Faculty of Electrical Engineering
Department of Computer Graphics and Interaction

Master Thesis

Motivation Methods for Crowdsourcing Accessibility Attributes

Bc. et Bc. Michaela Riganová

Supervisor: Ing. Jan Balata, Ph.D.
Field of study: Open Informatics
Subfield: Human-Computer Interaction
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ZADÁNÍ DIPLOMOVÉ PRÁCE

I. OSOBNÍ A STUDIJNÍ ÚDAJE

Příjmení: **Riganová** Jméno: **Michaela** Osobní číslo: **434694**

Fakulta/ústav: **Fakulta elektrotechnická**

Zadávající katedra/ústav: **Katedra počítačové grafiky a interakce**

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II. ÚDAJE K DIPLOMOVÉ PRÁCI

Název diplomové práce:

Metody motivace veřejnosti k davovém sběru dat o přístupnosti

Název diplomové práce anglicky:

Motivation Methods for Crowdsourcing Accessibility Attributes

Pokyny pro vypracování:

Analyzujte a navrhněte metody pro motivaci při davovém sběru dat přístupnosti. Zaměřte se především na motivační prvky, které povedou ke zvýšení kvality a množství sesbíraných dat. Vytvořte low-fidelity prototyp a ověřte s cílovou skupinou mladých lidí od 20 do 35 let. Dále vytvořte elektronický prototyp aplikace pro davový sběr dat přístupnosti a porovnejte různé navržené metody motivace s cílovou skupinou v dlouhodobé studii.

Seznam doporučené literatury:

1) SPINDELDREHER, Kai; SCHLAGWEIN, Daniel. What Drives the Crowd? A Meta-Analysis of the Motivation of Participants in Crowdsourcing. In: PACIS. 2016. p.119.
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Jméno a pracoviště vedoucí(ho) diplomové práce:

Ing. Jan Balata, Ph.D., Katedra počítačové grafiky a interakce

Jméno a pracoviště druhé(ho) vedoucí(ho) nebo konzultanta(ky) diplomové práce:

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Ing. Jan Balata, Ph.D.	podpis vedoucí(ho) ústavu/katedry	prof. Mgr. Petr Páta, Ph.D.
podpis vedoucí(ho) práce		podpis děkana(ky)

III. PŘEVZETÍ ZADÁNÍ

Diplomantka bere na vědomí, že je povinna vypracovat diplomovou práci samostatně, bez cizí pomoci, s výjimkou poskytnutých konzultací. Seznam použité literatury, jiných pramenů a jmen konzultantů je třeba uvést v diplomové práci.

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Podpis studentky

DECLARATION

I hereby declare that I have written this master thesis independently and quoted all the sources of information in accordance with Methodical instructions about ethical principles for writing academic theses.

In Prague, January 2020

Bc. et Bc. Michaela Riganová

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Firstly, I would like to express my sincere gratitude to my supervisor Ing. Jan Balata, Ph.D., for the continuous support, aspiring guidance and invaluable advice during the whole period. Secondly, I would like to thank all the people who participated in the research and the usability tests for their cooperation and feedback. I am also grateful to my family for supporting me during my studies. At last but not least, I would like to thank my beloved Anton for being my biggest fan.

ABSTRACT

A key to online crowdsourcing platforms is a sufficient amount of high-quality data collected by users. Therefore it is essential to define motivation methods which would attract a large crowd and make it perform at a high level. In this thesis, we report on the results of our research focused on designing the most effective motivation methods for an online non-profit crowdsourcing platform focused on collecting accessibility data. Following the User-Centered Design methodology and based on the comprehensive analysis of the literature available, we have identified five main motivational factors and incorporated them into low-fidelity and high-fidelity prototypes of the mobile application. The prototypes were evaluated with the target group, the low-fidelity prototype via usability testing (N = 5, mean age = 27.6) and the high-fidelity prototype via diary study (N = 5, mean age = 27.2). The results suggest the feasibility of the approach supported by enhancing causal importance and perceived self-efficacy of users, providing them training and feedback on contributions, supporting a feeling of cooperation and allowing them to share data collection with friends.

KEYWORDS

non-profit crowdsourcing, motivation, motivational factors, accessibility data, User-Centered Design

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ABSTRAKT

Dostatočné množstvo a vysoká kvalita dát zozbieraných užívateľmi sú kľúčové pre online platformy založené na davovom zbere. Preto je nevyhnutné definovať metódy motivácie, ktoré by prilákali širokú verejnosť a viedli ju k vysoko kvalitnej práci. V diplomovej práci uvádzame výsledky nášho výskumu zameraného na návrh najúčinnejších metód motivácie pre online neziskovú crowdsourcing platformu zameranú na zber dát o prístupnosti. Využitím princípov User-Centered Designu a na základe komplexnej analýzy dostupnej literatúry sme identifikovali päť hlavných motivačných faktorov a začlenili sme ich do low-fidelity a high-fidelity prototypov mobilnej aplikácie. Prototypy boli otestované s cieľovou skupinou, low-fidelity prototyp pomocou užívateľského testovania (N = 5, priemerný vek = 27.6) a high-fidelity prototyp pomocou denníkovej štúdie (N = 5, priemerný vek = 27.2). Výsledky testovania naznačujú aplikovateľnosť tohto prístupu do praxe, ak u užívateľov zvýšime vnímanie kauzality a efektivity ich vlastného zberu, poskytneme im tréning a spätnú väzbu k zozbieraným dátam, podporíme v nich pocit spolupráce a umožníme im zdieľať aktivitu s priateľmi.

KĽÚČOVÉ SLOVÁ

neziskový crowdsourcing, motivácia, motivačné faktory, údaje o prístupnosti, User-Centered design

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1. INTRODUCTION

According to Sammer et al. (2012), almost 16 % of the population is limited in mobility, namely visually impaired, hearing impaired, wheelchair users, and people with impaired ability to walk. When in an unknown environment, navigation and orientation is especially difficult for people with limitations in mobility. Appropriate navigation system considering pedestrian networks and their accessibility attributes can help to ensure safe and independent navigation. However, many navigation systems are available worldwide, they are primarily designed for cars, thus ignoring sidewalks, crosswalks, landmark information and important accessibility attributes. To address this issue, CTU in Prague designed a sidewalk-based geodatabase (Geographical Information System – GIS) with line features representing pedestrian segments such as sidewalks, crosswalks and underpasses, and point features representing obstacles on segments, and landmarks, i.e. corners and recesses. GIS further contains their attributes e.g. sidewalk slope, passable width, material, corner shape. The features and their attributes were carefully designed and selected in cooperation with orientation and mobility specialists. The GIS designed in this way enabled us, for example, to generate landmark-enhanced itineraries for blind pedestrians (Balata, Mikovec, Bures, Mulickova 2016). The GIS is created in two phases: 1) Pedestrian segments with line and point features are drawn into the GIS by professionals using resources such as satellite images and maps of town utilities, creating a template for the second phase. 2) The template is filled in with attributes assigned to the features via professional on-site reconnaissance. Using professionals to fill attributes into GIS is highly labour demanding. Our aim is to reduce the costs of the on-site reconnaissance and speed up the data collection by designing a mobile application for collection of pedestrian attributes using crowdsourcing. The non-experts will fill the data in the professionally created template of the GIS for a fraction of the effort of professional on-site reconnaissance. Successful crowdsourcing platforms should be both attractive to potential participants and also fulfilling sufficient data quality standards (Graham et al. 2015). In our previous research (Riganova, Balata, Mikovec 2017) we examined the capabilities of a crowd in collecting accessibility attributes. According to results, if provided training, feedback, and monitoring, contributions from non-expert crowd could rival those of professionals and if enough people review collected data, their quality should not differ significantly. Our research confirmed that geo-crowdsourcing can be used as an alternative tool for geodata collection, but also raised a concern about people's motivation to get involved in crowdsourcing platform. To introduce a successful platform, we added a gamification layer as a motivation tool to supplement the data collection layer of our application prototype. According to prototypes' evaluation, added motivation layer can support the collection of accessibility data (Riganova 2017). As users' participation in online crowdsourcing platforms is crucial, we decided to investigate motivating factors in crowdsourcing further in depth to understand how to attract a large number of crowds and lead them to high-quality work.

The main research questions are: What motivate people to participate in crowdsourcing platforms? What are the drivers for attracting a large number of participants? How to sustain participants' motivation for a longer period? How can we lead participants to high-quality work?

2. RELATED WORK

2.1. DEFINING CROWDSOURCING

Over the past years, crowdsourcing has gained significant interest in research and online content creation. The term crowdsourcing is a neologism that combines *crowd*, which refers to the notion of 'the wisdom of crowds' (Surowiecki 2004) and *outsourcing* as the process of obtaining information or services from a foreign supplier. The term was coined in 2006 by Jeff Howe, contributing editor of Wired Magazine, as meaning "the process by which the power of the many can be leveraged to accomplish feats that were once the province of a specialized few" (Howe 2008). In other words, crowdsourcing uses the power and wisdom of large groups of people to accomplish tasks that would otherwise be too cumbersome, large, or impractical for any one person or organization to attempt (Armstrong, 2014). With the development of new technologies, the term 'crowdsourcing' is undergoing constant evolution. Estellés-Arolas and González-Ladrón-de-Guevara (2012) provides a wide definition that covers the majority of existing crowdsourcing processes emphasizing online and voluntary character of crowdsourcing: *Crowdsourcing is a type of participative online activity in which an individual, an institution, a non-profit organization, or company proposes to a group of individuals of varying knowledge, heterogeneity, and number, via a flexible open call, the voluntary undertaking of a task. The undertaking of the task, of variable complexity and modularity, and in which the crowd should participate bringing their work, money, knowledge and/or experience, always entails mutual benefit. The user will receive the satisfaction of a given type of need, be it economic, social recognition, self-esteem, or the development of individual skills, while the crowdsourcer will obtain and utilize to their advantage what the user has brought to the venture, whose form will depend on the type of activity undertaken.* (Estellés-Arolas and González-Ladrón-de-Guevara 2012).

Crowdsourcing is an umbrella concept, which covers a variety of types of activities. Geigler and Schader (2014) distinguish four kinds of crowdsourcing based on the deriving value from contributions and differentiating value between contributions: crowd processing, crowd solving, crowd creating and crowd rating. In crowd processing, all members of the crowd perform the same tasks. Valid contributions thus represent qualitatively identical chunks of work. The accuracy of the result is derived from the number of identical solutions for the task. Crowd solving refers to finding a solution to a complex problem by letting the crowd resolve it. The wide range of crowd solutions are qualitatively different and thus represent alternative or complementary solutions to a given problem increasing the likelihood that the problem will be solved correctly. Crowd creating is a process of creating unique works as part of a larger desired complex. Contributions have a complementary share in the collective outcome depending on their individual qualities and their relationship with others. Crowd rating represents an effort to deduce collective response from large amounts of homogeneous contributions which represent votes on a given topic.

Although crowdsourcing refers to multiple types of activities, these activities share common characteristic: the crowd; the task at hand; the recompense obtained; the crowdsourcer or initiator of the crowdsourcing activity; what is obtained by them following the crowdsourcing process; the type of process; the call to participate; and the medium (Estellés-Arolas and González-Ladrón-de-Guevara 2012). This means crowdsourcing can be considered as one wider phenomenon. The biggest challenges crowdsourcing is dealing with are how to get high-quality data and how to attract large crowds to involve

in crowdsourcing activities. The common denominator of these two challenges is motivation. Motivation determines the quality and quantity of contributions (Janzik 2010).

2.2. THE MOTIVATION THEORY

Aim of the motivation theory is to explain a drive that forces an individual to take action and work in a certain way. Motivation is not a unitary phenomenon. People can have different amounts and different types of motivation based on their level of activation, which reflects their specific needs, goals and attitudes (Ryan and Deci 2000). Based on the Self-Determination Theory introduced by Deci and Ryan (2000), motivations can be split into two main types: intrinsic motivation and extrinsic motivation. Intrinsic motivation refers to the task itself being enough for satisfaction and no further reward apart from the activity is needed, e.g. acting for fun or challenge. Extrinsic motivation contrast with intrinsic motivation. Extrinsic motivation is present when an activity is done in order to attain some separable outcome, e.g. acting for money or prize. Furthermore, the Self-Determination Theory declares that extrinsic motivations can undermine the effect of intrinsic motivations such that if someone is offered a monetary reward for doing an activity which he/she actually enjoys, he/she will become less likely to do the activity if no reward is offered in the future. In addition to intrinsic and extrinsic motivation, social motivation as a third category of motivational factors has been identified (Antikainen and Vaataja 2010). Social motivation can be seen as a continuum with intrinsic motivation on one end, extrinsic motivation on the other end, and social motivations positioned between them (Frey et al. 2011). Supplement concept to motivation is amotivation which exists if a person's behaviour lacks intentionality and a sense of personal causation, i.e. a person's behaviour lacks an intention to act (Ryan and Deci 2000). Amotivation can be a consequence of not valuing an activity (Ryan 1995), feeling incompetent to do an activity (Deci 1975), or disbelief it will produce the desired result (Seligman, 1975).

2.3. MOTIVATION FOR CROWDSOURCING

In order to create a successful crowdsourcing platform, it is very important to answer the following question: Why do people participate in crowdsourcing? A variety of studies have been conducted to propose answers to this question. Among studies, there is a great variety of factors that are claimed to motivate people to participate and incentives which can increase motivation to participate in crowdsourcing activities. Based on the motivation theory these factors can be categorized to three main categories: 1) intrinsic motivational factors when the reward for participating comes from the activity itself; 2) extrinsic motivational factors when the rewards for participating come as a result of one's activity, and not from performing the activity itself; 3) social motivational factors when participation is impacted by social motives. Namousi and Kohl (2016) identified 25 distinct motivational factors and expand categorization above to sub-categories: hedonism, learning, ideology, individual and economic related motivations (see Table 1).

MAIN CATEGORIES OF MOTIVATIONAL FACTORS	SUB-CATEGORIES OF MOTIVATIONAL FACTORS	MOTIVATIONAL FACTORS
intrinsic	hedonism	enjoyment and fun; intellectual stimulation; entrepreneurship; an outlet of creative energy; a chance to exercise amateur skills
	learning	knowledge creation; knowledge exchange; improving creative skills
	ideology	self-esteem; a sense of efficacy
extrinsic	individual	reputation; competition; firm recognition; career opportunities; freelance opportunities; self-marketing; a user need
	economic	tangible rewards; an implicit promise of rewards
social	-	altruism; care for community; friendship; peer recognition; addiction to a community

Table 1 Categorization of motivational factors for participation in crowdsourcing by Namousi and Kohl (2016)

In order to identify which intrinsic, extrinsic and social motivational factors are important, Spindeldreher and Schlagwein (2016) analyzed number of empirical quantitative studies on the motivation of crowdsourcing participants and identified six salient motivational factors, which have statistically-significant positive impact on the likelihood of participation:

- salient intrinsic motivational factors: enjoyment, challenge and passing of time,
- salient extrinsic motivational factors: compensation and outward recognition,
- salient social motivational factors: sense of community.

Enjoyment. Enjoyment, referring to an individual's wish to feel pleasure, to have fun or to be entertained, is the most dominant intrinsic motivational factors present in crowdsourcing platforms (Brabham 2008; Ståhlbröst and Bergvall-Kåreborn 2011; Sun, Wang and Peng 2011; Schroer and Hertel 2009). According to Spindeldreher and Schlagwein (2016), enjoyment is a salient motivational factor which generally has a significant positive impact on participation and can increase contributions (Olson and Rosacker 2013; Tokarchuk et al. 2012).

Challenge. Challenge refers to an individual's wish to develop or improve skills, to enhance knowledge or to do something intellectually stimulating. Challenge has been shown to be a strong motivational factor for participation (Füller 2006; Kosonen et al. 2014; Ståhlbröst and Bergvall-Kåreborn 2011). According to Spindeldreher and Schlagwein (2016) challenge has a typically positive but not always significant impact on participation.

Passing of time. The passing of time refers to an individual's wish to fight a sense of boredom or to bridge a gap between other activities. Passing of time shares some similarities with the enjoyment factor

and has a statistically significant positive impact on the likelihood of participation in crowdsourcing activities (Spindeldreher and Schlagwein 2016).

Compensation. Compensation refers to an individual's wish for tangible rewards such as money, prizes, gifts, or free products or services. Several studies have found compensation a key motivating factor in crowdsourcing platforms where payment is offered (Brabham 2010; Lakhani et al. 2007). Compensation generally increases workers' willingness to accept a task, leads to a faster and higher output of results, but do not improve the quality of the work (Mason & Watts 2009; Shaw et al. 2011). On the other hand, Zheng et al. (2011) found no significant correlation between compensation and participation, thus rewards are not always a driving motivation. Moreover, the impact of the rewards might under certain circumstances be negative. This appears to be the case in creatively (Toubia 2006) and altruistically framed crowdsourcing (Spindeldreher and Schlagwein 2016).

Outward recognition. Outward recognition refers to an individual's wish for reputation, recognition, fame or status. There is a positive correlation between the willingness to participate and gaining an outward recognition. Participants get involved in crowdsourcing to obtain reputation and recognition (Tokarchuk et al. 2012; Zheng et al. 2011). According to Spindeldreher and Schlagwein (2016), outward recognition has a typically positive but not always significant impact on participation. Reputation is strongly related to competition. Improving reputation by showing that participants are better or do more than others is a strong motivational factor (Tokarchuk et al. 2012). Competitive gamification mechanisms like leaderboards of the most active participants can be seen in many crowdsourcing platforms and are frequently cited as key enablers (Reed et al. 2013; Bowser et al. 2013). On the other hand, Eveleigh et al. (2013) argue that gamification mechanisms which motivate leading participants can be ignored by more casual participants and even discourage them from participation.

Sense of community. Sense of community refers to an individual's wish to be part of a group of like-minded people and interest communities. According to Spindeldreher and Schlagwein (2016), a sense of community has a statistically significant positive impact on the likelihood of participation. Wasko and Faraj (2000) argue that the primary reason for using forums and communities is not socializing or developing relationship but care for community. Giving back help to the community in return can be a strong reason for participating in crowdsourcing.

Some of the factors introduced in this section can be seen as parts of a broader concept of psychological empowerment. Psychological empowerment '*links individual strengths and competencies, natural helping systems, and proactive behaviours to matters of social policy and social change. It is thought to be a process by which individuals gain mastery or control over their own lives and democratic participation in the life of their community*' (Zimmerman and Rappaport 1988). Psychological empowerment has been proved to be an efficient tool in improving citizen participation (Zimmerman and Rappaport 1988) and also an efficient motivational tool for crowdsourcing activities (Goncalves et al. 2015). According to the study of Goncalves et al. (2015), psychological empowerment elicits more positive types of contribution and increased participation. The study highlights two psychological empowerment approaches, i.e. causal importance and perceived self-efficacy, as effective motivational factors which can increase participation and also improve the quality of contributions. On the other

hand, in contrast to prior research (Spindeldreher and Schlagwein 2016), sense of community as psychological empowerment approach does not substantially increase participation.

Crowdsourcing platforms usually include more than one of the listed motivational factors. Motivational factors must be thoroughly combined. Using factors that are essentially extrinsic to motivate participants in activities where motivations are largely intrinsic may have a negative effect on motivation (Deci et al. 1999). Furthermore, Gneezy et al. (2000) found that when extrinsic motivations factors are in the form of insufficient monetary rewards it tends to override the possibly larger effect of the intrinsic motivational factors, thus the performance is likely to be worse than when no reward is offered at all. Moreover, the causality between increased reward and increased quality of contributions has not been confirmed (Mason and Watts 2009). On the other hand, Rogstadius et al. (2011) suggest that participants' performance can be improved significantly through intrinsic motivational factors.

2.4. MOTIVATION FOR NON-PROFIT CROWDSOURCING

Non-profit crowdsourcing is a special case of crowdsourcing focusing on activities which directly or indirectly increase the welfare and help other people e.g. people in need, people with disabilities or people affected by a disaster. The main motivational factor applicable here is altruism. People motivated by altruistic considerations are convicted about the importance of the project and are willing to expend significant time and effort for the right cause without any expectation or need for compensation (Wasko and Faraj 2000; Chandler and Kapelner 2013; Olson and Rosacker 2013). Presenting crowdsourcing activities meaningfully motivates people to participate, increases the quantity of output, but it has no effect on the quality of contributions (Chandler and Kapelner 2013). On the other hand, Rogstadius et al. (2011) argue that framing a task as helping others can succeed in improving output quality. Altruism itself should be enough of a motivator since it appeals to people's desire to help, but this can only work if participants actually think the problem being solved is interesting and important which is in most cases hard to achieve (Goncalves et al., 2013). Therefore, altruism is typically not sufficient as a motivational factor (Goncalves et al. 2015).

Baruch, May and Yu (2016) held an experiment with the aim to explore motivation and potential barriers to engaging in non-profit crowdsourcing. They have studied motivation of nearly 3000 participants of the non-profit crowdsourcing online project Tomnod for identifying objects and places in satellite images. Tomnod works on the principle of campaigns, from which the participant can choose and tag objects on images for different purposes including assisting in disaster response. Tomnod provides a suitable platform for expanding the research into crowdsourcing as an online volunteering activity as its campaigns are unique and largely altruistic, aiming to help disadvantaged communities. Baruch, May and Yu discovered that although motivations of Tomnod participants are largely altruistic, perceiving it as an alternative to charity work, helping alone may not be enough to keep all participants engaged. Even though volunteers may be drawn to the platform with altruistic intentions, their continued participation depends also on other motivational factors.

Based on the study of Baruch, May and Yu (2016) we can identify other important motivation factors for non-profit crowdsourcing as an addition to motivational factors listed in the previous section:

Follow-up information. Participants are interested in follow-up information about the use and news on how much they are actually helping. Not knowing the impact of their activities might discourage the participants from their continued participation in crowdsourcing activities.

Feedback on the accuracy of data. Participants raised concerns about the accuracy and quality of their contributions. Uncertainty of contributions' accuracy might result in becoming less active on the platform.

Contribution to the design of the platform. Shows that the functionality and aesthetics of the website also play a key role in determining its popularity. Letting these volunteers contribute to the design of the platform by listening to their feedback evidently plays a critical role in keeping them engaged.

Contact with the task submitter. This motivational factor is linked with the providing follow-up information on the impact of participants' contributions, giving feedback on data accuracy and contributing to the design of platform which can be feasible only if the sufficient level of contact with the task submitter is given.

Training. Central to participant motivation and willingness to volunteer is increased training on how to identify objects with examples and guides.

Feeling of cooperation. Based on the study, a feeling of cooperation is far more important for the participants of non-profit crowdsourcing than competition between them. Gamification is more popular amongst younger participants, but there is a high risk that gamification will destroy the user experience of other participants who are more casual. This supports arguments made in Eveleigh et al. (2013) that gamification mechanisms can discourage some participants from participation.

Certificate. Giving participants a certificate or some kind of award, which will manifest their contribution, can strengthen their engagement to the crowdsourcing platform. However, as mentioned earlier in connection with gamification mechanisms, this kind of rewards might cause some to feel ignored.

Community forum. This study also highlights the importance of the forum in generating a sense of collectivism, breaking down barriers between volunteers who participate in isolation and improving data quality among participants.

Personal circumstances. Contrary to expectations that majority of crowdsourcing participants are young adults, the study shows that a large part of the user base is made up of retired participants and participants with a disability or a long-term problem, thus highlighting the personal circumstances of participants as a strong motivational factor. Simple crowdsourcing tasks are considered as an alternative to charity work, which can be done from the convenience of participants' home and may even improve their health condition.

2.5. DESIGN OF CROWDSOURCING TASKS

Besides factors which motivate participants to solve the task, the quality of the crowdsourced data is also related to the design of the task itself (Kittur et al. 2013). The design of tasks contains many aspects such as interface, description, guidance or difficulty level. Participants of crowdsourcing platforms have different needs, some like to be challenged with more difficult tasks while others prefer easier tasks with greater guidance. However, interfaces that are very complex might result in decreased task result quality (Kittur et al. 2013). Finnerty et al. (2013) proved that keeping tasks simple and requiring less demand for workers' attention provide more accurate results. Moreover, the study of Baruch, May and Yu (2016) found out that if the crowd is asked to do one task at a time, they do a much better job because they can fully focus on it. Thus, the simplicity of tasks can lead to better quality results of crowdsourcing activities.

3. DESIGN

3.1. METHODOLOGY AND BASIC TERMS

This thesis was written with a User-Centered Design (UCD) approach. UCD is an iterative design approach which focuses on putting users at the centre of each phase of the design process and development. Users' needs, wishes, mental processes, contexts and interactions are researched to create highly usable products for them (Norman, 1986).

Terminology related to UCD used in this thesis:

T1 Scenario - A fictitious story of a user's interaction with the product in the context of a user's everyday life.

T2 Storyboard - An illustration of the interaction between a user and a product in a narrative format.

T3 Prototype - A draft version of a product used for testing.

T4 Hierarchical Task Analysis (HTA) - Decomposition of a high-level task into a hierarchy of subtasks a user needs to perform to fulfil it.

3.2. DESIGN WORKSHOP

The design workshop was organized in collaboration with designer M.A. Marie Doucet, Ph.D. from the Institute of Industrial Design, CTU in Prague.

3.2.1. RESEARCH QUESTIONS

The design workshop has been conducted to research the main areas of crowdsourcing which have a proclaimed impact on contributions to crowdsourcing projects and the quality of crowdsourced data:

- Motivation: What motivates people to participate in crowdsourcing? How can we make crowdsourcing a habit? What value would participants get out of a crowdsourcing application?
- Task design: How to design a task to collect high-quality data?

3.2.2. PARTICIPANTS

Participants of the design workshop are first-year university students of Department of Product Design, CTU in Prague. We have invited 12 students, both females and males. Participants were asked to work in couples.

3.2.3. APPARATUS

The first part of the design workshop was held in the exterior in the vicinity of Faculty of Architecture, CTU in Prague. Every couple was given a map with marked pedestrian segments in the faculty vicinity

(see Figure 1) and a paper form for a collection of accessibility attributes of the marked segments. The form included numerous tasks for different types of segments, e.g. select the slope of the sidewalk in the direction of your route, select the sidewalk surface type, select the corner shape, select the crossing ramp type, select the tactile elements present on the crossing. The second part of the workshop was situated in the classroom interior. Every participant was given a workbook[1], a template for mobile prototypes, post-it notes and three sticky dots for voting. Furthermore, materials for creating paper objects, e.g. papers of different colours and thickness, scissors, glues, markers were available. At the end of the workshop, from each participant we received a completed workbook with captured ideation process, post-its with found problems and a sketch, a paper mobile prototype or a paper object of a solution to one selected problem.

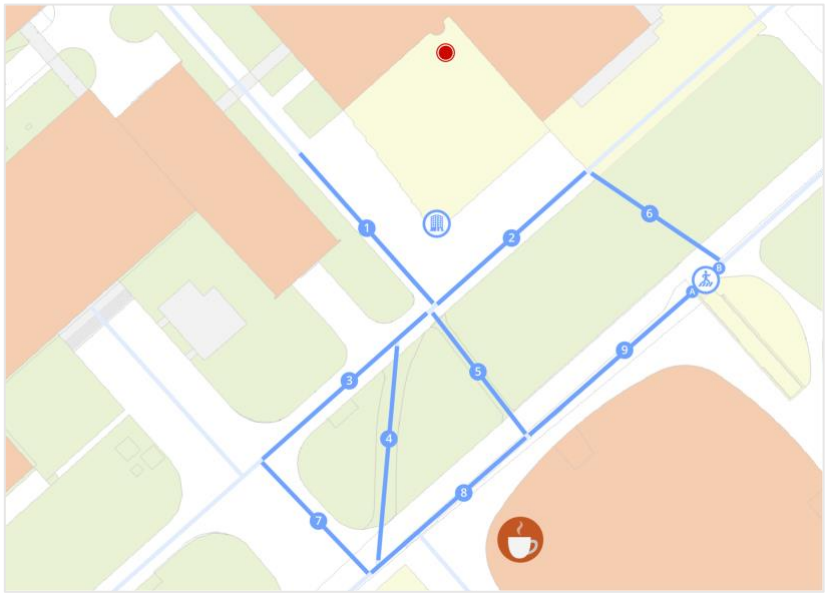

Figure 1 The map with marked segments for accessibility data collection

3.2.4. PROCEDURE

At the very beginning of the workshop, participants were introduced to the navigation system for visually impaired people, which uses sidewalk-based geodatabase with accessibility attributes designed at CTU, and the purpose of the workshop was presented. The workshop was divided into two main parts: 1) the hands-on experience with crowdsourcing of accessibility data and 2) the design studio (see Figures 2 - 3). In the first part, participants were asked to step outside and walk from the faculty to the nearest coffee shop using one of the routes consisting from pedestrian segments marked on the map. Along the way, they were supposed to collect accessibility features of segments using given paper form. In the second part, participants were asked to redesign the crowdsourcing experience of collecting accessibility data. Detailed program of the design studio can be seen in Table 2. The whole workshop lasted 2.5 hours.

[1] The workbook template has been downloaded and modified from The Stanford d.school's materials available online at https://dschool-old.stanford.edu/groups/designresources/.

1) Empathy Description: Short interviews in pairs. Number of iterations: 2 Instructions: First iteration – ask about the previous experience with crowdsourcing, charitable work, habits etc. (e.g. When was the last time you did something for others/charitable work/start a new habit?; What did motivate/discourage you?; What was difficult?; What helped you?). Second iteration – select one area and go into more detail - ask for stories, feelings and emotions (ask Why?).
2) Problem definition Description: Capturing findings and discussing them with the group. Number of iterations: 1 Instructions: Synthesize your learning into two groups: your partner's goals and wishes, and insights you discovered. Select the most compelling need and the most interesting insight to articulate a point-of-view. Use the template '[Name] needs to [action] because [insight]'. Write it on a post-it, present it to the group and discuss.
3) Ideation Description: Individual sketching based on previous interviews and the defined problem. Number of iterations: 2 Instructions: First iteration – Create a solution to the problem you have identified, sketch as many ideas as possible. Share your sketches with your partner and listen to his/her reactions and questions. Second iteration – Based on the partner's feedback, take the strongest elements of various ideas and combine them into a new idea, sketch it in detail and get feedback from your partner.
4) Prototype Description: Building and testing a paper prototype. Number of iterations: 1 Instructions: Create a physical prototype of your solution. Use whatever materials are available to you. If your solution is a mobile app, use a mobile template. If your solution is a service or a system, create a scenario that allows your partner to experience it. Share your prototype with your partner.
5) Reflection Description: Presenting a solution to the group and discussing ideas. Number of iterations: 1 Instructions: Present your solution to the group. Try to convince them about the relevance of your found problem and its solution. You have one minute.
6) Prioritization Description: Voting for the best ideas. Number of iterations: 1 Instructions: Vote with sticky dost (3 each) to choose the best ideas. You can vote for one idea or more.

Table 2 Program of the design workshop

Figure 2 Design studio: Short interviews in pairs

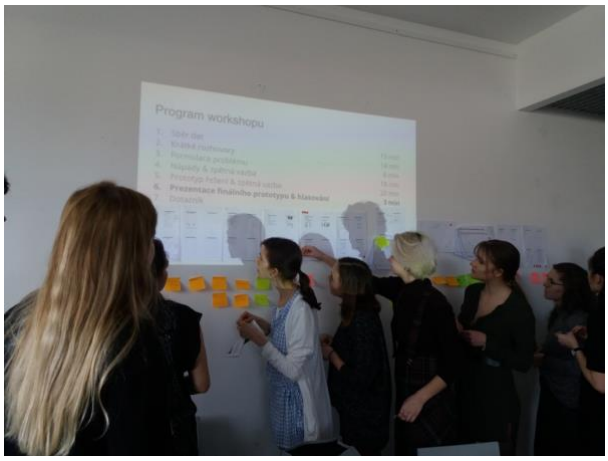

Figure 3 Design studio: Voting for the best ideas

3.2.5. BIAS, LIMITATIONS OF THE METHOD

Participants were first-year design students, they had either any or only a little experience with a design process of a product or an application. They had little to no experience with the specific user group. During the whole design studio, we tried to guide them and introduce them to the best design practices.

3.2.6. RESULTS

Found problems and needs of the participants are grouped based on similarities and sorted by their relevance, i.e. by a number of repetitions. Proposed solutions to the problems and needs found are based on the final prototypes created by participants of the design workshop (see Figures 4 - 5 for examples).

Finding no. 1: Collection of accessibility data is a difficult, slow and boring activity.

Solution proposed:

- Give the possibility to report the problem quickly and effectively by uploading photography.
- Include runners, dog owners, parents with children, bikers and Nordic walkers. Data collection can be done from videos recorded when doing these activities or from running/walking statistics.
- Use simple UI elements such as sliders, pictograms, photos and hints.
- Highlight the data in the map which need to be collected with high importance.
- Use AI for image recognition of obstacles.
- Encourage exploration by treasure hunt experience.

Finding no. 2: Participants have low awareness about the life of disabled people in society. They are unable to empathize with disabled people because of the lack of information about their lives. They don't know how exactly the data collection will help and whom.

Solution proposed:

- Raise awareness about the life of people with disabilities through blogs, social media, disabled honest guide, videos and extra content in the application, and live events for educational purpose.
- Learn how people with disabilities perceive the world around them by walking tour with a disabled person, provide Prague obstacle/accessibility fail Facebook page or sound pexeso.

Figure 4 Design studio: Example of a final prototype

Figure 5 Design studio: Example of a final prototype

Finding no. 3: Low confidence in the ability to help and lack of knowledge of how it should be done properly are barriers for participants to join the data collection.

Solution proposed:

- Provide an educational game "Guess the obstacle". Let user guess on which picture of the pairs of pictures is an obstacle and explain to him/her why. User will learn how to identify the obstacle in an entertaining way.

Finding no. 4: Participants expect a reward for their collaboration.

Solution proposed:

- Collaboration with sponsors.
- Show the physical distance to various rewards (e.g. coffee) and let the user select the distance he/she is willing to cover.

Finding no. 5: Participants want to share their activity with friends (see who is involved and how much).

Solution proposed:

- Add friends with Facebook.
- Compare the user's activity with friends.

Finding no. 6: Participants want to compare their results with others.

Solution proposed:

- Provide statistics of own data collection e.g. points, ranks, charts, kilometres mapped.
- Compare the user's activity with friends.
- Give plus points for a difficult route or attribute.

Finding no. 7: Data collection needs to be periodically reminded to participants.

Solution proposed:

- Use notifications to remind activity.
- Make the collection of data a civic duty, use sirens to invite people to collect data on the first Wednesday of the month.

Finding no. 8: For participants who don't have an active mobile data plan, on-site collection data through a mobile application is not possible.

Solution proposed:

- Allow to take a picture of the place offline and then collect data from it from the comfort of the home.
- Partnership with a telecom provider.

3.2.7. DISCUSSION

The results agree with claims of Goncalves et al. (2015) that in order to attract large user base we need to raise awareness about the life of disabled people and convince users that navigation of people with disabilities in an urban environment is an important problem. Further, in line with the statement of Kittur et al. (2013) results show that good design, usability and simplicity of the crowdsourcing tasks are key enablers of crowdsourcing activities. To speed up the data collection, the inclusion of photographs as a source of data should be considered. Moreover, the user should be in charge of deciding how much he/she want to be involved in data collection. The results also agree with Baruch, May and Yu (2016) on training being central to participant motivation and willingness to volunteer. Results suggest that providing it in a fun and educational way might increase users' self-confidence and encourage them to start mapping their city. What is more, one of the findings refers to an individual's wish for tangible rewards such as money, prizes, gifts, free products or services, as a key enabler for crowdsourcing of accessibility data. However, as Spindeldreher and Schlagwein (2016) pointed out, the impact of the rewards might be negative in case of altruistically framed crowdsourcing. The results also suggest that providing gamification elements such as leaderboards, points or rewards, might appeal especially to younger users. However, based on the findings of Baruch, May and Yu (2016) the feeling of cooperation might be a stronger long-term motivational factor in the non-profit crowdsourcing project.

3.3. Application Design

Using the gathered information from the analysis of available literature and the conducted workshop we designed the initial draft of the motivational layer of the crowdsourcing application. We present recognized motivational factors which might be relevant for non-profit crowdsourcing of accessibility data and we describe three main use-cases, in which motivational factors can be used. All three use-cases are outlined in storyboards and scenarios. Model of the future solution is introduced. Furthermore, the low-fidelity paper prototype and the high-fidelity prototype are presented.

3.3.1. Motivational factors

Based on the non-profit nature of the accessibility application with the aim to help a specific group of people, i.e. wheelchair users and blind pedestrians, altruism is the primary motivational factor. As framing a task as helping others might not be sufficient as a motivational factor (Goncalves et al. 2015), we have identified five additional factors with intention to increase participation and motivate participants for higher quality results of crowdsourcing activities. These factors also have a supportive role for altruism and should lead the participant to recognize that the problem being solved is interesting and important. We implement these factors in the motivational layer of the crowdsourcing application for collection of accessibility data and describe them in the storyboards and scenarios. The suggested motivational factors are as follows:

- psychological empowerment to enhance causal importance and perceived self-efficacy, referring to an individual's wish to receive follow-up information on the use of collected data and news on how much he/she is actually helping,
- training referring to an individual's wish to be trained on how to collect data properly,
- feedback on the accuracy of data referring to an individual's wish to be informed about the accuracy and quality of his/her contributions,
- feeling of cooperation referring to an individual's wish to be part of a community, which cooperate in solving one bigger task,
- sharing activity with friends referring to an individual's wish to see who from his/her friends is involved and how much.

3.3.2. Use-cases

Use-case 1. Impact recognition

Motivational factors: psychological empowerment enhancing causal importance and perceived self-efficacy

Scenario: Anna has just recently found out about the application which maps accessibility attributes. She likes the idea of being able to help the people with disabilities during the few free minutes of the day. She doesn't know anything about how the visually impaired pedestrians are moving across the city. After seeing the video in the application, she realized how dangerous this can be for them. On her way to school, she has decided to mark a few crossings into the application in order to help visually impaired pedestrians to move around the city safely. The next day, Anna has received a thank you note from the actual user of the navigation system for visually impaired people. Anna was really pleased that the data

she has collected helped an actual person with a handicap. This was a big encouragement for her, and she is determined to collect and map more data into the application.

Storyboard: See Figure 6.

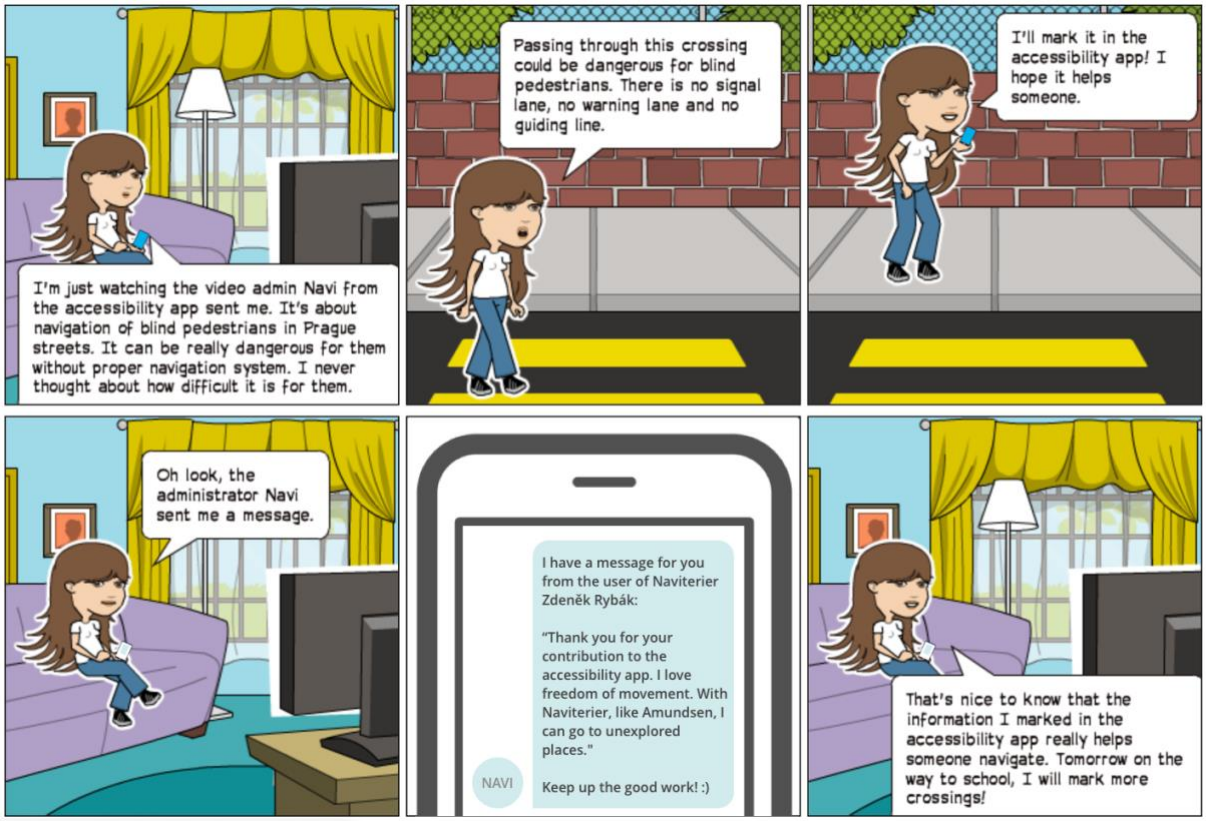

Figure 6 Storyboard: Impact recognition

Use-case 2. Providing training materials and feedback on collected data

Motivational factors: training, feedback on the accuracy of collected data

Scenario: Peter has installed the application for mapping accessibility attributes a few months ago. He used it a couple of times, but he wasn't sure whether the information he has entered was correct. On his way to school, the application prompted him to play 'Guess the obstacle' game. It was a fun game and at the same time, it taught Peter how to properly identify the relevant obstacles for visually impaired pedestrians and people on wheelchairs. Peter wanted to practice the freshly gained knowledge, so he kept collecting the obstacles for the whole week. The application gave Peter detailed statistics about the collected data. It turned out that Peter achieved 100% accuracy while collecting the information about obstacles, but only 60% of accuracy while collecting information about pedestrian crossings. The application offered Peter to play another game - 'Identify the pedestrian crossing elements'. This will help Peter to identify the mistakes he has been doing and will increase his accuracy for the future.

Storyboard: See Figure 7.

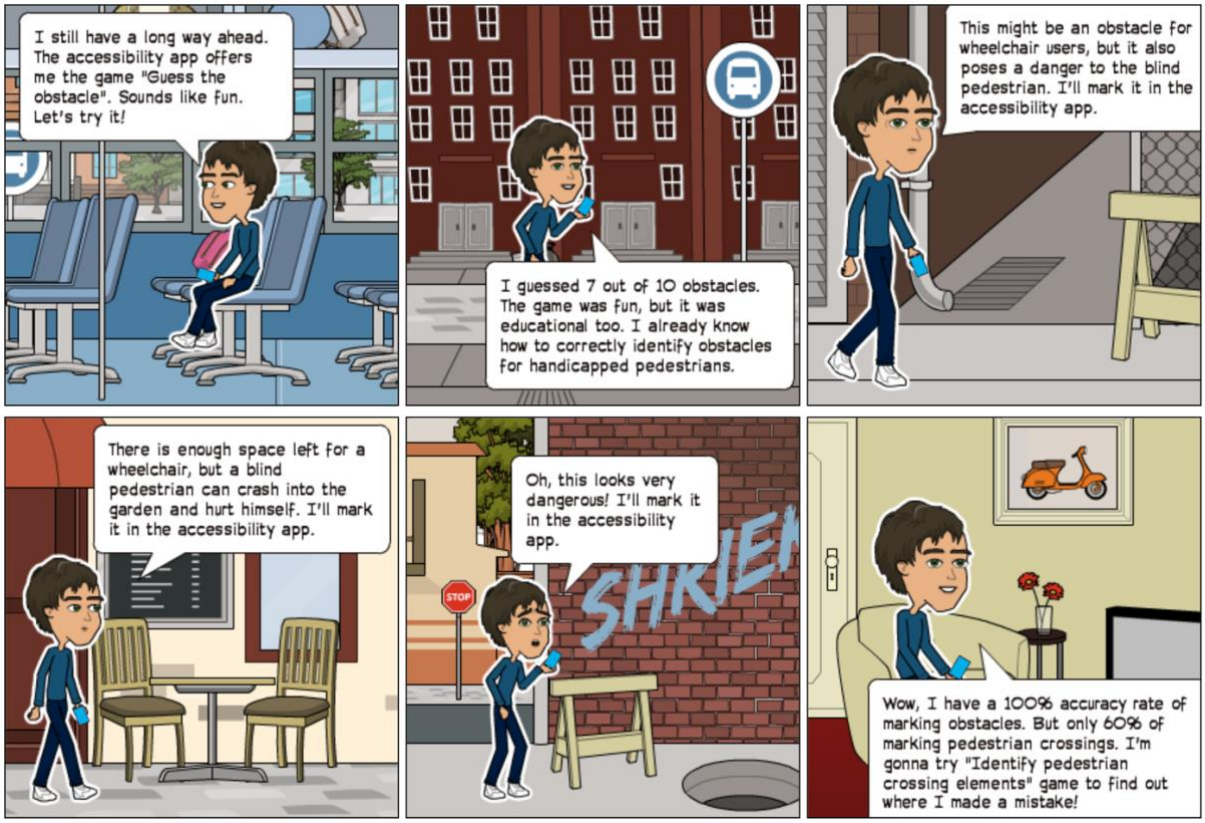

Figure 7 Storyboard: Providing training materials and feedback on collected data

Use-case 3. Building communities

Motivational factors: feeling of cooperation, sharing an activity with friends

Scenario: Anna has been using the application for almost a month now. She is happy to see that the map of Prague is filling up with the collected data. The application assisted during more than 250+ routes planning. She is also following her friends' activities. She has noticed that her friend Olivia is a frequent user as well and she is trying to keep up with her. She enjoys the collaboration between users while helping the disabled people and friendly competition between her and her friends as well. She is motivated to keep on contributing with the information which is currently missing.

Storyboard: See Figure 8.

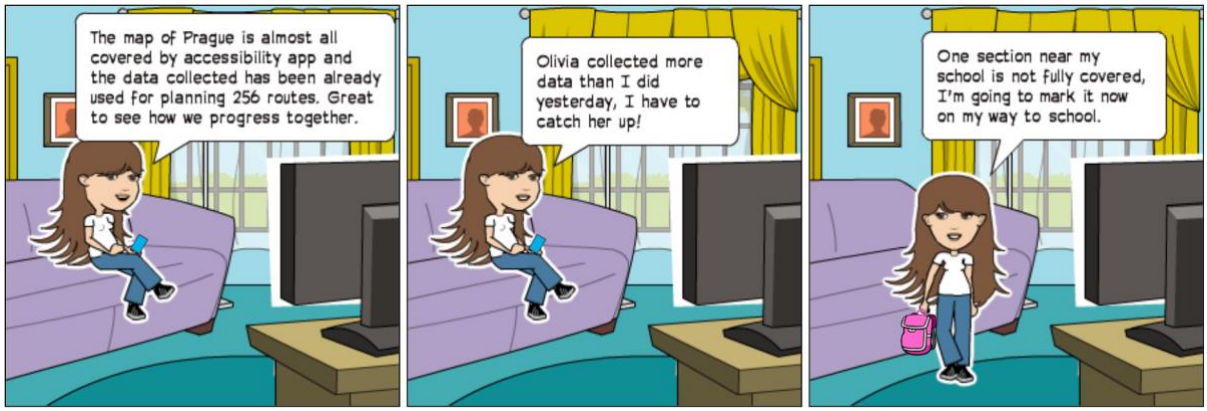

Figure 8 Storyboard: Building communities

3.3.3. THE HIERARCHICAL TASK ANALYSIS

To specify the behaviour of the system, we described main application processes for increasing motivation using The Hierarchical Task Analysis (HTA).

Arousing empathy (see Figure 9).
Plan A: 1. - 2. - 3.

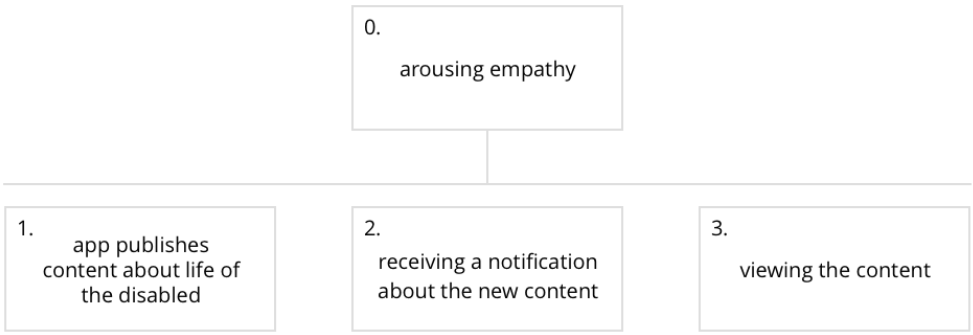

Figure 9 HTA: Arousing empathy

Providing a user with follow-up information (see Figure 10).
Plan A: 1. - 2. - 3.

Figure 10 HTA: Providing a user with follow-up information

Providing a user with training materials (see Figure 11).
Plan A: 1. - (2.1. - 2.2. - 2.3.)* - 3.

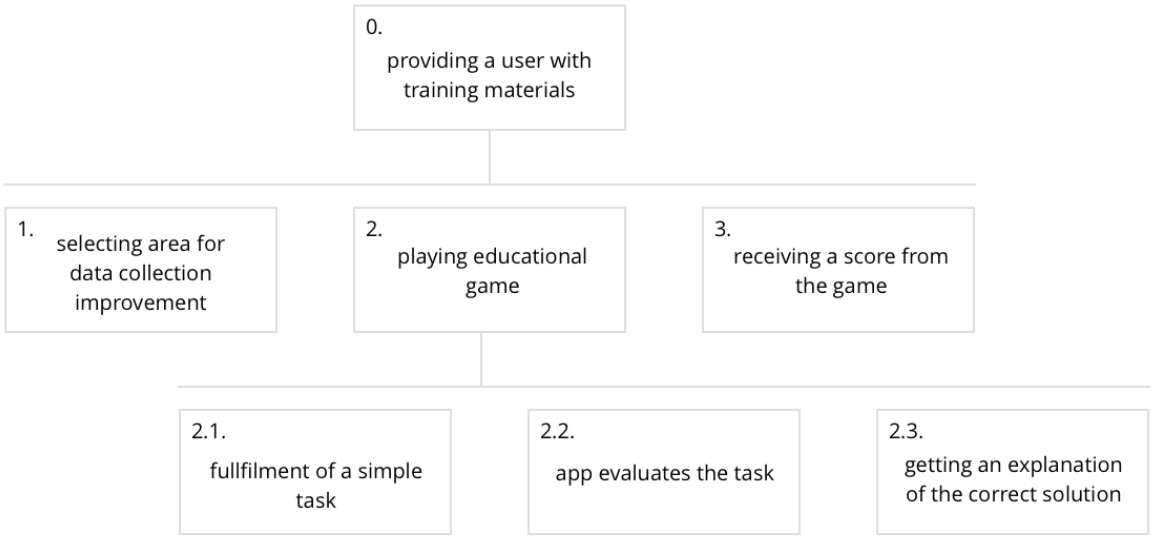

Figure 11 HTA: Providing a user with training materials

Getting feedback on the accuracy of collected data (see Figure 12).
Plan A: 1. - 2. - 3. - 4.

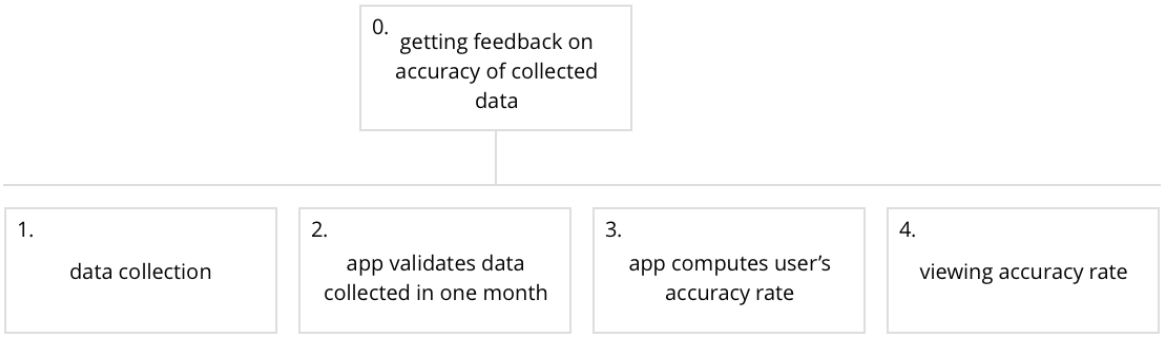

Figure 12 HTA: Getting feedback on the accuracy of collected data

Providing a feeling of cooperation (see Figure 13).
Plan A – viewing the progress of mapping a user's city: 1.
Plan B – viewing number of routes: 2.
Plan C – sharing an activity with friends: 3.

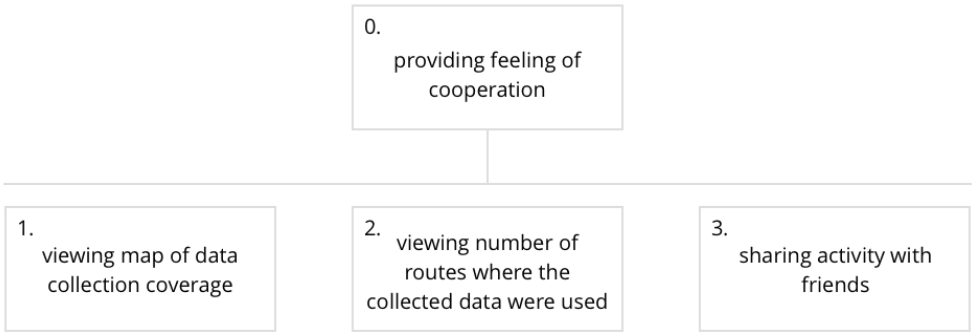

Figure 13 HTA: Providing a feeling of cooperation

Sharing activity with friends (see Figure 14).
Plan A – following friend newsfeed: 1. - 2.
Plan B – viewing friends' statistics: 1. - 3.

Figure 14 HTA: Sharing activity with friends

3.3.4. SKETCHES OF THE MAIN DESIGN IDEAS

Empathy content. Arousing empathy through videos, reportages and events with disabled people (see Figure 15).

Figure 15 Sketch: Empathy content

Mascot Navi. Introducing mascot of the application, assistance dog Navi who will guide the user through the whole crowdsourcing experience (see Figure 16). Navi will inform the user about the use of collected data and will act as a liaison between the user and visually impaired pedestrians and wheelchair users who benefit from the collected data.

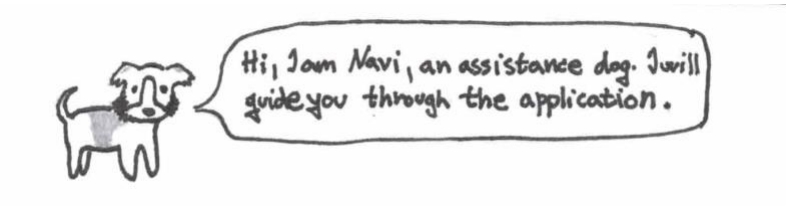

Figure 16 Sketch: Mascot Navi

Edutainment. Providing users with training in the form of fun educational games (see Figure 17).

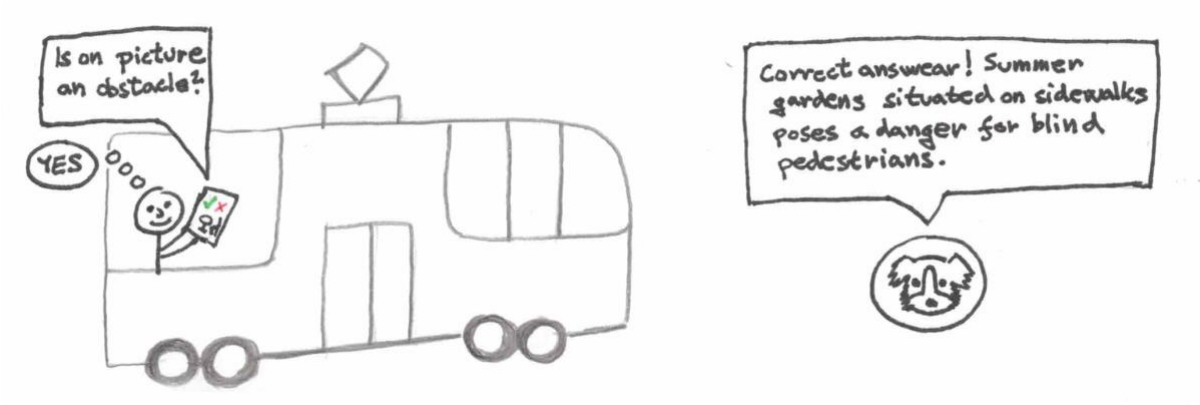

Figure 17 Sketch: Edutainment

Accuracy rate. Providing users with information on how precise their collected data are (see Figure 18).

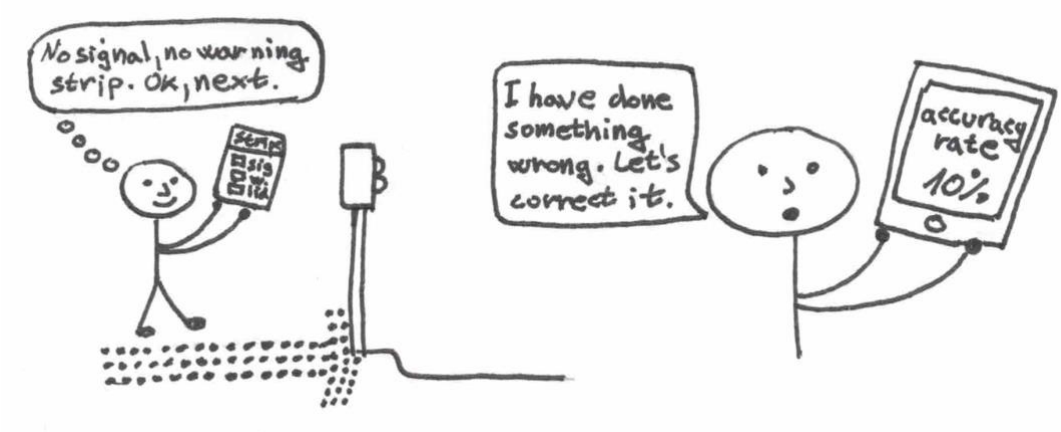

Figure 18 Sketch: Accuracy rate

Community. Providing users with the results of an effort of the whole community (see Figure 19).

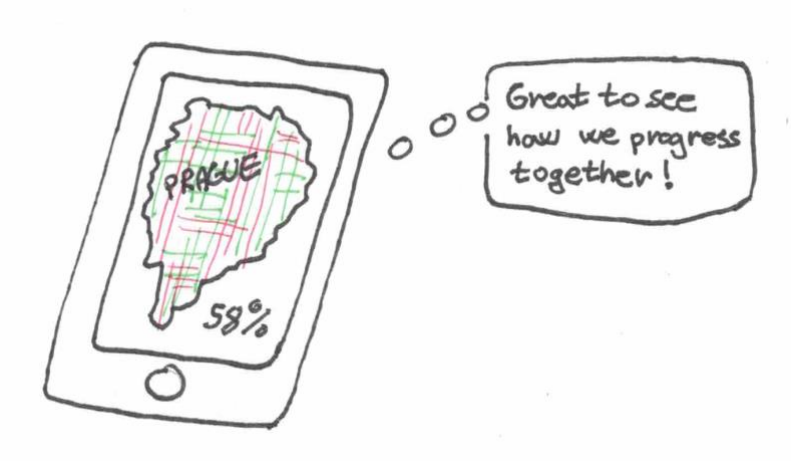

Figure 19 Sketch: Community

Sharing with friends. Allowing users to see who from their friends is involved and how much (see Figure 20).

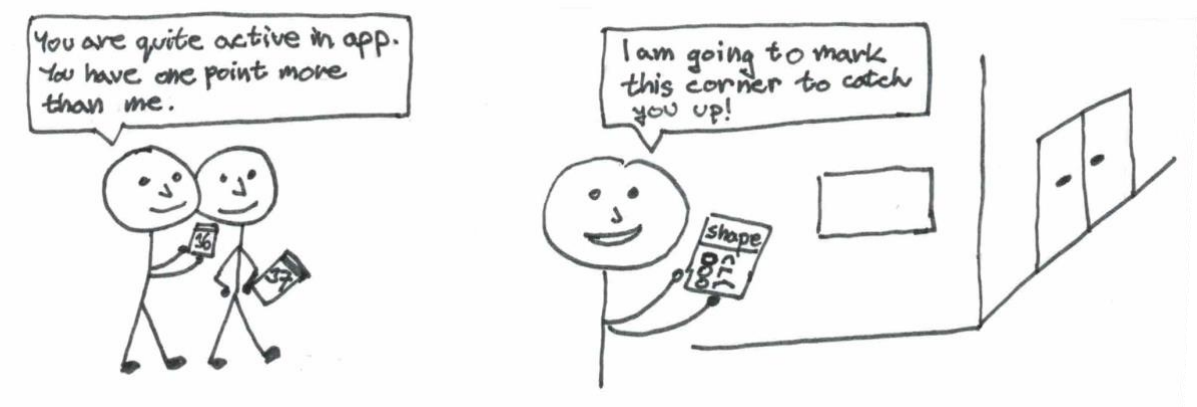

Figure 20 Sketch: Sharing with friends

3.3.5. LOW-FIDELITY PROTOTYPE

The low-fidelity prototype was created in a paper form. We used a mobile template cut out of a black cardstock paper (see Figure 21) and the content of the application was drawn on the white cardstock paper strips (see Figure 22). The created prototype is semi-interactive - a user can scroll or swipe content. When tapping on buttons, content can be changed easily according to taken action.

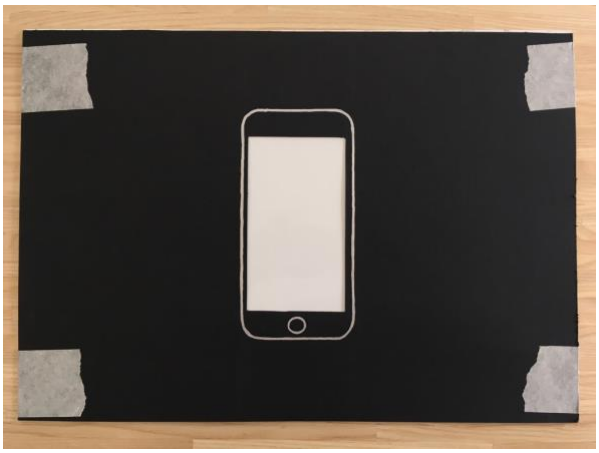

Figure 21 Low-fidelity prototype: Mobile template.

Figure 22 Low-fidelity prototype: Application Content

Home screen. The initial screen of the prototype is an application home screen (see Figure 23) which provides links to main sections of the app:

- Accessibility mapping
- Data collection from photos
- Educational games
- Life with disabilities
- User's collection profile
- Community activity

Other features of the application can be found at the bottom navigation panel which is used for switching between home screen, notifications and messages, and personal profile with basic settings.

Figure 23 Low-fidelity prototype: Home screen

Notifications & messages. This section of the application covers: 1) messages from the application guide Navi the dog, which informs the user about the use of the collected data and how much he/she is actually helping, and 2) notifications about the news in the individual sections of the application and reminders of data collection (see Figure 24).

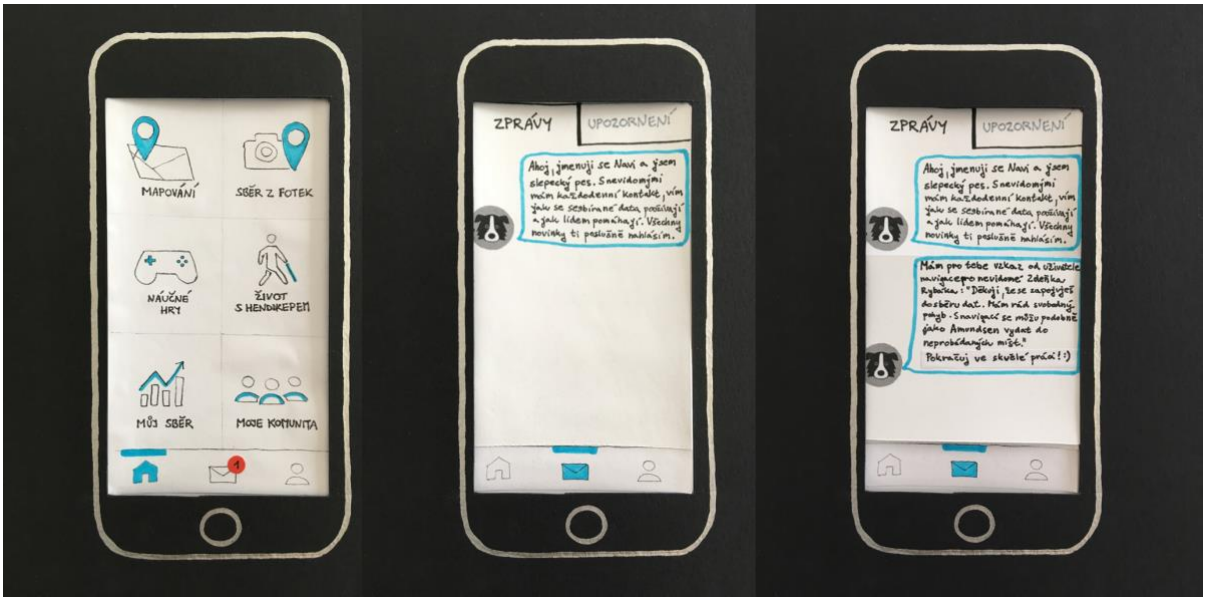

Figure 24 Low-fidelity prototype: Notifications & messages

Educational games. In this section, the training materials can be found (see Figure 25). Two educational games are offered - Guess the obstacle, Tactile guidelines for blind pedestrians. Only the first one is covered in the low-fidelity prototype. A user is gradually presented with five pictures of a street and is asked to decide whether there is or not an obstacle for visually impaired pedestrians. Every answer is evaluated, and an explanation is given to the user by application guide Navi. At the end of the game, the user gets a score based on the correct answers.

Life with disabilities. This section provides a user with videos, reportages and blogs about the life of disabled people (see Figure 26). It also suggests events such as Walking tour with a disabled person or visiting Cafe in the dark.

My collection. In this section, detailed statistics of user's activity can be found – the number of collected data divided by their type, and accuracy of collected data for every passed month. User can also find here a hint of how he/she can improve his/her contributions (see Figure 26).

My community. This section shows the progress in mapping the user's city by the cooperation of the whole application community. Furthermore, it shows a number of how many times the collected data were used to generate a safe route for visually impaired users. It also enables the user to see who from his/her friends is involved and how much (see Figure 26). This might encourage friendly competition between friends within the application.

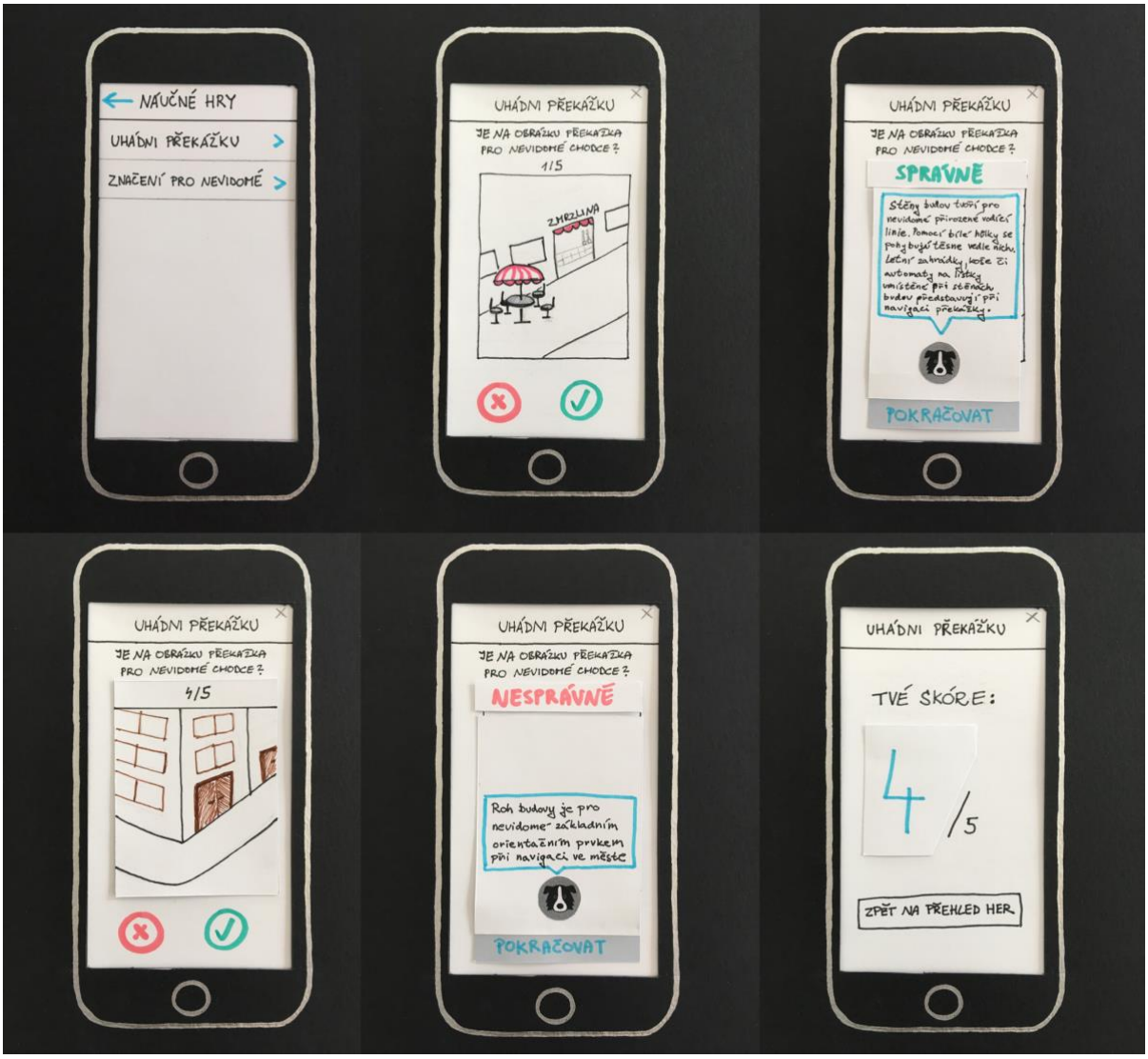

Figure 25 Low-fidelity prototype: Educational games

Figure 26 Low-fidelity prototype: Sections - Life with disabilities, User's collection profile, Community activity

Data collection from photos. This section is a faster alternative to direct data mapping on a street. User can collect data from the photos displayed in the application (see Figure 27). This allows the user to collect the data whenever and wherever he/she wants.

Figure 27 Low-fidelity prototype: Data collection from photos

3.3.6. HIGH-FIDELITY PROTOTYPE

The high-fidelity prototype was created based on the results of the low-fidelity prototype evaluation. The prototype is implemented for mobile use (see a description of the implementation in Chapter 4.).

Improvements. When testing the low-fidelity prototype, we have identified several usability issues (see Subchapter 5.1.6). Based on the recommendations for solving these problems a few improvements were implemented in the high-fidelity prototype. Firstly, we have changed in-app navigation. Having regard to the accessibility data collection being the main purpose of the application we have replaced the low-fidelity home screen with a map and a photo gallery. This change leaves no room for hesitation what is the main purpose of the application and provides quick access to data collection. Navi's initial message was also changed and now is informing the user about how he/she can start data collection. Sections with motivational factors can be newly entered from the main navigation bar. Navigation bar now consists of five main sections: home screen for data collection, life with disabilities, educational games, community activity and user's collection profile. In an attempt to clarify the relationship between the information displayed in the community section, we added the label "my community" to the posts which were related only to data collected by the community of user's friends. Moreover, we added missing information on how the accuracy rate in the user profile is computed. Data collection section was divided to 1) map with markers indicating segments with missing attributes, and 2) photos gallery divided to subsections based on the segment's attributes. Users can now collect a single attribute from multiple photos, instead of collecting multiple attributes from a single photo. By allowing the user to focus only on single attribute we are aiming to simplify and speed up the data collection. For each attribute, we added a label with a number of photos waiting in the gallery to be processed. Moreover,

for the most discussible attributes i.e. crossing type and types of tactile guidelines, we added tooltips with photo examples.

Visual design. The visual style of the application is meant to be friendly and playful. The high-fidelity prototype is using a light theme with simple graphics customized for exterior mobile usage. The colour theme of the application consists of two main colours, blue being primary and yellow being secondary. Furthermore, we use a palette of contrasting colours to increase recognition and readability in exterior conditions. On the home screen of the application, we use a map background with simple markers on it. Markers are rendered in bright colours to contrast with subdued map colour palette and are distinguished by respective pictograms for corners, sidewalks, pedestrian crossings zebras and platforms. The application adheres to the Material Design guidelines and uses the Material icon set and customized self-made icons.

Examples of the UI. In this section, we present several screens of the user interface of the high-fidelity prototype.

Data collection: The initial screen of the high-fidelity prototype is dedicated to data collection and is divided into two sections 1) map with markers (see Figure 28), and 2) photo gallery (see Figure 29). The map section is a primary section for data collection. For better orientation on the map, the application provides the user with his/her actual location which is indicated with a blue circle on the map and updates seamlessly with every move of the user. Markers on the map are grouped to clusters by their proximity. The map can be also customized by layer filtering of pedestrian segment types. Data collection can be started with a simple tap on the selected marker. The process of collecting data is divided into several small sub-tasks, each subtask is asking user about one attribute of the selected segment. Each question can be skipped to ease and speed up the data collection. When all attributes of the segment are successfully collected or skipped, the marker disappears from the map. The photo gallery allows the user to collect data regardless of his/her actual location. It is divided into categories by attributes of segments. User can choose one attribute and collect its value from multiple photos one by one. Red labels indicate a number of photos waiting in the gallery to be processed for each attribute. Each photo can be skipped to ease and speed up the data collection.

Motivational factors: Sections with designed motivational factors can be accessed through the main navigation bar located in the bottom of the application. The first section is 'Life with disabilities' section (see Figure 30) which is divided into 1) subsection with reportages about the navigation of visually impaired pedestrians or wheelchair users and how the collected data are used to support this navigation, and 2) subsection with life stories of actual people who benefit from collected data. The second section contains educational games (see Figure 31). The third section is 'Community' section (see Figure 32) which is divided into 1) subsection with community activities and achievements, and 2) subsection with information about the number of data collected by user's friends ordered into the leaderboard. The last section (see Figure 33) is divided into 1) subsection with personal messages from application guide Navi with follow-up information on the use of collected data, reminders of data collection, news on how much the user is actually helping and news in the application, and 2) personal statistics of user's data collection with the total number of collected attributes and accuracy rate for each type of pavement segment.

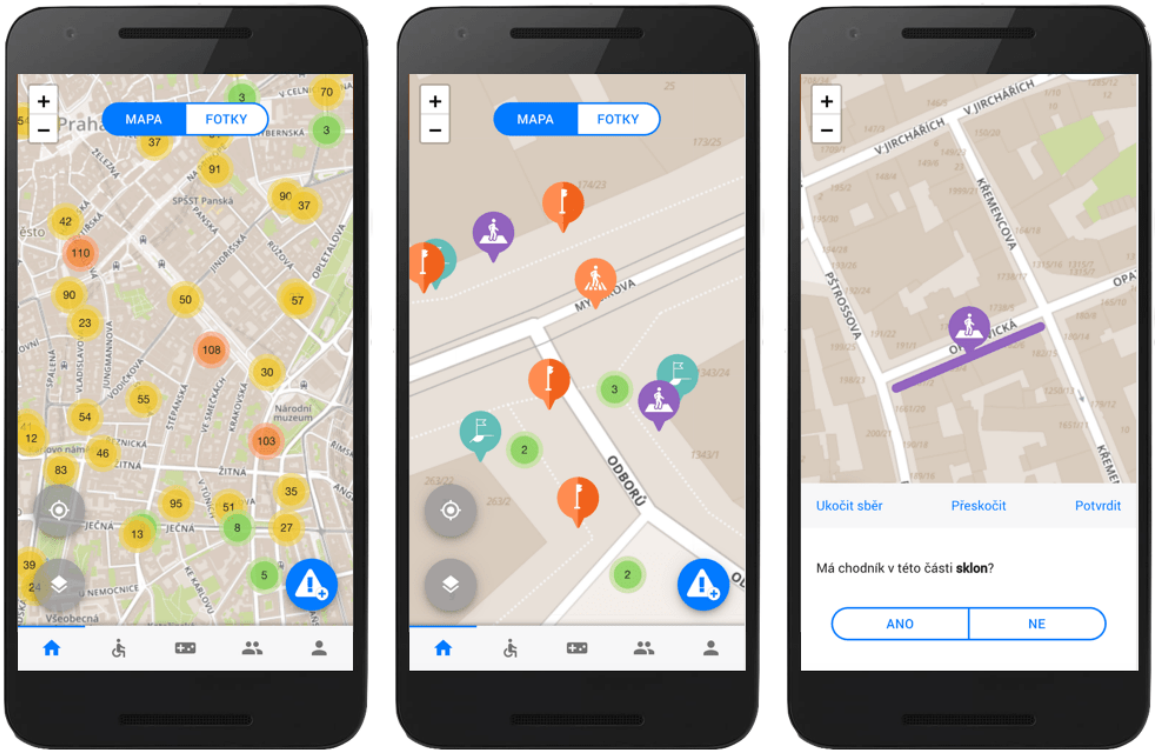

Figure 28 High-fidelity prototype: Data collection from a map

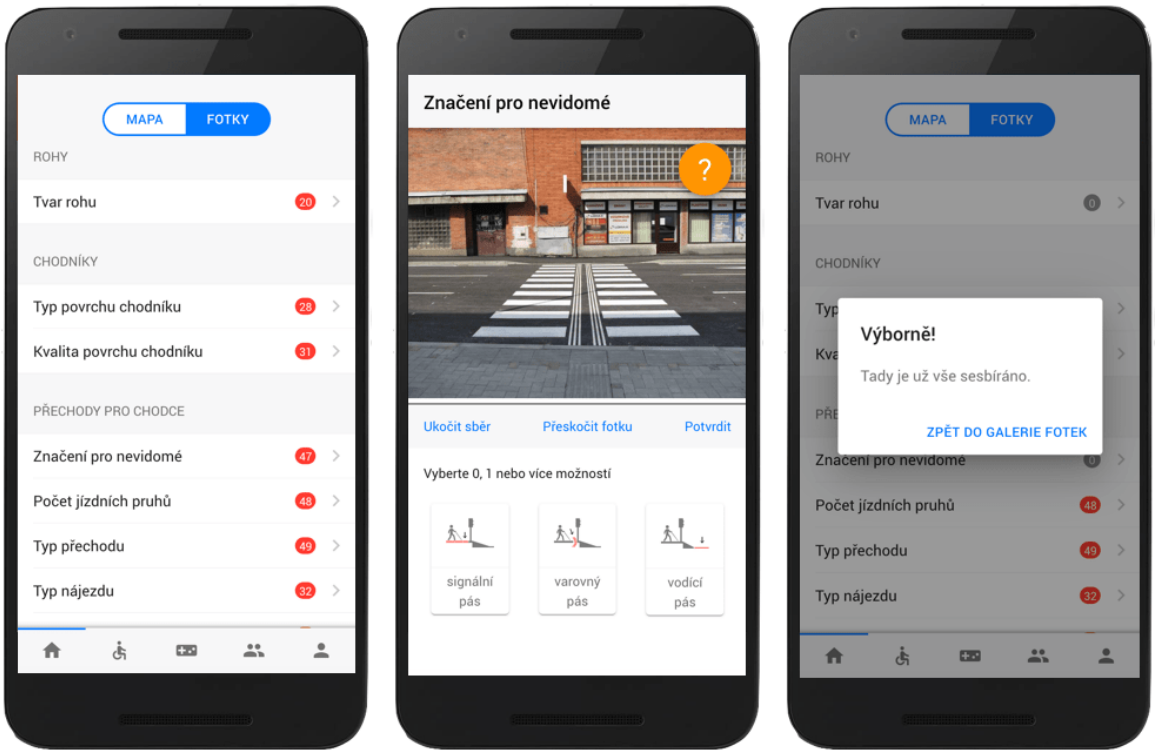

Figure 29 High-fidelity prototype: Data collection from photos

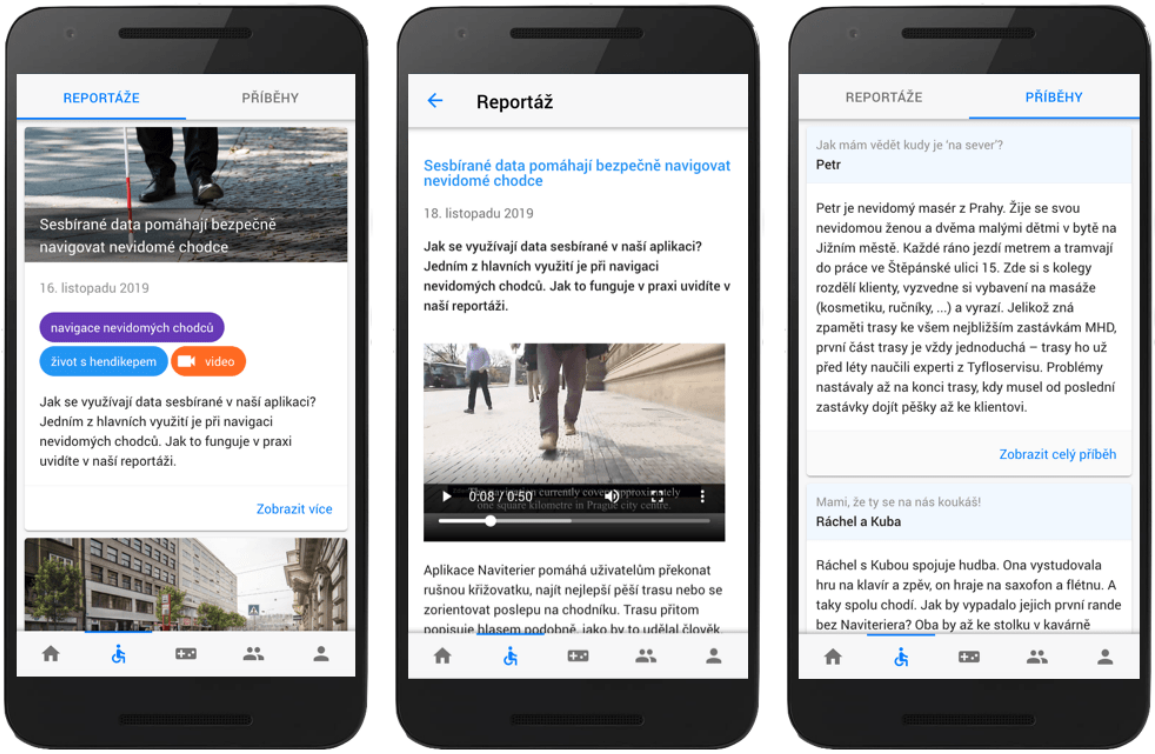

Figure 30 High-fidelity prototype: Life with disabilities

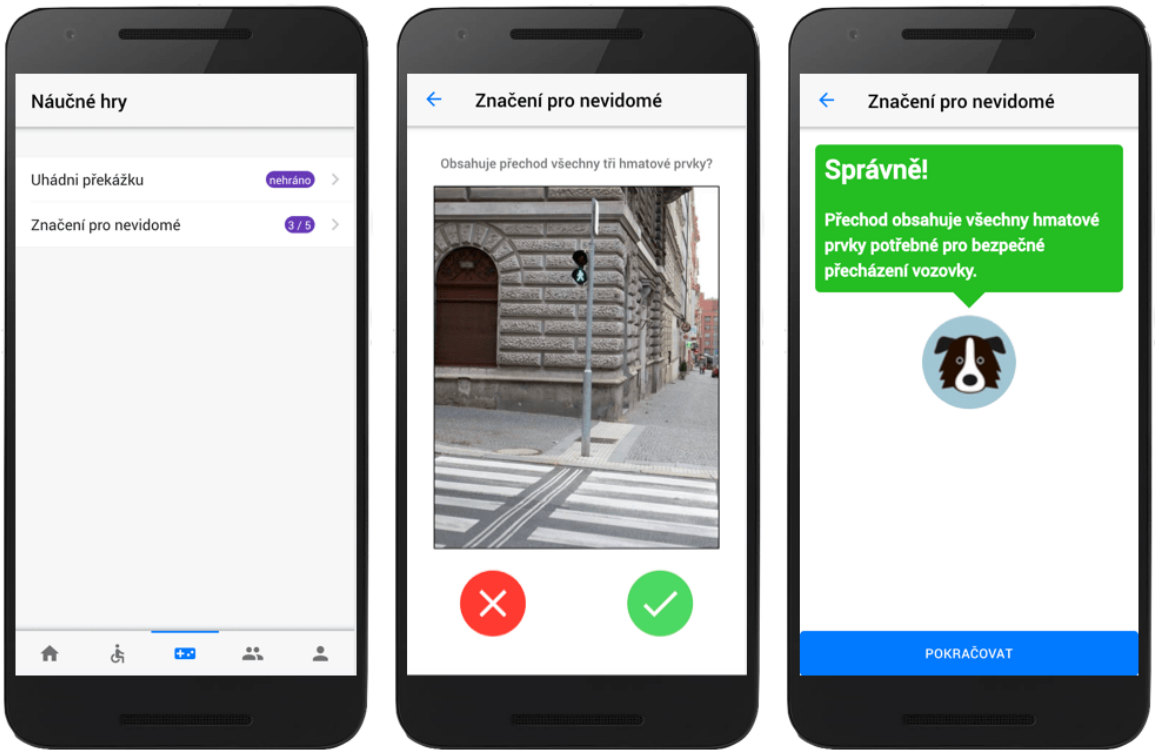

Figure 31 High-fidelity prototype: Educational games

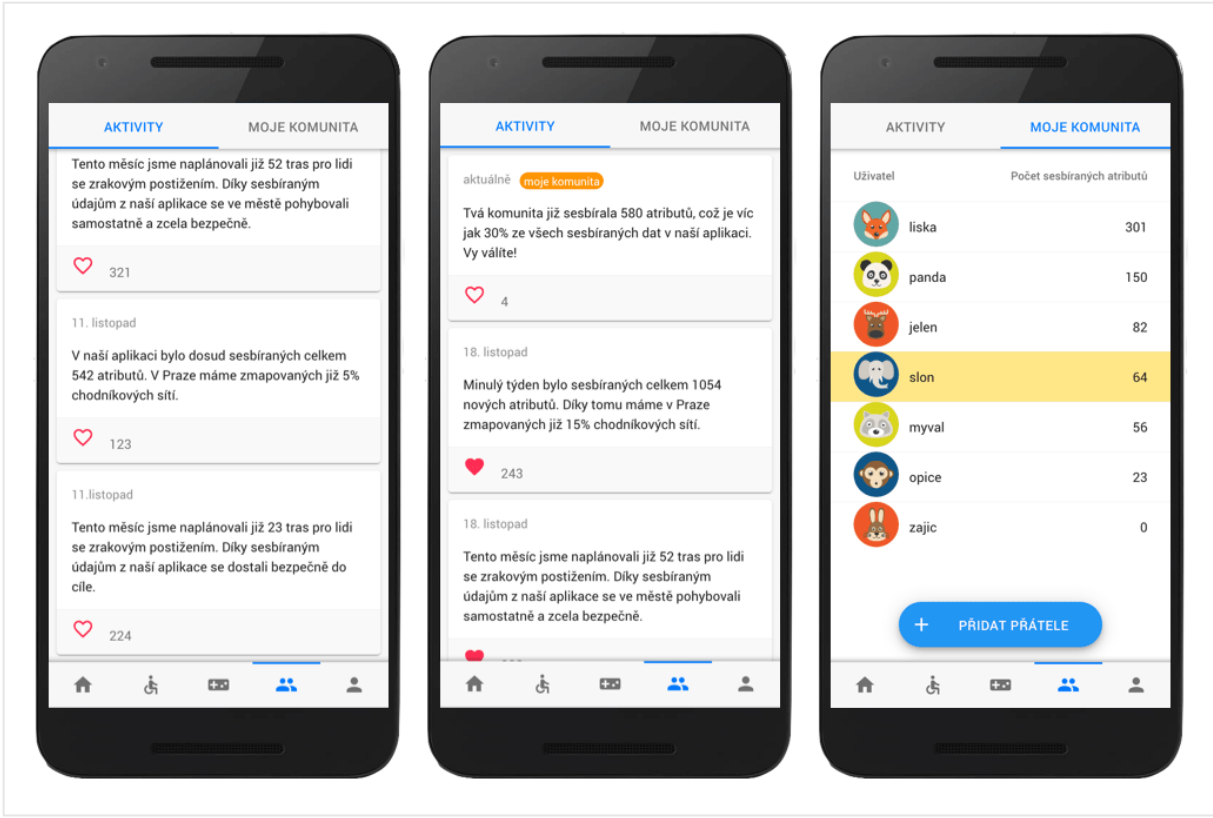

Figure 32 High-fidelity prototype: Community

Figure 33 High-fidelity prototype: Messages from Navi and personal statistics

4. IMPLEMENTATION

The low-fidelity prototype was implemented as a set of semi-interactive paper cards, created manually by hand. The high-fidelity prototype was implemented as a fully functional, interactive mobile application with a proper backend system as well, with a little number of mocked parts. This was done so that the high-fidelity prototype can be used in a natural environment and evaluated in a longitudinal usability study.

4.1. TECHNOLOGIES USED

The high-fidelity prototype consists of two separate parts. The first one is the client application. It was written in HTML/JavaScript, using features of Framework 7[2] to achieve native look and feel. This HTML/JavaScript code was later compiled to native Android executable by using the Apache Cordova framework[3]. A core component of the client side is the interactive map. Leaflet JS[4] library was used to implement this feature with one key plugin – MarkerCluster[5]. This was necessary to prevent cluttering of the markers on the map. This plugin allows clustering multiple markers with close geographical location to be represented by one single marker icon. Geolocation is also fully implemented, it is updated automatically when the device location changes. The second part is the backend application. It was implemented in Java 8 using the Spring Boot framework[6] and it exposes REST API to be consumed by the client. It stores and read all the data using the PostgreSQL database.

The backend system serves the following functions:

- to serve the data i.e. location of the crosswalks, sidewalks, corners etc. - these data were initially extracted from the Naviterier API[7] as a one-time operation,
- to store the data collected by the users i.e. accessibility attributes of the segments,
- to capture an audit log of user's action from the client side - these data were later used during the diary study evaluation.

4.2. ARCHITECTURE AND DEPLOYMENT

The relationship between the components of the high-fidelity prototype is depicted in Figure 34. Backend application communicates with the PostgreSQL database using JDBC driver[8]. Backend

[2] https://framework7.io/

[3] https://cordova.apache.org/

[4] https://leafletjs.com/

[5] http://leaflet.github.io/Leaflet.markercluster/

[6] https://spring.io/projects/spring-boot

[7] http://147.32.81.71/NaviTerier.ProcessingService/metadata

[8] https://www.oracle.com/database/technologies/appdev/jdbc.html

application also exposes REST API for accessing the data. Client application directly uses this REST API using the HTTP protocol. For the sake of simplicity of the prototype, we decided not to use HTTPS protocol for the communication and we also didn't deploy additional component, such as API Gateway, between the client and backend application to control the traffic. Should this be a production application this would have to be reconsidered.

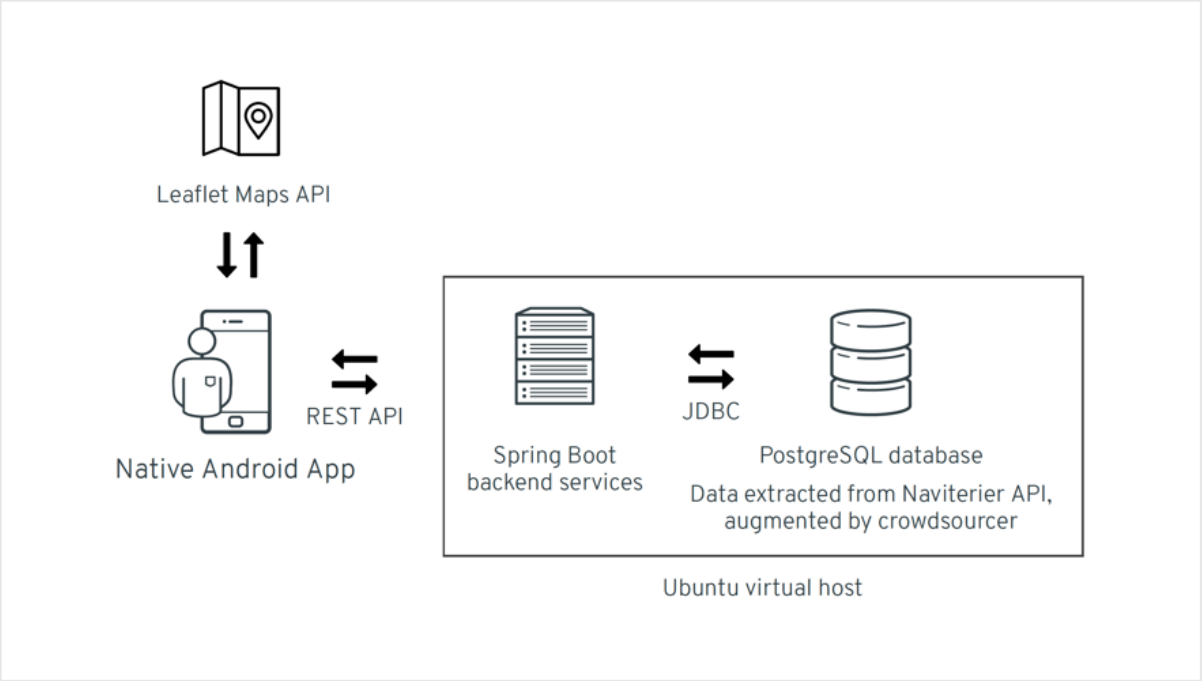

Figure 34 Architecture of the high-fidelity prototype

Backend application was deployed as an executable JAR file on the Ubuntu virtual host and right before the experiment started, it was initialized with the data extracted from the Naviterier API. The backend code was not being updated throughout the experiment. However additional data were being uploaded via REST API during the experiment, e.g. new photos to photo gallery. The client application was being distributed as native android APK application. It was being periodically updated with new features, content and notifications. These updates were implemented using CodePush Service[9] which allows achieving seamless experience with no downtime whatsoever as these changes were automatically installed on the user's device in real-time (see Figure 35).

[9] https://microsoft.github.io/code-push/

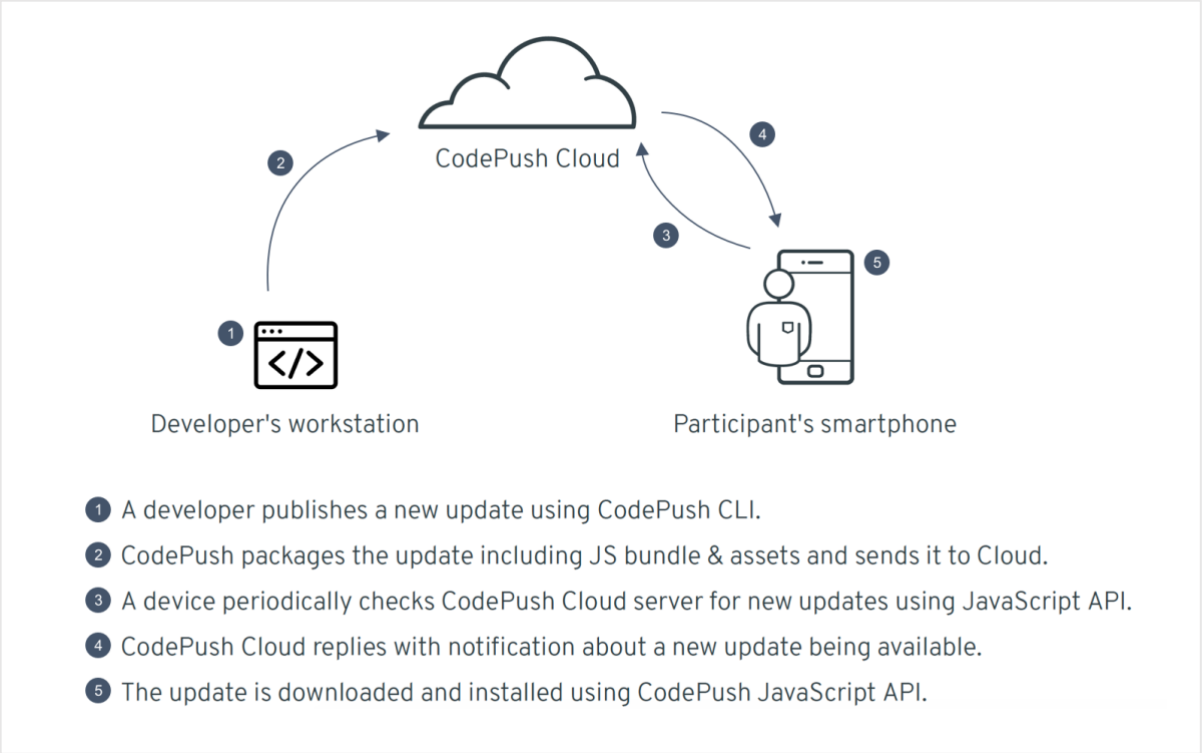

Figure 35 Real-time application updates using CodePush Service

5. EVALUATION

5.1. EVALUATION OF THE LOW-FIDELITY PROTOTYPE

To get early feedback from potential users a qualitative usability test was conducted for evaluation of the low-fidelity prototype described in Subchapter 3.3.5.

5.1.1. GOALS OF EVALUATION

The main goal of the evaluation is to test prototype functionality on the main use-cases of the application described in Subchapter 3.3.2. The second goal is to find out people's views and opinions on the tested prototype through the think-aloud protocol and the post-test interviews.

5.1.2. PARTICIPANTS

The prototype was evaluated with five participants, young adults with age ranged from 25 - 30, 3 females and 2 males (P1-P5, mean age = 27.6, SD = 1.625). P2, P4 and P5 had no previous experiences with crowdsourcing. P1 regularly contributes to the public databases of books and vinyl records. P3 had experience with contributions to Wikipedia. Two of the participants, P1 and P4, were also involved in our previous usability study for testing high-fidelity prototype for accessibility data collection. Our aim was to let them compare these two experiences and see if the added motivational factors make any difference. Details about the participants can be found in Table 3.

	P1	P2	P3	P4	P5
Age	28	28	30	27	25
Gender	M	F	M	F	F
Previous experience with crowdsourcing	little	none	little	none	none
Participation in previous usability study[10]	yes	no	no	yes	no

Table 3 Evaluation of the low-fidelity prototype: Participants

[10] Evaluation of the prototype for crowdsourcing accessibility data (Riganová, 2017).

5.1.3. PROCEDURE

Usability testing was rather informal. To create a relaxed and pleasant atmosphere, each session took place at a participant's home or office and it took a maximum of 45 minutes. Firstly, participants were introduced to the purpose of the application. They were asked to think aloud during the whole session. After that, tasks were assigned to the participants. Some of these were explicitly assigned by the moderator and some naturally emerged from the application UI. Tasks were designed to cover all defined use-cases and are as follows:

1. Look at the home screen of the application. Describe what content you expect in the given sections.
2. Display the new notification.
3. Discover how the visually impaired pedestrians navigate around the city[11].
4. Using the photo, collect the data about pedestrian crossing.
5. Discover what percentage of your collected data is collected correctly. Find the data type which you have the most difficulties with during the collection process.
6. Practice the obstacle data collection.
7. Using the photo, collect the data about the obstacle.
8. Display the new notification.
9. Check out your friend's activities. Find out what your friends collected during this week. Describe what other information you have learned from this screen.

After they have completed the tasks, a short semi-structured interview was conducted to research the impact of used motivational factors on participants and get their views and opinions on the tested prototype and testing session. Interview questions were following:

- What new have you learnt about the navigation of blind pedestrians? What has interested you the most? What has surprised you the most?
- How did you like the game 'Guess the obstacle'? Was it useful for you? Can you name some of the objects which act as obstacles for the navigation of blind pedestrians?
- Have you noticed assistance dog Navi during the testing? What are your impressions of him? What messages do you expect from him in the future?
- How did you like the community section? What is your understanding of it? Would you visit it regularly?
- Was the data collection from the photo difficult for you?
- What do you like the most about the application? What do you dislike?
- What other functionalities would you like to add into the application? What other improvements can you think of?
- Do you plan to participate in the data collection once the application will be available? What encouraged/discouraged you?
- Rate today's testing session using the school grading system 1-5 (1 – the best, 5 – the worst).

[11] After the participants clicked the play video button in paper prototype, the video report from the PrahaTV portal was played for them on a mobile device.
Video can be found at https://prahatv.eu/zpravy/praha/praha/8599/nevidomym-s-cestou-pomaha-aplikace.

5.1.4. Bias, limitations of the method

The selected evaluation method was not able to reveal the long-term effects of the designed motivation factors on the motivation of participants to engage in data collection neither on the quality of the collected data. However, this method was suitable for testing prototype usability and getting opinions about designed motivational factors at the early stage of the design process.

5.1.5. Results

All participants managed to finish all the given tasks in a short time period. All participants were able to navigate through the prototype without any problem. Participants appreciated the simplicity and clarity of the prototype and had an overall positive experience with it.

Tasks

Task 1. Navigation at home screen and sections' content

The participants didn't struggle with most sections. P1, P2, P4 have misinterpreted section with data collection from the photos. They have anticipated that after opening this section a camera app in their smartphone will be launched and they will be prompted to take a picture of an obstacle. P2 and P4 thought that the message section will serve as a place to share their activities with their friends.

Task 2. Displaying a new notification

The participants had no problem with solving this task. A new message was indicated by a label located in the main navigation bar and all of the participants opened it without being prompted. Once the section was opened, P2 and P4 quickly realized that the purpose of this section is receiving messages and notifications. P3 expressed excitement from discovering that there will be an "application helper". P1 was expecting that Navi will show him the way how to start using the application - i.e. what to do first.

Task 3. Looking for information about the navigation of visually impaired pedestrians

The participants had no problem with solving this task. All participants were able to find the desired information and play the video about navigation easily.

Task 4. Data collection from photos

All the participants opened the section for collecting data from the photos without hesitation and chose the data type they wanted to collect. Once the task was given, P1, P2 and P4 quickly realized that there will be no camera application involved, but instead, they will be using a gallery of photos to collect the data. When collecting the data about tactile guidelines, all the participants used the help icon. P1 and P5 would appreciate example photos of all tactile guidelines. Once P2 and P3 completed the data collection of the first photo, they immediately proceed with the next one.

Task 5. Discovering an accuracy rate

The participants had no problem with solving this task. All participants were able to find accuracy rate and easily identified the type of data which they had the most difficulties with during the collection process. P2 and P4 required information on how the accuracy rate is computed.

Task 6. Playing educational game

P1, P2, P3 and P4 proceed to the game automatically without being prompted, as soon as they have seen the hint on how to increase their precision during the data collection. Participants had no issues during playing the game. P1 was also expecting some sort of reward at the end of the game. P2 and P3 wanted to continue playing more games.

Task 7. Obstacle validation

All participants completed this task without issue. After completing the task P2, P3, P4 and P5 wanted to continue collecting data from another picture.

Task 8. Displaying a new notification

All participants opened and read the message without being prompted.

Task 9. Checking community activities

All participants knew where to look for the information and found them without issues. P4 wasn't sure what exact data map includes - whether these are only data collected by her or also by her friends, or by all users. Remaining participants understood this section correctly.

Post-test interviews

Use of the app. All participants found the application intuitive and simple to use and liked the general idea behind it. P1 and P4 have participated in the previous usability study for evaluation of prototype for crowdsourcing of accessibility data so they were somewhat familiar with the topic already. P1 and P4 appreciated the ability to collect the data from the photos. P4 likes the idea of taking pictures when walking down the street and then processing them in her spare time. She knew she would not have enough time to collect the data outside but to do it from the photo later on, is feasible for her. P2, P3 and P5 were new to this topic and were not aware that visually impaired pedestrians are using special navigation systems, so this application was surprising to them. They were really intrigued about the idea of helping people to navigate around the city safely.

P1 and P3 really appreciated that there was a dedicated section which provided a detailed explanation about different types of tactile guidelines. P3 was wondering about these pedestrian crossing properties for a long time and he wasn't sure what was their purpose.

On the other hand, one thing P1 didn't appreciate was the getting started experience. He wasn't sure where/how exactly he can begin to use the application so he would prefer to have some kind of onboarding guide. Moreover, P3 would like to have a slightly different format when collecting data from photos, he would prefer collecting a single attribute from multiple pictures, instead of collecting multiple attributes from a single picture. This is because of all the context switching. Moreover, P5 would appreciate information about the number of photos in the gallery waiting to be processed - this would help her prioritize.

As opposed to the previous usability study, P1 and P4 are now more determined to actively use it. There are two main reasons for that: 1) The data collection is now possible from the picture. 2) The application let the user see how/when his/her collected data were used by people with disabilities. P2, P3 and P5 can imagine using this application in their spare time, e.g. instead of playing games on their smartphones or browsing social networks. All participants graded the testing session with score 1.

In-app motivational elements. Feedback on in-app motivational elements is divided by main sections in the application which represent one or more motivational factors described in Subchapter 3.3.1.

Life with disabilities: Each of the participants enjoyed the video about the navigation of visually impaired pedestrians, as it made participants feel more connected to them.

Educational games: All participants liked the section with educational games and had a good time playing them. They liked that it was all well explained, fast, and not demanding. P2, P3, P4 and P5 found the game useful and were able to utilize their gained knowledge successfully during her next attempt of collecting data. Even though P1 has found the game in the application rather trivial, he admitted there were some parts he will be able to utilize during the data collection.

Community activity: Community section was appealing to P3 and P4. P3 would even like to see further statistics amongst his friends so he could compete with them. For P1 and P5 it wasn't a priority to have it in the application but it was nice to have. P2 does not care much for the community section - she does not plan to use it, nor she does not need to share her activities with anyone.

Navi's messages: Navi the dog aroused positive emotions in all participants. They enjoyed communication from him. They found him cute and useful. Participants expected some further communication from him, mainly reminders about data collections, encouraging to commence the data collection, news and statistics. P2 appreciated that it is not required to acknowledge or react to the messages explicitly. All participants were pleased with the message from the visually impaired user of navigation system which uses collected data. Although, they didn't need to maintain further contact with him. P3 would only like to have a possibility of reaching out to him if needed. P5 liked that Navi acts like an interpreter of thank you messages from consumers of collected data. It would feel a lot weirder to her if messages would be coming directly from an actual blind person. It would make her feel uneasy. Moreover, P4 would appreciate if the Navi's notifications are customizable.

User's collection profile: All participants appreciated statistics of their collection, especially the accuracy rate. According to them, this might help them to provide more precise data. P2 and P3 were demanding information about how exactly it was calculated.

5.1.6. FINDINGS

In this subchapter, we describe usability defects of the low-fidelity prototype which were found during the testing sessions. For the sake of clarity, we have defined three priorities of findings. Low, medium or high priority (see Table 4) is assigned to each finding according to its impact on the usability of the application.

PRIORITY	EXPLANATION
high	The defect makes the application unusable.
medium	Removal of this defect would improve the usability of the application.
low	Removal of this defect would enhance the user experience of the application.

Table 4 Evaluation of the low-fidelity prototype: Defined priorities of findings

Finding no. 1. Uncertainty about what the first steps in the application should be
Priority: medium
Description: Although participants like the simplicity and briefness of the application home screen, they were still quite uncertain how to start using the application.

Recommendation: We recommend changing the home screen with the menu to a map with marked segments which need to be collected so that the main purpose of the application is clear at first sight. Further, we recommend extending Navi's initial message to instructions in which sections users can find useful information and how they can start data collection.

Finding no. 2. Unclear relationship between the information displayed in the community section
Priority: low
Description: In the community section, it is not clear whether the information about data and their use are regarding data which were collected by the user, his/her friends or all of the users.
Recommendation: We recommend noticeable labelling for friends' activity so that the success of the entire user community is separate from sharing activity among friends.

Finding no. 3. Missing information regarding the evaluation of the user's contributions
Priority: low
Description: Participants required information on how the accuracy rate is computed.
Recommendation: We recommend adding tooltip about the evaluation of collected data to the accuracy rate section.

Finding no. 4. Unintuitive iconography for data collection from photographs
Priority: medium
Description: Participants have misinterpreted section with data collection from the picture. Because of the use of camera icon, they have anticipated that after opening this section a camera app in their smartphone will be launched and they will be prompted to take a picture of an obstacle.
Recommendation: We recommend replacing the current icon with the icon of the photo gallery and adding a label to it with a number of photos waiting in the gallery to be processed.

Finding no. 5. Missing photo examples of tactile guidelines for visually impaired pedestrians
Priority: medium
Description: Participants would appreciate example photos of all tactile guidelines so that they can compare it with the photo they are collecting data from.
Recommendation: We recommend supplementing of the used pictograms with photographs of all possible types of tactile guidelines for better illustration.

Finding no. 6. Difficult context switching when collecting data from photos
Priority: low
Description: Allowing users to collect a single attribute from multiple photos, instead of collecting multiple attributes from a single photo might speed up the data collection.
Recommendation: We recommend changing the format of data collection from photos so that users can collect a single attribute from multiple photos.

5.2. EVALUATION OF THE HIGH-FIDELITY PROTOTYPE

To examine the effect of motivational factors on crowdsourcing of accessibility data, we have evaluated the high-fidelity prototype described in Subchapter 3.3.6 in a longitudinal usability study.

5.2.1. GOALS OF EVALUATION

The main goals of the evaluation are to determine the long-term impact of motivational factors on motivation to participate in crowdsourcing in a natural environment and to find out people's views and opinions on the tested prototype through diary study and post-test interviews.

5.2.2. PARTICIPANTS

Participants for this study were recruited via an online survey distributed over social networks and communication channels of the university and university's partner companies. We were interested in both females and males with age between 18-35, who are using android based smartphones, have active mobile data plan and have a point of interest, e.g. school, work, sports, in the selected area of the Prague city centre.

The prototype was evaluated with five participants, young adults with age ranged from 23 - 33, 3 females and 2 males (P1-P5, mean age = 27.2, SD = 3.37). P3, P4 and P5 had no previous experiences with crowdsourcing. P1 regularly contributed to the Google crowdsourcing app with text translation and reviews and also helped translate subtitles on YouTube. P2 has experience with contributions to Wikipedia and Waze. Three of the participants, P3, P4 and P5, have a close relationship. Details about the participants can be found in Table 5.

	P1	P2	P3	P4	P5
Age	23	28	27	25	33
Gender	F	M	F	F	M
Previous experience with crowdsourcing	medium	little	none	none	none

Table 5 Evaluation of the high-fidelity prototype: Participants

5.2.3. PROCEDURE

To evaluate the high-fidelity prototype, the diary study method was chosen. A diary study is a research method which uses diary logs to collect qualitative data about user experiences, activities and behaviours over time (Kuniavsky, 2003). The procedure of our study was mostly inspired by the Nielsen Norman Group's methodology composed of five phases: planning and preparation, pre-study brief, logging period, post-study interview, data analysis (Flaherty, 2016).

Briefing. Before starting the study, we met each participant in person and informed him/her about the diary study process. During the meeting, the application was installed on each participant's device and

each participant was introduced to its purpose and basic functionalities. Participants were instructed to fill in the diary every evening for a period of two weeks. It was made clear to them that they didn't need to use the application on a daily basis if they didn't feel like to. The only mandatory part of the study was the submission of the daily log. This point was made because we wanted the study to resemble the real-time real-life behaviours and experiences as much as possible. Participants were also informed about the data we were going to store and use for follow-up analysis.

Pre-study interview. After the briefing, a short semi-structured interview was conducted with each participant to research their habits, mobile app usage, experience with crowdsourcing, non-profit and volunteer activities. Interview questions were following:

Movement in a city, commuting

- What activities do you like to do in your free time?
- Describe to me your usual day.
- How many minutes a day do you commute to work/school?
- What do you usually do while waiting for public transport?
- How do you kill time while travelling?
- How much do you walk every day? Where?

Daily use of mobile apps, learning about new apps

- How much time did you spend on your smartphone yesterday?
- What do you usually use your smartphone for?
- Where do you usually use your smartphone?
- What apps do you use daily?
- How do you learn about new apps?

Motivation for crowdsourcing activities

- What is your experience with crowdsourcing?

  {if he/she has experience}
  - What projects do you contribute to? Where did you hear about them?
  - How often do you contribute to crowdsourcing projects?
  - What form of reward do these projects provide? What are the main benefits of contribution to the application for you?
  - How much time (daily / weekly / monthly) do you spend collecting data?
  - Where do you use these services?
  - What form of crowdsourcing do you prefer?
  - What other crowdsourcing projects you are not involved in do you know? Why didn't you join?

  {if he/she has no experience}
  - What crowdsourcing projects do you know? Why didn't you join?

Non-profit and volunteer activities

- Do you notice people with disabilities near you? What is your experience of helping people with disabilities?
- What charity activities do you participate in? How much time do you spend on these activities (monthly / weekly / daily)?
- What apps that help other people do you know? What apps that help other people do you use?

{if he/she has experience}

- How much time do you spend daily on these apps?

{if he/she has no experience but knows such apps}

- Why didn't you participate in in-app activities? What discouraged you?

Diary logging period. Since the comprehensive and complete diary was the key to successful study, daily email reminders to fill in the diary were sent to each participant every evening. We asked participants to log their experiences with the application over a period of two weeks. Every day during this period, participants filled in a short diary about their usage of the app. During the logging period, the application was regularly updated with new content. Each update represented one of the motivational factors defined in Subchapter 3.3.1. Participants were notified about new content directly in the application (see Figure 36) and for new messages from Navi also by emails (see Figure 37).

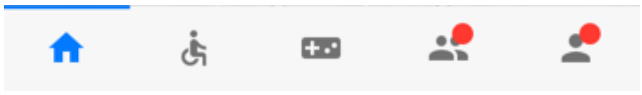

Figure 36 Evaluation of the high-fidelity prototype: In-app update indication

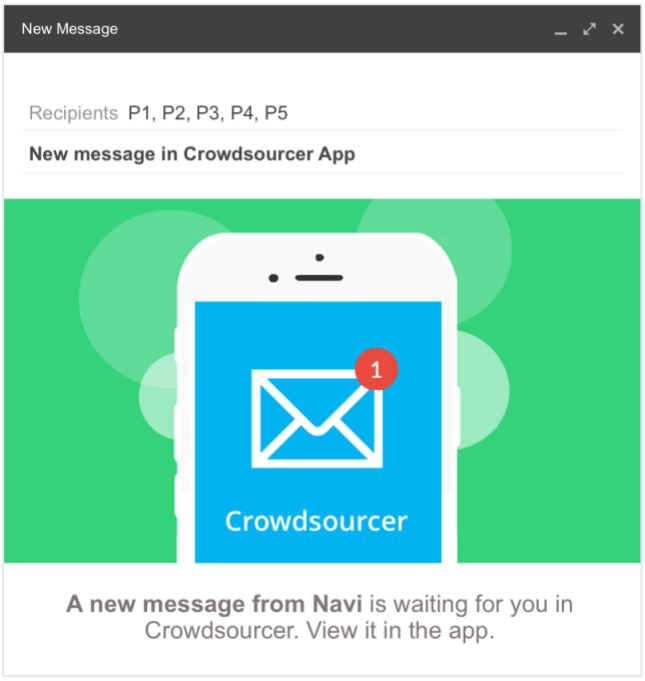

Figure 37 Evaluation of the high-fidelity prototype: E-mail notification

Diary. The diary was designed in the form of an online survey and included the following questions:

- Did you use the application today? [No, Yes]

{if the answer on the first question is No}

- Why didn't you use the application today? What discouraged you?

{if the answer on the first question is Yes}

- Why did you use the application today? What made you use the app? [open question]

- Where and in what situation were you using the application today? (If you have used it multiple times a day, write down all the places/situations.) [open question]
- Mark on the scales how the following things affected your decision to use the application today (1 = no influence, 5 = significant influence) [Likert scales]
  - Fun activity [1-5]
  - Time killing [1-5]
  - Too much unmapped data in the application [1-5]
  - Good deed [1-5]
  - Meaningful activity [1-5]
  - Learn something about the lives of people with disabilities [1-5]
  - Improving my ranking in the leaderboard [1-5]
  - Community involvement [1-5]
  - Obligation (in relation to study) [1-5]
  - Something else [1-5, optional]
- When using the application today [open question, optional]
  - I was pleased with…
  - I was intrigued by…
  - I was saddened by…
  - I was worried about…

- Notes – Any additional comments regarding the app? [optional]

In-app updates. The application was regularly updated with the new content (see Table 6).

DAY OF THE STUDY	UPDATE TYPE	UPDATE DETAIL
1.	new message from Navi	introduction of Navi and encouraging data collection
1.	new message from Navi	recommendation of educational games as a great start for data collection
5.	new message from Navi	[if a participant collected any data] acknowledgement of the collected data [if a participant didn't collect any data] encouraging participant to collect data
6.	new reportage in section Life with disabilities	adding a new article on the practical usage of the data collected in the app
6.	new message from Navi	Navi informs the user about new reportage
7.	new activity in the community section	adding information on how many routes have the data already been used and how much we have covered from Prague
8.	computed accuracy rate in a user profile	adding the accuracy rate for the first week of using the app

8.	new message from Navi	Navi informs the user about the newly added accuracy rate
9.	new life story in section Life with disabilities	adding a new life story about the life of the user of navigation for visually impaired pedestrians
9.	new message from Navi	Navi informs the user about the new story
10.	new message from Navi	[if a participant collected any data] personal acknowledgement of the collected data from the user of the navigation for visually impaired pedestrians [if a participant didn't collect any data] encouraging participant to collect data from the user of the navigation for visually impaired pedestrians
13.	new activity in the community section	adding information on the progress of the user's community
14.	computed accuracy rate in a user profile	adding the accuracy rate for the first two weeks of using the app
14.	new message from Navi	Navi informs the user about the newly added accuracy rate

Table 6 Evaluation of the high-fidelity prototype: In-app updates

Data capture. User's in-app activities were stored for later analysis. When the user visited a certain section of the application, we stored the following attributes: application version, name of a visited section, date, username. When the user collected accessibility attributes of any given segment, we stored the following attributes: list of attributes collected by the user, username, date, information about whether data were collected from a picture.

Post-study interview. After the logging period, a short semi-structured interview was conducted with each participant to research the impact of used motivational factors on participants and get their views and opinions on the tested prototype and testing session. Interview questions were following:

Use of the app

- How was your experience when using the app?
- What is your impression of the app? Choose 3-5 cards from Product reaction cards[12] and explain why you chose those.
- Was the data collection difficult for you?
- What do you like most about the app?
- What do you dislike about the app?

[12] Product reaction cards can be found at https://www.pouzitelnost.info/wp-content/uploads/2015/06/emocni-karty.pdf

- What other features would you like to see in this app? What were you missing there? What could improve it?
- What would encourage you to use the application more often, on a daily basis?

Motivation

- What did motivate you to use the application during the past two weeks?
- If I tell you that the application will be available on Google Play in a month, will you consider downloading it and join the data collection? What discouraged you / what convinced you?

In-app motivational elements

- What new did you learn about the lives of people with disabilities? Were you interested in the section with articles and stories about the lives of people with disabilities? Why?
- Did you play any of the educational games? Why yes / why no? How did you like it? Were they useful for you?
- Have you noticed the Navi dog in the app? What are your impressions of him? What messages do you expect from him in the future? What messages would you like to receive from him?
- Do you remember the message from Zdeněk, a user of the navigation for visually impaired pedestrians? How did it affect you? Would you like to have direct contact with Zdeněk?
- How did you like the community section? What information do you expect here in the future? What additional information would you like to find here?
- Have you followed your ranking in the leaderboard? Why yes / why no?
- Were the personal statistics useful for you? Were you missing any info? How do you understand the stated accuracy rate?

5.2.4. Bias, limitations of the method

The chosen test setting will not allow us to objectively examine the impact of individual motivation factors on the collection of data and their quality. Chosen motivational factors are all implemented in one application and are designed to complement each other. For an objective evaluation of each motivational factors separately, several versions of the application each with only one motivational factor would have to be tested with different groups of participants. Based on post-study interviews and completed Likert scales, we can get participants' feelings and opinions on each motivational factor. Furthermore, because of the number of pavement segments on the map is too high and the data about them are missing, quality of collected data cannot be evaluated objectively, but only on the basis of the participants' opinions and the use of elements designed to enhance the quality of the data, namely educational games, tooltips and accuracy rate.

5.2.5. Results

Pre-study interview

Movement in a city, commuting. Every participant uses public transport for commuting to work or school. Walking time to the stops vary from 5 to 15 minutes, travelling time varies from 15 to 30 minutes per one ride. While waiting for the arrival of public transport and while travelling, participants often spend time reading a book, listening to music or audiobooks, playing games on mobile, and browsing

social networks. Participants prefer to walk when they go for lunch, dinner and go shopping in the neighbourhood of their work or school.

Daily use of mobile apps. Participants mainly use their mobile phones in their free time. They most often use applications such as alarm clock app, Messenger, social networks, public transport apps, maps and Spotify. P1 also uses pedometer app synchronized with her Garmin watch and compares steps with the family members on a daily basis. Every time someone from her family takes more steps than her it motivates her to take extra steps to catch up.

Learning about new apps. Obtaining new applications is based mainly on participants' needs. Participants are usually actively searching for new apps directly in an app store to meet these needs. For P1, P2 and P5 works best if someone recommends them new apps. P3, P4 and P5 also get new apps based on advertising on social networks.

Motivation for crowdsourcing activities. P3, P4 and P5 had no experience with crowdsourcing. P1 joined two crowdsourcing projects in the recent past. The first one was from Google which focused on improving various Google service, i.e. Google Translate. Based on her activity she earned points and progressed to higher levels. It always motivated her to translate another text so she could reach a higher level. The second project was from YouTube - she was translating subtitles and she was most pleased that her name was included in the video to which she translated the subtitles. P2 contributed to Wikipedia by correcting erroneous information because it irritated him. Regularly, he is actively involved in Waze to ensure road safety. For all the participants the greatest barrier to getting involved in crowdsourcing is unawareness of existing projects. Participants do not have an overview of existing crowdsourcing apps because they are usually unrelated to their personal needs, so they are not actively searching for them in an app store and also have poor promotion in their circles.

Non-profit and volunteer activities. P1, P2 and P5 are not actively involved in volunteer activities. P3 and P4 have experience of active volunteering to repair the chapel at their hometown. P3 was also involved in the "Reading helps" project which sent some money to charity for every book she read. P1, P2, P3 and P5 have no close contact with people with disabilities. P1 is only aware of their lives from reportages seen on television. P4 has a colleague in a wheelchair but she doesn't know much about how he handles everyday life.

Data collection

In sum 745 attributes were collected throughout the study, 388 of these were collected from photos. Each of the participants collected data from the map, only two of them collected data also from photos. The number of attributes collected per day can be seen in Figure 38.

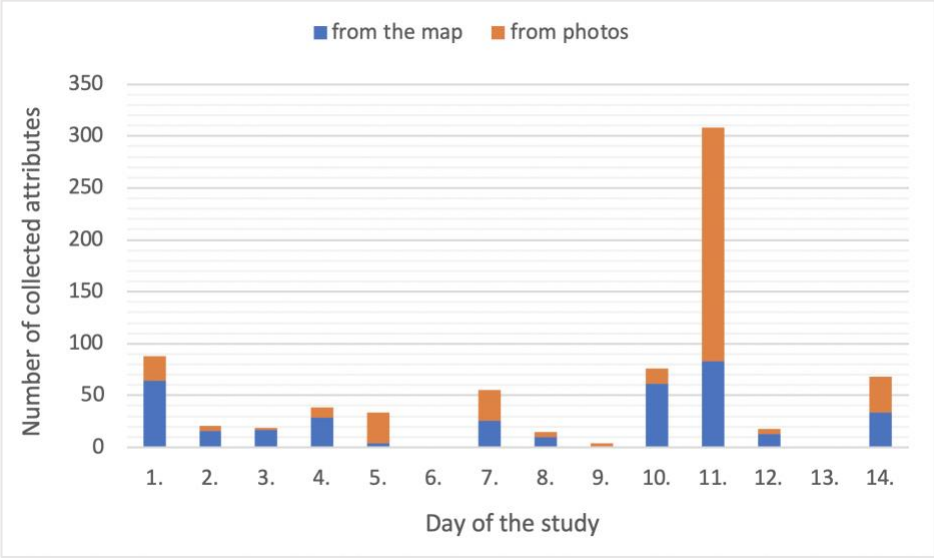

Figure 38 Evaluation of the high-fidelity prototype: The number of collected data

Diary logs

Each participant used the application on at least 4 different days throughout the whole study. The maximum number of days that the application was used by one participant was 8. Participants used the application one or two times a day, but mostly only once a day. The total number of participants who used the application on a given day of the study can be seen in Figure 39.

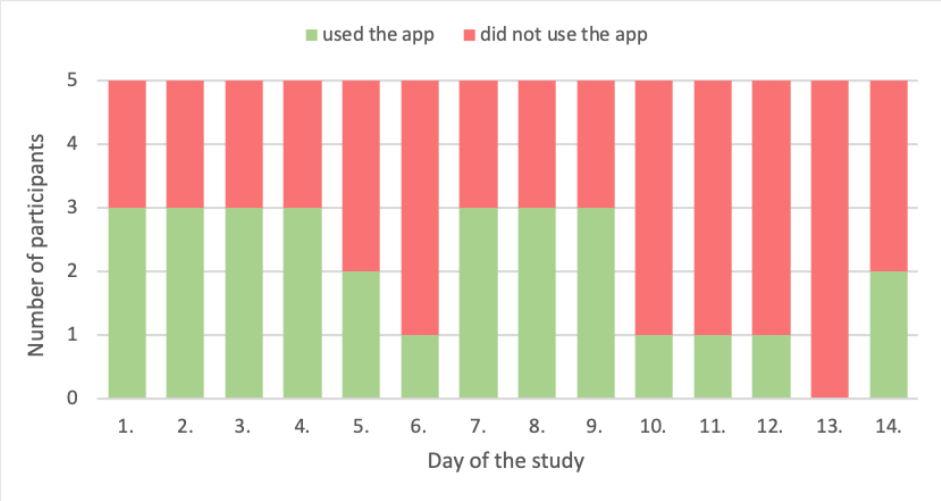

Figure 39 Evaluation of the high-fidelity prototype: Use of the application

The main reasons why participants did not use the application during the study were lack of free time, unsuitable weather for data collection, walking only in places where there were no markers on the map and spending weekends outside the Prague. On the other hand, many reasons why the participants used the application were listed in the diaries. In the first days of the study, the main reasons why participants used the application were curiosity about how it works, what are its main functions and how the data collection works. Later in the study, the participants focused on data collection and visited

the application to collect data to help people to navigate easily in their neighbourhood. Most often they visited the application to use their free time meaningfully. The participants were also attracted to the application by mascot Navi's messages or they opened it to check if there is some new content. The application also provided users with a break from a hard day at work or school.

The participants most often used the application while waiting for public transport, waiting to meet friends, on their way to a meeting if they were well ahead of time, on their way to lunch and on their way home from work and school. Three participants forgot about the possibility to collect data from photos, others collected data from photos when at home or travelling by tram, car or bus. They were unable to collect data from photos when travelling by metro where there is no signal.

Based on the provided Likert scales we can assume factors which had the biggest influence on the decision to use the application (see Figure 40).

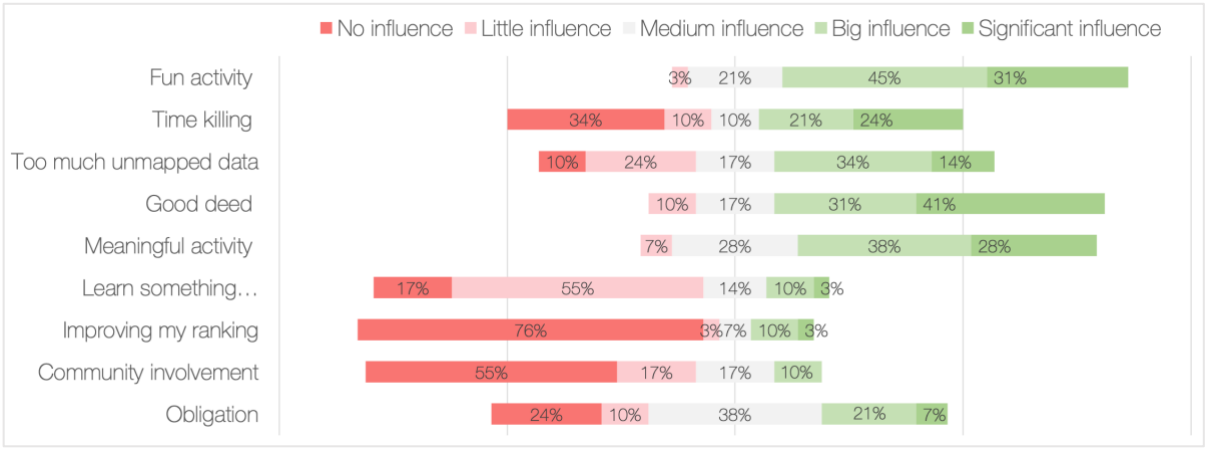

Figure 40 Evaluation of the high-fidelity prototype: Influence of selected factors on a decision to use the application – data gathered throughout the whole study

Contributing to the application by data collection was perceived as a good deed and a meaningful activity which also entertained the participants. These three factors had the most significant influence on participants' decisions to use the application throughout the whole study (see Figures 41 - 43). Furthermore, visualisation of a large number of pavement segments which attributes need to be collected had also a big influence on using the application throughout the whole study (see Figure 44).

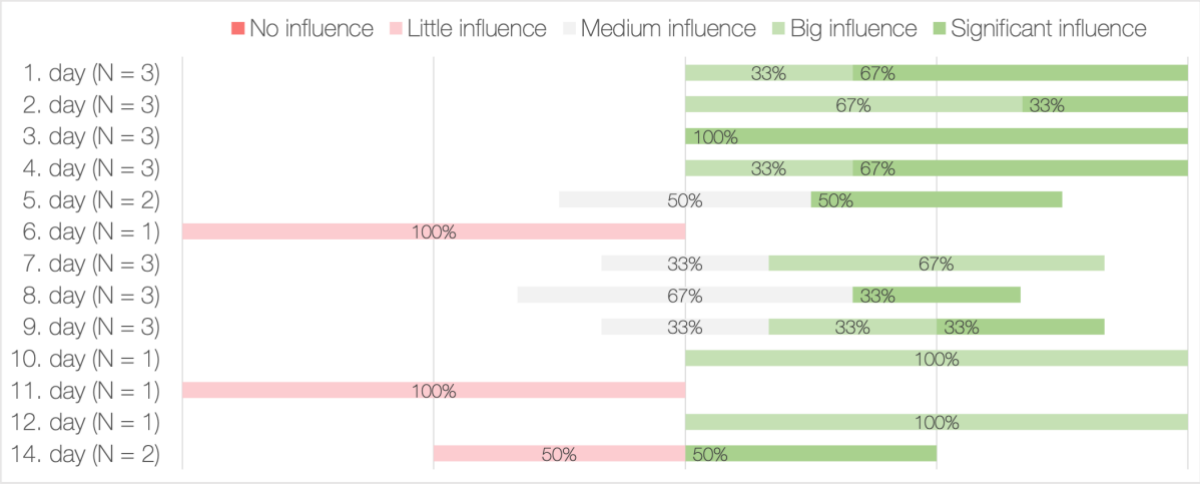

Figure 41 Evaluation of the high-fidelity prototype: Influence on a decision to use the application - Good deed

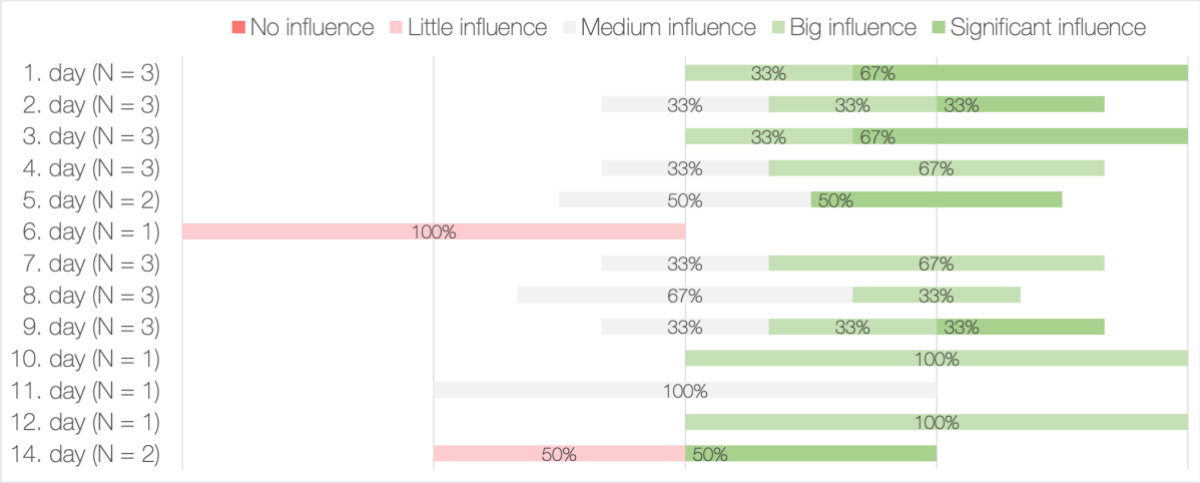

Figure 42 Evaluation of the high-fidelity prototype: Influence on a decision to use the application - Meaningful activity

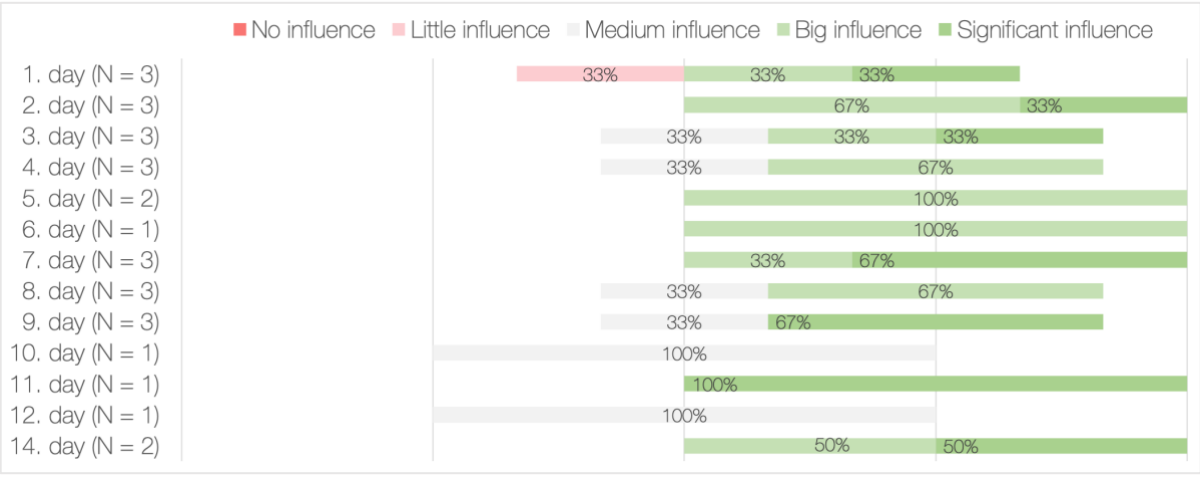

Figure 43 Evaluation of the high-fidelity prototype: Influence on a decision to use the application - Fun activity

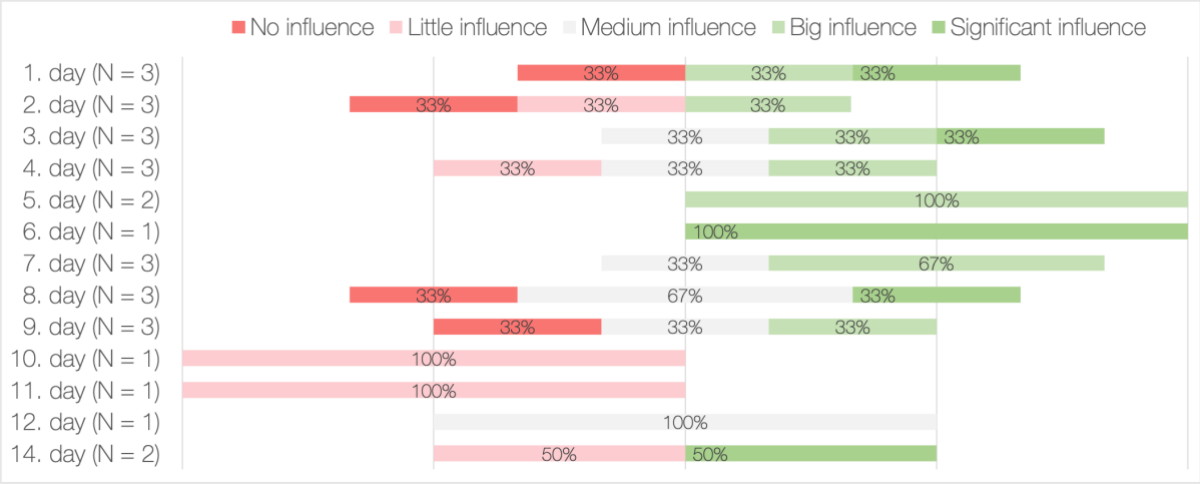

Figure 44 Evaluation of the high-fidelity prototype: Influence on a decision to use the application - Too much unmapped data

After first days of study, the proactive use of the application was reduced, and participants started to perceive it as a good way how to kill time (see Figure 45), especially when waiting for something or someone or while travelling, as mentioned earlier in this section.

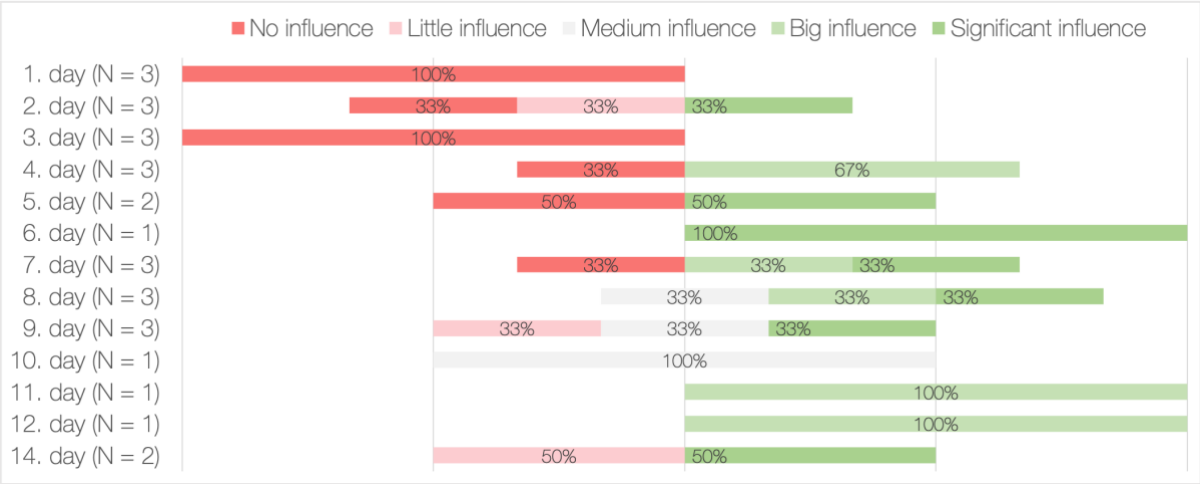

Figure 45 Evaluation of the high-fidelity prototype: Influence on a decision to use the application - Killing time

On the other hand, only a few participants were interested in learning something new about the lives of people with disabilities through the application (see Figure 46). It had a little influence on them throughout the whole study. Moreover, only one participant was highly interested in improving his ranking in the leaderboard (see Figure 47). Interest in the community involvement was low and this did not change even with the updates on community success (see Figure 48).

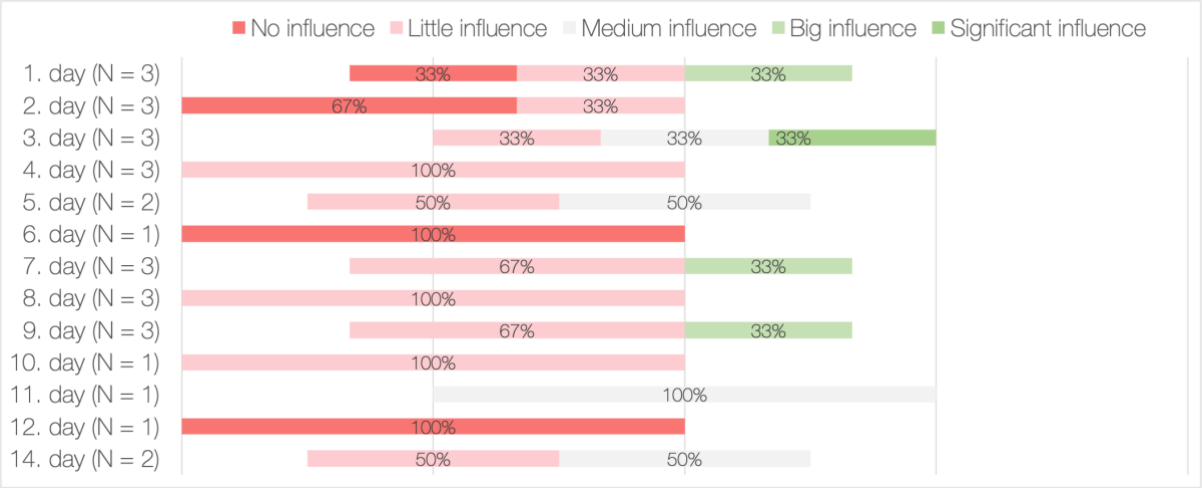

Figure 46 Evaluation of the high-fidelity prototype: Influence on a decision to use the application - Learn something about the lives of people with disabilities

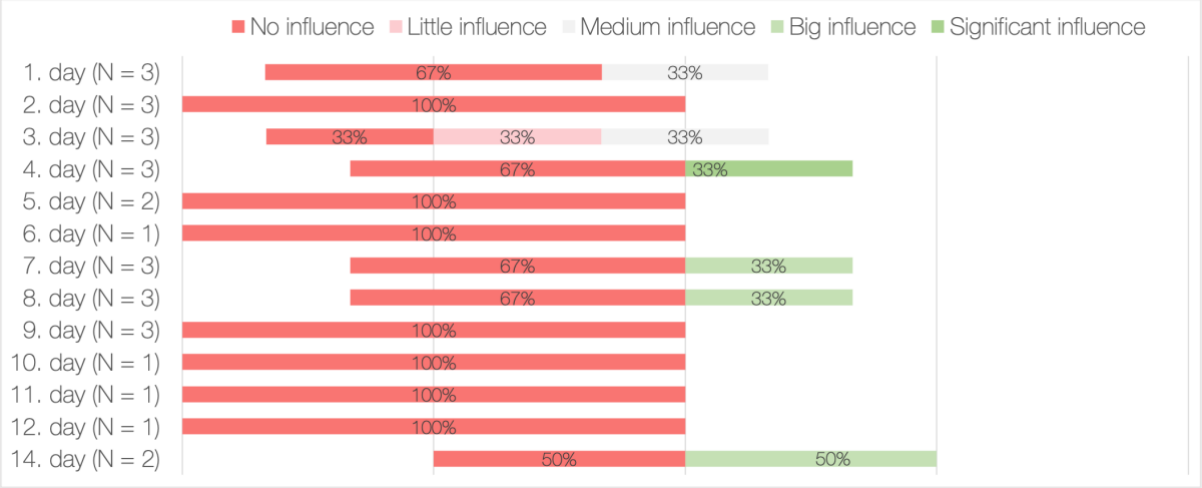

Figure 47 Evaluation of the high-fidelity prototype: Influence on a decision to use the application - Improving a ranking in the leaderboard

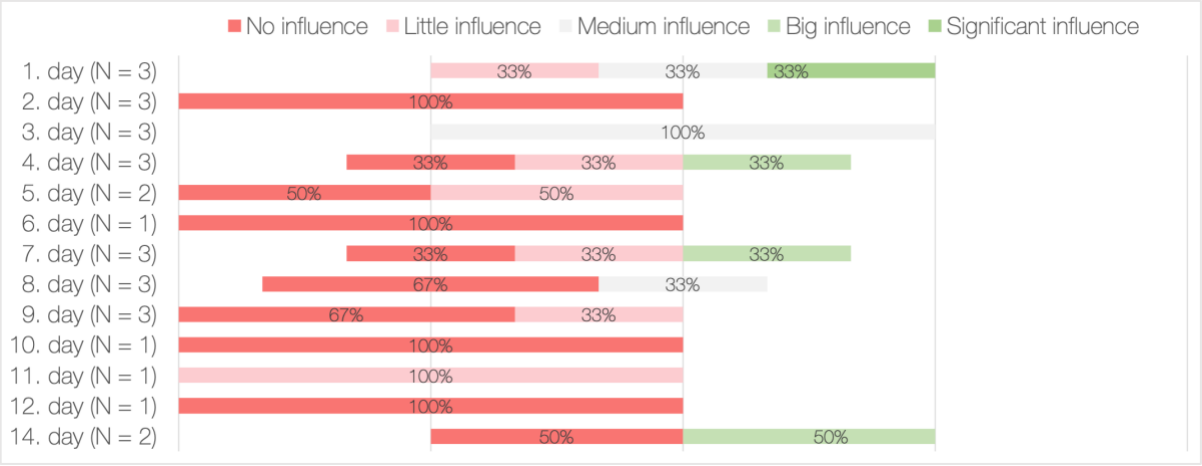

Figure 48 Evaluation of the high-fidelity prototype: Influence on a decision to use the application - Community involvement

Some participants perceived the use of the application as an obligation because they were hired to participate in the study. This influence was strong especially during the first days of the study. On the other hand, some of the participants did not feel any obligation to use the application or felt it only moderately. This influence has diminished with the progress of the study (see Figure 49).

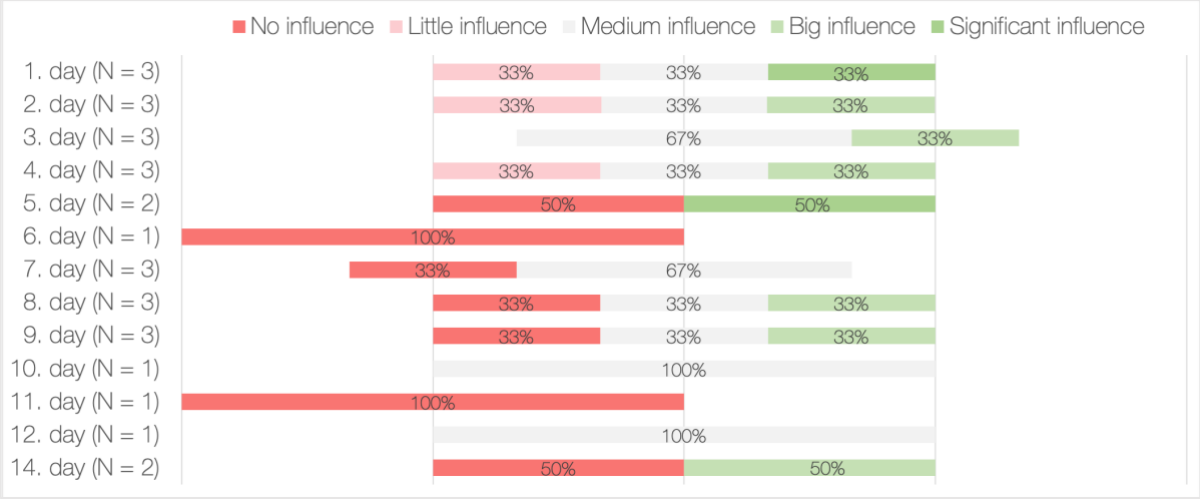

Figure 49 Evaluation of the high-fidelity prototype: Influence on a decision to use the application - Obligation (in relation to the study)

In the last section of the diary, the participants could highlight the most pleasurable and interesting features of the application, express their worries, mention things which had saddened them or capture any thoughts associated with the app. This section was optional, so participants usually skipped it. At the beginning of the study, P1, P2 and P3 mentioned that they were pleased with the smooth functioning of the map and maturity of the application. Among the motivational factors, P1 was pleased with the messages received from Navi. P2 was pleased with tooltips during the data collection. P3 and P4 were intrigued by the report on the use of the collected data in the navigation system for visually impaired pedestrians. P1 was worried whether she had collected certain attributes correctly.

Post-study interview

Use of the app. All participants claimed that the application was very user-friendly and easy to use. They had solely a positive impression of it. Selected reaction cards that most characterize the application according to the participants are listed in Table 7. The design of tasks suited all the participants. They appreciated that one segment was divided into a number of subtasks and each of them could be skipped. They also appreciated tooltips with helpful information. For one segment, a number of questions about its attributes was just right for all participants. All participants enjoyed the collection of data from a map and perceived it as the main feature of the application. P1 appreciated the most that there was also a possibility to collect data from photos, it was a great benefit, which allowed her to participate also from home. She also liked that the map was interactive, and she could easily find out which data needed to be collected. She also liked tooltips and pictograms which helped her to collect data properly. P2 and P5 didn't have the most favourite feature of the app, but they liked the whole experience with it. P3 appreciated a large number of marked places on the map, so she could easily collect data. P4 was pleased with the ease of use of the application. She was able to quickly access the

desired information or data. On the other hand, P3 didn't like that there was no information on how to collect sidewalk slope correctly. Other participants were not able to come up with something that they didn't like on the application. P1, P2 and P5 would appreciate if there was a possibility to undo submitting collected data or possibility to edit them after submitting. It happened to them, that they had collected data and later realized that they had done it wrong. They are worried that it might have serious consequences for people who rely on this data. P2 and P4 would benefit from user profile for personalization of the application, e.g. notification settings, storing user's shoe size for measuring of passable width.

SELECTED REACTION CARD	NUMBER OF PARTICIPANTS WHO SELECTED THE CARD	REASON FOR SELECTING THE CARD
intuitive	5	the application guides you and helps you to collect relevant data; it's modern, simple, easy to work with
meaningful	4	easy activity with a great impact
trustworthy	3	the application looks professionally and collects important data for a certain group of people
practical	3	the application has the potential to help other people
friendly	1	Navi the dog creates a friendly atmosphere
clean	1	the application contains only relevant information; it is not overcrowded
understandable	1	the application makes clear what actions are needed from a user
motivational	1	the application shows specific people to whom it helps
useful	1	the application makes life easier for people with disabilities
important	1	the application has an important mission

Table 7 Evaluation of the high-fidelity prototype: Selected product reaction cards on impressions of the application

Motivation. P1 was very happy about using the application. Every time she used it, she had a warm feeling that she was helping someone, and her activity is meaningful. She didn't feel obliged to use the application in relation to the study. A big motivation for her was to see a number of unmapped photos, she had the urge to put it to zero. She was also happy when markers were gradually disappearing from the map. She is convinced to join the application when it is available. P2 felt the urge to collect data because he was part of the study, but his main goal was to get involved to help other people navigate safely, the urgency passed by the end of the study, but his goal remained. He would continue using the application after the study in case he needs to kill time. For P3 the main motivation to use the application was to collect more data than P3 and P5 (as mentioned earlier, P3, P4 and P5 are in a close relationship).

During the study, P3, P4 and P5 were teasing each other which strongly motivated them to join in data collection and ranked above each other. P3 would download the application once is released because she sees it as a great way how not to procrastinate when waiting on public transport and it was also fun for her. For P4 and P5 participation in the study wasn't the main reason to join in data collection. The main reason for them was that it makes sense and it helps people who are disadvantaged in term of navigation in cities. It was the simplest way how to do something nice for other people. For this reason, P4 and P5 would definitely download the application as soon as is available in store. P2, P3 and P5 claimed that the main reason why they didn't use the application on some days of the study was lack of free time or opportunities and it wasn't related to some missing feature of the app. P1 and P4 were convinced that daily reminder would help them to join the application more frequently. P4 would appreciate if the application could inform her that she is passing a place where something needs to be collected.

In-app motivational elements. Feedback on in-app motivational elements is divided by main sections in the application which represent one or more motivational factors described in Subchapter 3.3.1.

Life with disabilities: None of the users was proactively reading reportages. P1 watched reportage once when Navi sent her message and notified her about it. For P1, P3, P4 and P5 the initial intro of the application they received at the beginning of the study was sufficient hence they no longer needed to read more about it. P2 was already familiar with the navigation application which utilized the collected data and therefore had no need to learn more about it.

Educational games: All of the participants were pleased with educational games, they played all the games available. They referred to them as funny and educational at the same time. P1 and P3 were particularly surprised at what objects present obstacles for the visually impaired pedestrians. They were equally surprised about objects which creates guiding elements. Participants claimed that the information explained in the games helped them later during the data collection. P1, P2 and P3 would like to see more educational games in the application.

Community activity: All participants appreciated the information about the total amount of collected data and Prague coverage. Participants were more interested in watching the progress of all the users of the application as opposed to watching only their community progress. This was because every person shared one goal - to map as many accessibility attributes as possible. They liked the fact that they saw that more people are involved thus the amount of collected data was growing faster, it had a greater impact and made more sense to join.

Leaderboard: Each participant treated this section differently. P1 regularly visited this section to see her ranking. From the very beginning of the study, she was placed on the top rungs of the ranking. When she got a big lead, she was wondering if she should have slowed down, she didn't want to stand out. P2 didn't visit this section often as he wasn't interested in competing with anyone but was pleased that he ranked second at the end. He would appreciate if he could see the leaderboard for all users of the application. P3, P4 and P5 came here often to compare with other participants. During the whole study, P3 was annoyed that P1 had so many points that she could no longer catch up with her. On the other hand, she had fun competing with her close friends P4 and P5.

Navi's messages: All participants positively rated character of Navi. They perceived it as a suitable mascot to cover communication from the application to the users. They opened the application to see Navi's messages after receiving regular email notifications. They expect him to perform or take part in

following activities: support during data collection, acknowledgement when data are collected properly or provide advice on how to improve, publish application news, provide notifications regarding data collection, describe how the collected data are being utilized. Three participants would prefer to receive notification after longer periods of inactivity. P1 and P3 had the urge to react on Navi's messages with like or comment. Every participant appreciated the regular email notification regarding Navi's new messages. P3 would also appreciate in-app notification as well. Participants would like to customize the frequency of the notifications. P4 would like to receive one notification per day, others mentioned that 1-2 notifications per week would be preferred. The received message from Zdeněk, the visually impaired user of navigation that uses the collected data, pleased all participants. It had a strong impact on them. However, participants wouldn't want to have more contact with him than they had so far. They had no need to establish communication with him. P1 claimed that she would be very uncomfortable if Zdeněk approached her directly without the Navi as a liaison and would probably back out of the project. Thanks to the introvert personality of P2, he didn't want to have direct contact with Zdeněk either. In addition, P3 and P4 would not want to receive such messages often, it might have been perceived as emotional blackmail. P4 doesn't think that direct contact with the consumers of collected data belongs to this kind of application.

User's collection profile: All participants appreciated the content of this section. They find it useful. They were most curious about the accuracy rate of their collection. It reassured them that they were doing data collection right or warned them that they were doing something wrong and needed to improve. After the publication of the accurate rate for the first week of the study, participants claimed that they were more cautious when collecting data. At the end of the study, participants were pleased that they managed to improve their accuracy or at least they didn't worsen it. All participants correctly understood how the accuracy rate in the application is computed. P3 would appreciate if the application could provide her information about exact segment and its attribute which she didn't collect correctly.

6. DISCUSSION

The results indicate that altruism plays a major role in crowdsourcing of accessibility data. However, based on the findings of Baruch, May and Yu (2016) and Goncalves et al. (2015) it may not be enough to keep all participants engaged for a longer period. Additional motivational factors are needed. The results agree with claims of Goncalves et al. (2015) that using psychological empowerment to enhance causal importance and perceived self-efficacy might lead participants to recognize that solving crowdsourcing task is an important, useful and meaningful activity. Introducing friendly mascot Navi the dog who provides a user with follow-up information on the use of collected data, news on how much a the user is actually helping and thank you messages from consumers of collected data proved to keep participants more engaged to crowdsourcing accessibility data. Navi also helped increase the number of application visits. Notifications for new messages from Navi that were regularly sent by e-mail also helped to remind users about the data collection itself as collecting accessibility data is not based on user's daily needs and can be easily overwhelmed. Moreover, Navi acted as a successful liaison between the user and visually impaired pedestrians who benefit from the collected data, direct contact between these two groups proved uncomfortable for users of the application.

The results fit with the theory of Kittur et al. (2013) that user-friendly interface, good design and simplicity of the tasks play an important role in crowdsourcing activities. Well-designed tasks can provide participants with enjoyment and fun. Moreover, the results suggest that easier tasks with greater guidance i.e. detailed description of task, tooltips, training and feedback on the accuracy of collected data can keep participants engaged in crowdsourcing and lead them to high-quality data. These results support findings of Baruch, May and Yu (2016) and provide new insight into how training of the crowd should be provided. Presented educational games helped the crowd to learn important information about the requested data in a fun and friendly way. The information they learned while playing the game gave them a sense of assurance that they are competent to collect relevant data. In addition, when collecting data from photos, if the crowd is asked to collect one attribute from multiple photos, the collection is fast and accurate because they can fully focus on this one attribute which also supports findings of Baruch, May and Yu (2016).

The study confirmed claims of Baruch, May and Yu (2016) that a feeling of cooperation is far more important for the participants of non-profit crowdsourcing than competition between them. The participants shared a common goal, i.e. collect accessibility data to ensure safe navigation for people with disabilities, and therefore were more interested in information about how they progress together rather than in their ranking in the leaderboard. Although, results suggest that gamification can work within smaller communities of friends and create friendly competition which drives the crowd in data collection as opposed to the claims of Eveleigh et al. (2013). The results indicate that these smaller communities could be better balanced without big extremes in contributions as we assume that the amount of free time which can be dedicated to crowdsourcing of accessibility data relate to social and work environment. Supporting the claims of Goncalves et al. (2015) and contrary to the research of Spindeldreher and Schlagwein (2016) sense of community was not perceived by participants as something that would increase their participation. However, as mentioned above, they appreciated the feeling of cooperation across all participants and provided information about the success they achieved together.

The overall results indicate that the application can have its own place in the daily life of the public. Crowdsourcing of accessibility data can enrich a free time with meaningful activity and provide enjoyment and fun while commuting or waiting for someone or something. Besides the motivational factors, stability, fast response and intuitive interface of the application have a strong impact on the likelihood of participation.

Last but not least, the study pointed out the importance of raising awareness about the life of people with disabilities and bringing attention to non-profit crowdsourcing projects in which lay public can participate and help. Public awareness of crowdsourcing projects is key to get a large number of people involved.

7. CONCLUSION

The main objective of this thesis was to research people's motivation to get involved in crowdsourcing platform and explore possibilities of how to attract a large number of crowds and lead them to high-quality work. Based on the analysis of available literature and results of the conducted design workshop, we have identified 5 main motivational factors which might lead to higher contributions and high-quality results when crowdsourcing accessibility data. Based on these motivational factors we defined three main use-cases for our crowdsourcing application, described them in scenarios and storyboards, and the model of the future solution was presented. Aiming at early feedback from the potential users, we created the low-fidelity paper prototype of mobile application which covered all the defined use-cases. The prototype was evaluated via usability testing with the target group (N = 5, mean age = 27.6). The results didn't show major usability issues with only a few design changes to implement. Used motivational factors have been positively rated by the participants and have contributed to the overall positive experience with the low-fidelity prototype. After that, the high-fidelity prototype was created with a few improvements applied. It was implemented as a native mobile application so that it can be tested in a natural environment in the longitudinal study. To evaluate the high-fidelity prototype and examine the effect of motivational factors on a number of contributions and quality of collected data, the diary study method was chosen with participants (N = 5, mean age = 27.2) logging their experiences with the application over a period of two weeks. The results suggest the feasibility of the approach supported by enhancing causal importance and perceived self-efficacy of users, providing them training and feedback on contributions, supporting a feeling of cooperation and allowing them to share data collection with friends.

For the future work, the results of the high-fidelity evaluation will be used to further improve the application before it would be made available for the public.

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APPENDIX

Deliverables. At the time of this writing, the source code of the high-fidelity prototype and application package for installation on android mobile devices are available at https://github.com/misnlog/diploma-thesis-crowdsourcer. The application installed on an android device can be accessed using the following credentials: username = slon; password = i3d. After initial login, it is necessary to allow usage of location services and then restart the application.

The web version of the high-fidelity prototype optimized for mobile use consists of two separate deployments - front-end and back-end. Before accessing the front-end it is first necessary to open back-end URL in your browser at https://147.32.81.90:8444/actuator/health and confirm the usage of a self-signed certificate. Then it is possible to access the front-end application at https://147.32.81.90:8095/ using same credentials as for the mobile application.