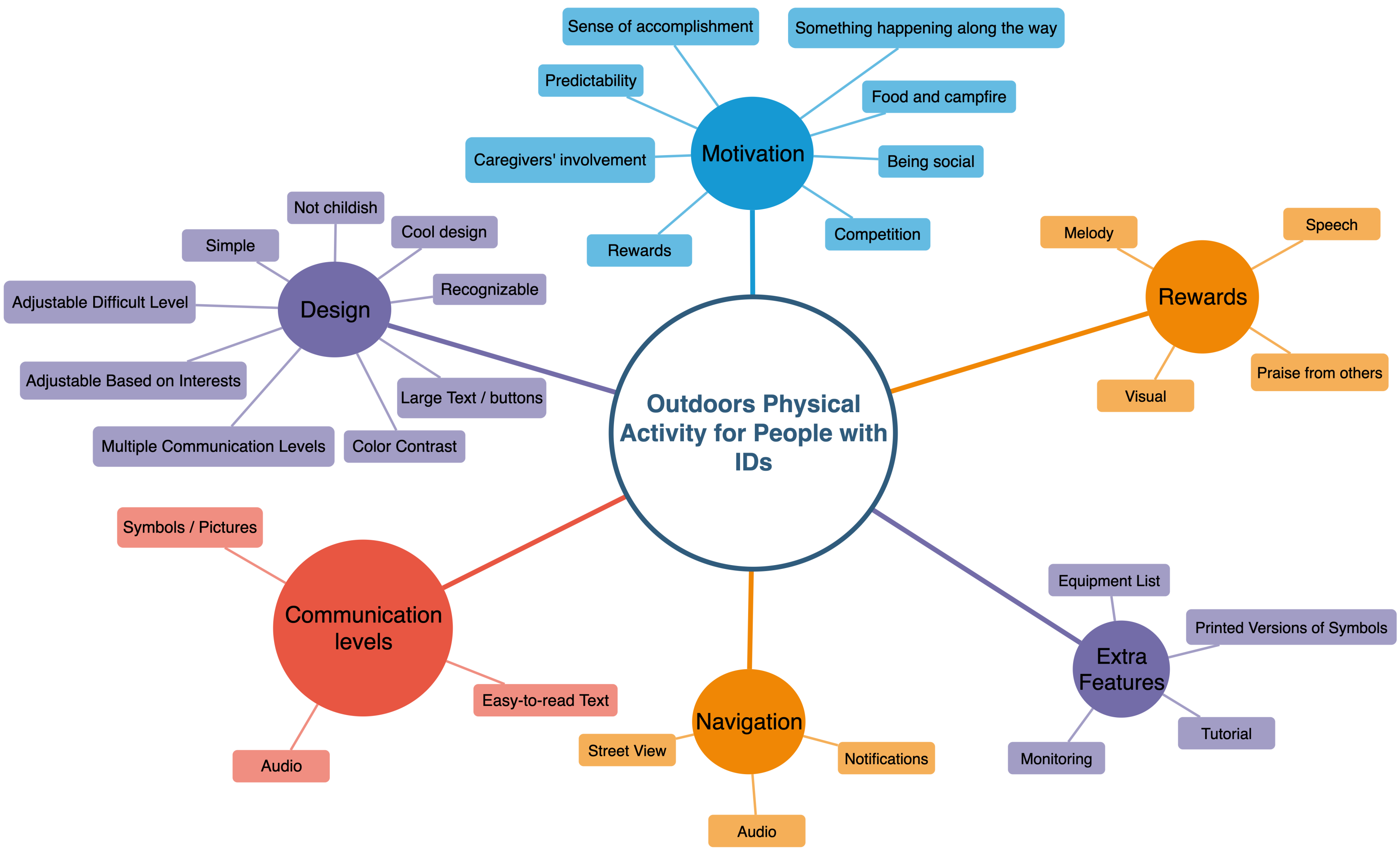

Figure 2: Categories extracted from the interviews

Goal	Guideline	Source
Motivation for physical activities	The game should be fun	[48], user test
	Caregiver should be included and previously motivated to do the physical activity	[14], focus group
	Social aspects should be included	[15, 16], user test
	A reward, medal or positive feedback should be given	interview with experts, focus group
	Motivation needs to be given throughout the activity	interview with experts, focus group, user test
	Motivation should be given by means straightforward concepts that are understandable for individuals with IDs	interview with experts, focus group
	The physical activity suggested should not cause pain or stress	interview with experts, user test
Designing accessible interface for people with IDs	The user interface should be straightforward and clean	[31, 32] [34]
	Independence and self advocacy should be encouraged	user test
	Text should be large and straightforward and colours should have high contrast	[32, 33]
	Interaction should be able to be done just with images and spoken instructions	[30]
	Themes should be customizable	focus group, user test
	Difficulty should be customisable in terms of the story presented and the walking distance	[33]
	The game should not be perceived as childish	interview with experts, focus group
	Changes and increased difficulty level should be introduced slowly	[33]
	Stakeholders should be present in the design process in order to confirm the decisions suggested above	[31]
	Language should be simple and do not include words from other languages, acronyms and metaphors	[33], focus group, user test
	Text should be easy-to-read, following the European standard [42]	[33]
	Text-to-audio reader and visual communication support for people struggling with reading should be included	[30]
Providing assisted navigation	Decision points should be indicated by street-level pictures	[30]
	Instructions should be provided through audio	user test
	Sound prompts and/or vibrations should be used at decision points	[30]
	Directional cues should be given in form of arrows	[30]
	Routes that are close to the traffic, deep water and places with many people should be avoided if possible	user test
	If the user may walk alone, a way to alert contacts should be provided	[30], focus group, user test

Table 4: Guidelines for designing mobile games to motivate individuals with intellectual disabilities to do physical activity outdoors

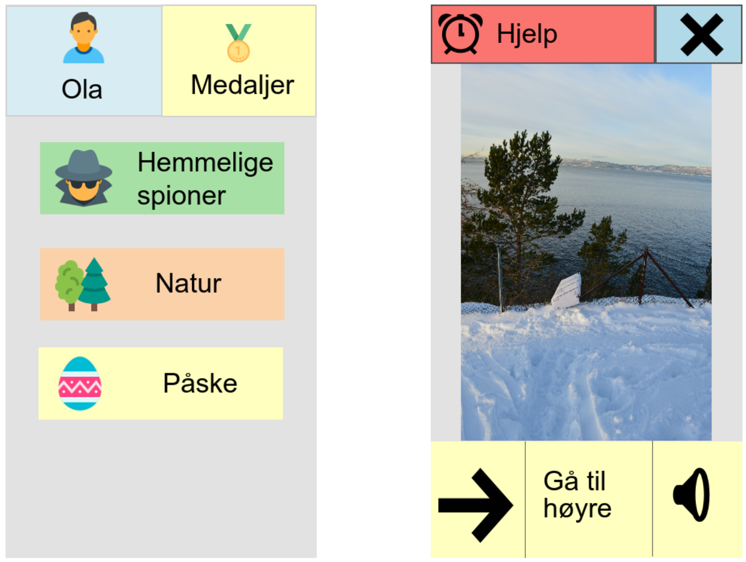

Figure 3: HikePal start screen (left). The text here says the profile name, "Medals", "Secret Spy", "Nature" and "Easter". Navigation assistance screen (right). The text here says "walk to the right".

In the game we used the "fun keys" guidelines from Isbister [51]. The player would switch between types of fun while playing. The prototype included some of these fun keys in the following way:

- The *hard fun* part of the game comes from navigation. For most individuals with intellectual disabilities, navigation will be a challenge and give a sens of accomplishment when done properly.
- The *easy fun* comes from the story, which increases the players curiosity and is used as a break between difficult navigation sections.
- The *serious fun* is included in the form of Physical Activity and the reward for exercising, but can also be added by making a quiz and including learning in the story.
- The *people fun* is included by interacting with caregivers, family and friends. The player can have different roles and interactions including: leader, mentor, cooperation and communication.

The "four fun keys" can be added and customized according to the people actually participating. Some individuals with IDs might like learning and

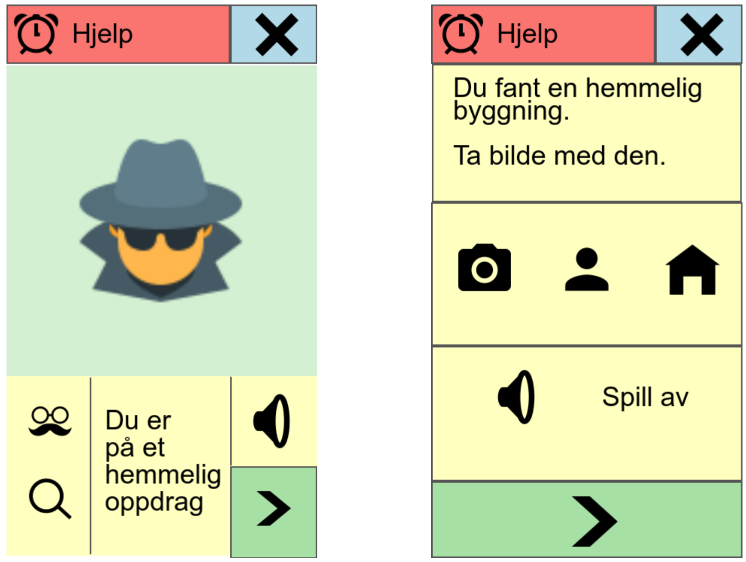

Figure 4: Two screenshots from story points of the spy story. "You are in a secret mission" (left) and "You found a secret building. Take a picture of it" (right)

want an informational story about birds for instance, while some others might want an entertaining story.

Since social interactions are motivational for most people with intellectual disabilities, 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 HikePal. HikePal 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.

Special care in the design of HikePal was put on having images and stories that were not perceived as childish. Therefore, the interface has a simple and straightforward design, but does not include typical childish elements like pinkish colors, princes and princesses and characters such as children, superheroes or cartoons.

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 3 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. The button is red with an alarm icon and has been chosen because of the cultural association with the idea of looking for help. In terms of safety, setting up routes in nature is recommended, since they are normally areas with little traffic and often less people than urban areas. Routes in urban areas close to where the user lives can also be used for more everyday hiking trips with less barriers to start.

4.3. Results from the Pilot User Test

The user test showed that the app was fun for the participants. Two of the participants in the user test was asked if they thought the app was fun and they both answered yes. Further they were asked if they thought they would like to play it again and this got mixed answers. One participant said that maybe once was enough and the other said yes he would like to play it again. One participant said that she did not like to take this many breaks and wanted an app that had less and shorter breaks. The concept of this game therefore does not fit her wishes for an app promoting physical activity. Caregiver 1 on the other hand said that she liked the concept, but said the app needed some improvements.

Motivation Through the Story

During the user test it did not seem like the story was exciting. The participants talked little about the story and when asked or talked to about the story the participants showed little interest. Caregiver 2 said that this story could be catchy for some, but it depended on who uses the app. The lack of interest in the story could be because some of the participants had difficulties following the story. Participant 1 managed to guess the correct thief, but when asked why she said that they had nearly the same hair color in the pictures. This similarity of hair color was just a coincidence and not one of the clues.

Motivation Through Navigation

During the first user test the participant seemed to find it exciting and fun to navigate. Participant 1 and Caregiver 1 had the following conversation about the app:

- **Caregiver 1** - "Participant 1, do you think that it was a bit fun?"
- **Participant 1** - "Yes, it was a bit fun"
- **Caregiver 1** - "Yes, I can see it on you"
- **Participant 1** - Some laughter

The participant in user test 1 was very focused on the navigation through the test session, this show some interest for the navigation. This is also supported by Caregiver 1 saying that it was more exciting to come to the intersection when talking about the motivational factor of the story.

Other Ideas for the App

Participant 4 expressed her wish for an app only counting the number of steps. She said herself that she had an app on her phone that counts the steps and that she likes to use it. She had a goal of 10,000 steps each day which is the recommended goal [52]. She then says that she struggles to reach this goal and almost never reach it, suggesting that this goal is to ambitious. [52] suggested that sedentary people should not start their goal at 10,000 steps each day, but instead set their goal 2,000 - 3,000 steps higher than their current number of steps. Caregiver 1 suggests adding a reward based on the number of steps into the current app. This was suggested with this user in mind and for other users with the same interest. For some users counting the number of steps could be distracting. Participant 3 suggest using this to explore the city and using it for tourists. Having a route exploring tourist attractions is also something that was mentioned in the expert interviews. He suggested that you could try to find Nidarosdomen based on a picture. Having a few routes of tourist attractions in some of Norway's most visited places could possibly fun and something the users would like.

Physical Activity

How physically demanding the app was depended very on the participants. In user test 1 the participant was clearly tiered, having a heavy breath throughout the test session. The participants in user test 2 however thought that they had to walk slowly to be able to use the app. This was because the app needed some time to know that the user was inside the radius of the target. Participant 4 called the speed they had to walk in "snail speed" and said that she usually walked twice as fast. The difference in walking speed is also something I noticed when participating in the hiking trips with NFU. To limit this problem the distance from the target could be set in the user setting, having two speeds of walking "normal" and "fast".

Social Interactions throughout the session

During user test 1 the participant was very concentrated and quiet. For this participant the social interactions was very limited. The participant was asked some questions, both related and not related to the app, but was to concentrated on the app to answer or gave very short answers. The participants in user test 2 talked throughout the test session. Participant 4 even said that she liked to only talk when walking, saying that she does not need something like this app. This difference in the wish for social interactions is consistent with what I have seen at the hiking trips with NFU, this was also what the interviews with experts found.

Reward

There was little response for the medals they got when completing the route in both user test. Participant 3 quickly closed the medal screen and the participant from the first user test showed little interest when the medals they got was mentioned. This could have several explanations, such as not understanding this digital medal or not wanting a medal. It is also possible that the user wanted to get back to the rest of the group quickly and was nervous about the user test.

Understanding the Instructions

It looked like the participants understood where to go when looking at the correct navigational screen. Most of the participants read some instructions out loud and when asked pointed the correct way. One participant did say that she already knew what way to walk and did not want to use the app in one intersection, so it is possible that some of the participants already knew the route. The street level pictures seemed helpful and Participant 3 said that he used the pictures to navigate. Participant 1 said she recognized where her location was based on the picture, there was a problem that many of the pictures looked similar. Participant 1 was asked if she thinks she would dare to walk on her own in the wood with this app, but answers that she would not. Caregiver 1 agrees and says that she thinks many would not be able to walk alone. Caregiver 1 also mention the usefulness of an navigational assistance app, mentioning learning to navigate to work or their parents house. Some of the instructions was difficult to understand for the participants. Participant 4 think the stop and wait instruction is difficult to understand, asking how long you should wait when discussing the stop and wait instruction. Caregiver 2 suggest changing it to “stop and click the forward button” (“Stopp og trykk videre” in Norwegian). She also think that left and right is used to much, since this is something many people with IDs struggle with.

4.3.1. Reading the Instructions at the Correct Time

Many of the participants struggled with knowing if they were at the correct screen or not. The navigational assistance system relayed on the user clicking the next button after reading the instruction. This was understood by the participants at the beginning of the test session. Participant 4 said “No, it is only each time it says “pling”, click (the button) and nothing more”. However the participants often need to be reminded to click the next button, using the lack of a beeping sound to check if they are at the correct screen. One participant got frustrated by the other participants phones beeping and not hers, this was mostly because she was further away from the target location. In the other user test this was not an issue because the participants where so focused on their own phones. Participant 3 did not think that the next button was annoying, but still did not seem completely comfortable with when to click the next button by the end of the test session. Both caregivers think that the navigational assistance system should be more automatic or at least include some sort of lock to stop the users from reaching screens further ahead in the story.

4.3.2. Using the App Outdoors

At the time of the user test there was some areas on the hiking trail that was covered in snow and ice. This made it a bit difficult for some of the participants to walk and some of them did not have the best shoes for walking this route. Because of the amount of snow and ice, one of the participants wanted to take a shortcut back. This could be a problem when the participant knows the target destination of the route and reach an obstacle, since the participant would miss several screens on the way. When using the app outdoors there is also some problems with hearing and seeing the screen. Some participants struggled with hearing what was said because of noise from other people in the area, this was solved by moving a bit further away from the noise. The sun also made it a bit difficult to see the screen when walking outside, especially some of the dark colored elements with low contrast. Having a high contrast is important for people with IDs [32] and the strong sunlight made it more difficult to see the screen.

User Interface

There was some small issues with the user interface, but also features that worked well. Always having the next button green seemed like it was appreciated and made it simple for the caregivers to explain how to move forward in the story. This became clear when the participants had to take a picture and there was a grey button instead of a green one. According to Caregiver 1 people with IDs like pictures and find the pictures used in this app straightforward. Some of the participates tried to click on the communication pictures, perhaps waiting for the sound of the picture or more information about the picture. It is also possible the participant thought that clicking the communication pictures was the way forward in the app.

Understanding the Story

All of the participants could read and would often read some text out loud. The caregiver also confirmed that Participant 1 could read. Participant 3 read the text quickly and had the following talk about reading the text:

- **Test leader** - “Don’t you want to read the story?”

- **Participant 3** - “Yes, I read quickly when it’s these small, short words”
- **Test leader** - “Yes, okay”
- **Participant 3** - “If it had been a newspaper page, then it would have taken half an hour. But when it is this small words, then it is alright”

The text refereed to here was written using the easy-to-read standard by [42], so using this standard does make the text easier to read. Because the participants in these user tests could read the audio instructions was not used. All of the participants tried playing the audio instruction after being told about the function, but did not use it without being told to play the audio instruction. The participants did not seem very interested in the story. Caregiver 1 think that the story and tasks were to difficult for the participant in user test 1. She also thinks that they were more interested in the pictures and that having tasks like click on the picture of the beaver would be better. Many participants clicked quickly through the screens and did not use a lot of time looking at each screen. They often only used enough time to read the screen very quickly and not looking at the images or thinking about the story. Caregiver 2 thinks this is something many people with IDs would do.

Take Picture Screen

Some participants struggled a bit with taking a picture and said they had taken a picture, but the app did not show this. Most likely the problem here was that the participant accidentally touched the screen. Some participants also wanted to rotate the phone when taking pictures, but the app did not support this. Overall taking pictures was received well with one participant taking out his own phone and taking a photo as well. In the hikes by NFU taking pictures was also observed as something people with IDs liked.

Accidentally Touching the Screen

Many participants struggled with accidentally touching the screen when walking between the target locations. Participants mostly touched the next button, changing to a screen further in the story, but also with the play audio instruction button. This accidentally clicking on buttons created some frustration for some of the participants. When Participant 4 accidentally touched the play audio instruction button, she said the following about the event:

- **Participant 4** - “But he talks to me anyways, because it said”
- **Test leader** - “You probably accidentally touch the button”
- **Participant 4** - “No I have not. I held it (the phone) like this (holding the phone and not touching the screen) and then it started talking”

The app did include a feature that made it possible to jump to a specific screen based on the screen ID. This feature was used several times, mostly if the participant had gone passed the current screen, but could also be used if the participant was behind the current screen.

Users Wanting to Use Their Own Phones

Several participants wanted to use their own phones for the user test, but had to use the phones belonging to our department. Participant 3 found it a bit difficult after exiting the app to go back to the app again, this was because he was not used to Samsung phones. He said that he had troubles with the Samsung phone throughout the test session and that the user should use the phone brand they are normally use. Participant 4 also said that she thought she would get the app on her own phone and was a bit disappointed when learning this was not the case. She early expressed her wish for using an app to increase her level of physical activity and wanted to use the app at home as well.

More Automatic Functions

The participants struggled with the next button, especially in the navigational screens. Caregiver 1 also mentioned the question screen as a place where the next button was a bit difficult and suggest continuing once the participant had answered the question correctly. Both caregivers think that the app should be more automatic, mentioning the navigational screen as the most important part to become more automatic. Their wish is that the system detects when the user has passed the target location and changes the screen automatically.

Participant Ending the User Test

One participant decided to stop the user test before reaching the end of the route. This participant clearly expressed her frustration over the next button and not knowing if she was at the correct screen. She understood how the next button work, in the beginning when talking about the next button being difficult, she said “No, it is only each time it says “pling”, click (the button) and nothing more”. When walking around it seems like it was more difficult to remember and the participant got very frustrated. Because of this frustration she is offered to only see the story screens, but declines this offer. The participant quits the test twice, after the first time starting to ask questions about the app again on her own. She explains her frustration the first time by saying “but I get frustrated by the clicking (of the button) and the beeping”. The participant is then asked if she likes to just walk without doing much else, where the participant answers yes. The participant had before the test expressed her interest in participating in research and her wish to help others through her participation, this could be the reason for giving the user test another try. After walking a bit further the participant is still frustrated by the navigation and gives back the phone she had borrowed. She has then completed about 75% of the route before walking of the trail and the caregiver walks after her. The other participant is then asked if he wants to continue with the test and said yes. The test leader felt it was important to ask again since the caregiver needed to follow the other participant, but also to check that the troubles with the next button had not made him that frustrated as well.

5. Limitations

Despite the innovative aspect of joining physical activity for individuals with intellectual disabilities and outdoors navigation, the lack of previous systems that combined those ideas presented some challenges and limitations that might have jeopardized the validity of some parts of the research. For instance, in the pilot study, some users struggled with too much happening at the same time and HikePal being too complex. Although this could come from a number of reasons such as remembering to click on the next button or the story being too difficult, it might have been as well that including navigation, the use of technology and physical activity at the same time was too complex. To determine this, new user tests should be conducted and some of the issues found during the user test should be addressed.

Additional, large scale experiments would also overcome potential biases that derive from the selection of participants who had a previous interest in hiking (which might have lead to some predisposition towards the HikePal and the activity carried out during the experiment), or the validity of self-reporting their emotional state and opinions in front of the researchers or caregivers (which sometimes lead to positive-acquiescence biases). more experts from each domain would be necessary to make their advice on the prototype more sound.

Adding more customisation to Hikepal in the future is likely to solve some of the aforementioned adaptive problems. Furthermore, the sample size was small, so conclusions extracted from the pilot user study should be taken carefully. An additional empirical study with a larger sample involving also participants with sensory and motor disability would shed light on the potential of this approach to foster motivation towards physical activity and suggest further improvements.

6. Conclusion

Although physical activity has proven to be beneficial for all, motivating it for people with disabilities, especially people with intellectual disabilities, is challenging and requires specialised and individualised intervention. In this paper, we study the development of a software that helps people with disabilities to get the motivation to do physical activity outdoors and describe the preliminary stages of the process in practice targeting people with intellectual disabilities. This process involves multidisciplinary requirement elicitation and participatory design. For that purpose, we have designed a working prototype of a mobile game that aims to provide navigational assistance and individualized motivation in their physical activity in outdoors environments. We also created a series of guidelines to be followed when developing applications with this purpose for people with intellectual disabilities, as the literature on this particular topic is not abundant. Both items have 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 different techniques. In our case, these "artifacts" were the working prototype of the mobile game and the design guidelines, and we employed 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 and guidelines obtained as results of the research.

Although the testing is limited in terms of sample size, usage time and user characteristics, 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. We expect that social motivation may be beneficial as well for sensory and people with motor disabilities, and we hope to test this aspect in our future work. Regarding the choose of walking as the target physical activity, we kept in mind that any activity (either physical or of other nature) must be presented in a very simple way, with clear and well-defined goals, so walking has been chosen as a starting point to design a game with this purpose, but other options can be definitively considered in the future. We must also keep in mind that offering too many options from the beginning is likely to create confusion, since people with intellectual disabilities often find decision-making a very challenging task. The selection of a 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 mild to severe intellectual disabilities, such as the requirement elicitation sessions in the interviews with experts and the focus groups, assessing the guidelines and giving opinions about the elements of the game interface.

This work brought us to reach a Technology Readiness Level (TRL [53]) of 5 for HikePal. The next steps of this research will: (1) testing Hikepal in presence of hearing and visual impairments; (2) enhancing the TRL by experimenting and demonstrating HikePal in an environment fully relevant, with a larger number of users involved.

Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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