Evaluation of a Usability Testing Guide for Mobile Applications Focused on People with Down Syndrome (USATESTDOWN)

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Abstract. Usability testing of mobile applications involving people with Down syndrome is an issue that has not been comprehensively investigated. There is no single proposal that takes on board all the issues that could potentially be taken into account to deal with the specific needs of people with Down syndrome. We propose a guide for a usability testing process involving participants with Down syndrome. This guide is called USATESTDOWN. It is based on a literature review and experience gained at a number of workshops where people with Down syndrome used mobile devices. This paper briefly describes USATESTDOWN and its application at a special employment centre called PRODIS with 10 participants.

Keywords: Usability testing · Mobile applications · Cognitive disability · Down syndrome · Human computer interaction (HCI) · Mobile devices

1 Introduction

An essential property of mobile devices and applications is usability. Usability is defined by three main attributes: effectiveness, efficiency and satisfaction [1]. Usable systems are easy to learn, efficient, not prone to errors and generate user satisfaction [2].

This paper is part of a research focused on usability for people with Down syndrome (DS). DS is a cognitive disability with specific characteristics. People with DS have impaired cognitive processing, language learning and physical abilities, as well as different personal and social characteristics [3]. Children with DS differ from neurotypical children or children with other types of developmental disabilities in that all three major types of abilities (cognitive, motor, and perceptual) are affected but the disability

often is slight [4]. The functional abilities of individuals with DS, related to the extent of the impairment in the sensory and motor channels [4], memory, cognition and communication skills, vary hugely [5]. Both the research and clinical literature report difficulties in the auditory [6], visual [2] and tactile [7] sensory areas. With regard to motor skills, low muscle tone and weak muscles are often a problem [8]. Researchers aiming to evaluate a mobile application in individuals with DS should take into consideration these sensory and motor issues.

On the grounds of the particular characteristics of people with DS, the products that they use need to be highly usable. Usable design calls for a user-centred approach, where users are involved in several steps of the process, including usability testing. In this context, the process of usability testing should fit the needs of people with DS. We have developed a guide to improve this process [9]. This paper explains how the guide was applied to one particular usability testing process.

The paper is structured as follows. Section 2 describes related work on usability evaluation involving people with DS. Section 3 provides a brief overview of the USATESTDOWN guide. Section 4 describes the evaluation of USATESTDOWN. Finally, Sect. 5 reports the findings and outlines future work.

2 Related Work

2.1 Usability Evaluation Methods

There are three types of evaluation methods: observational, analytical and inquiry evaluation methods [10]. Observational methods (such as usability testing and user performance testing) collect data by observing user experiences with a product [2]. Analytical methods (such as heuristic evaluation and cognitive walkthrough) rely on the opinion of experts rather than collecting data from user experiences [11]. Inquiry methods (such as user satisfaction questionnaires or focus groups) take a user-oriented view and identify broad usability problems or opinions on a product as a whole.

Given the specific characteristics of people with DS, inquiry methods are not adequate as they require communication skills and abstract logical thinking [12]. Likewise, analytical methods are unsuitable because people with DS have a wide range of different abilities. This means that observational and, in particular, usability testing methods are preferred. This is the focus of the research presented in this paper.

2.2 Usability Testing of Mobile Applications Involving People with DS

We have not found much research on the usability evaluation of ICT involving users with DS. Devan is a tool for detailed video analysis of user test data. It makes use of a table format for representing an interaction at multiple levels of abstraction. Devan has been successfully applied among children with DS [13]. Kumin and Lazar evaluated the usability of multi-touch tablet devices by adults with DS for workplace-related tasks. They concluded that people with DS can use a multi-touch-screen device to complete office-related tasks [14]. AR BACA SindD is a usability evaluation framework for an

augmented reality framework for learners with DS. The framework has been applied to the usability evaluation of learning courseware based on augmented reality [15].

2.3 Analysis of Related Work

While there is some related research, it is incomplete. Additionally, we failed to find a single proposal that took on board all the issues that might be taken into account. The paper on Devan does not consider mobile or touchscreen devices and does not describe a complete usability testing guide [13]. The usability evaluation by Kumin and Lazar set out to understand potential interface improvements and gave several tips on usability evaluation. However, they failed to define a usability test guide [14]. Although AR BACA SindD is a usability evaluation framework for an augmented reality framework for learners with DS, it focused specifically on AR systems. This evaluation cannot be generalized to other systems [15]. In short, there is no guide for evaluating usability in mobile applications focused on people with DS.

3 Overview of USATESTDOWN

USATESTDOWN [9] is a guide to support usability testing of mobile applications when the participants are people with DS. It has been developed by combining information collected from a literature review [16] and experience acquired during four workshops with approximately 100 children with DS [17, 18].

Table 1. Summary of recommendations provided by USATESTDOWN

Step	Recommendations
1. Recruit participants	<ul style="list-style-type: none"> • Recruit a minimum of 10–15 participants • Take into account the mental age (rather than their chronological age) of people with DS • Involve usability experts, DS experts and DS tutors
2. Establish tasks	<ul style="list-style-type: none"> • Define tasks with increasing levels of difficulty • Tasks should be simple and short (plan for 10 min. sessions) • Cooperate with experts in DS to define tasks • Do not limit time to finish a task
3. Write instructions	<ul style="list-style-type: none"> • Prepare an oral presentation of the test for participants • Use simple language to communicate with participants • Speak slowly when explaining the test
4. Define test plan	<ul style="list-style-type: none"> • Simplify evaluation scales down to 3 values (agree, neutral, disagree) and use faces (happy, neutral, sad) when possible • Minimize the amount of text presented to participants • Use short interview questions
5. Run pilot tests	<ul style="list-style-type: none"> • Have a meeting with the participant before the test • Make sure that parent, tutors or teachers are present during the test
6. Refine test plan	<ul style="list-style-type: none"> • Update the plan quickly if participants are found to have trouble during the pilot test
7. Run the test session	<ul style="list-style-type: none"> • Record videos of the session taking care not to film the participants' faces • Pay special attention to the reactions of the participants, as they may have trouble explaining their feelings during the test
8. Analyse data	<ul style="list-style-type: none"> • It is essential to combine quantitative and qualitative results • Carefully compare quantitative data with qualitative results, as they might be different
9. Report results	<ul style="list-style-type: none"> • Report the results to all stakeholders, including family or teachers of the participants

The guide reproduces the usual usability testing steps. The usability process is divided into the following steps: (1) recruit participants, (2) establish tasks, (3) write instructions, (4) define the test plan, (5) run the pilot test, (6) refine the test plan, (7) run the test session, (8) analyse the collected data, and (9) report results.

The guide provides recommendations taking into account the needs of people with DS in the usability testing process. Table 1 summarises some of the recommendations provided in the guide.

4 Evaluation of USATESTDOWN at PRODIS

This paper describes the application of USATESTDOWN in a real case at the PRODIS Centre in Madrid, Spain [19]. The goal was to evaluate the usability of the AssisT-Task tool [20], a mobile technology system that was especially designed to assist people with cognitive disabilities in their workplace. AssisT-Task is based on assistive technologies using QR codes and mobile devices. It is meant to help these people perform their daily life activities and gradually gain autonomy through its use. This application generates step-by-step manuals that can be adapted to the circumstances and needs of the user such as support for a wider set of tasks, enabling user interaction during application use.

USATESTDOWN was applied to the AssisT-Task tool, as described below:

1. **Recruit participants.** Participants were selected by the experts in the PRODIS Centre. The workshop was attended by seven women and four men aged from 21 to 28. The participants had no prior experience handling the insurance policy selection process.
2. **Establish tasks.** The tasks were defined by a team composed of two specialized tutors working on a daily basis with people who have DS, a usability evaluation expert and an expert in the AssisT-Task application. The test was held in the employment centre to assure that participants were in a familiar and normal environment. The tasks defined for the test were based on the common use of AssisT-Task.
3. **Write instructions.** Short documents were prepared to help participants understand what they were supposed to do.
4. **Define the test plan.** The defined test plan included a specific section on the training of the participants before performing the test. In addition, the test plan included an easy-to-read version of the System Usability Scale (SUS) questionnaire, which was put together with the support of experts in DS.
5. **Run the pilot test.** The pilot test showed that the cameras were not in the best position. In addition, the user seemed a little confused with the short explanation of the application.
6. **Refine the test plan.** It was decided that the tutors should be involved in task execution. The camera positions were modified, and more time was set aside for explanations.
7. **Run the test session.** The modified test plan was applied for all the participants.
8. **Analyse the results.** We viewed the videos and annotations and created a document with the collected data. The results for success (task completion), satisfaction and frustration were then analysed. Most participants were able to complete their tasks

and were satisfied with the tasks that they had completed. However, levels of frustration were higher, indicating that they had some trouble with each of the tasks. In addition, we analysed timing as recorded by the application, as well as the responses to the SUS questionnaire. In both cases, the results were positive.

9. **Report the results.** The results were reported to the development team and to the managers. These results will be taken into account to improve the AssisT-Task system.

5 Conclusions and Future Work

First, it was necessary to adapt the SUS questionnaire for people with DS because the language in which it is written is complex. The test results were overwhelmingly positive, and participants commented that they had enjoyed both the application and the process, which is also confirmed by the recorded videos.

Generally, the USATESTDOWN guide proved to be viable and can be successfully used and modified to meet the needs of specific projects. Expert tutors rated the guide positively.

The participation of these expert tutors was very important for the implementation of the test according to the guide. Additionally, it is critically important for the expert tutors to be in attendance during the participants' interactions with the application in order to create a relaxed and familiar environment.

A negative factor of this evaluation was the time limits placed during the application of the pilot test on participants. Participants found it stressful being subjected to the times taken by the first participant.

Note also that the participants quickly forgot the process. We suggest that an evaluation stage be added where devices are given back to participants in order to determine how long it takes for them to work independently and be able to do the activity unaided by a tutor or the application.

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