Digital Health and Informatics Innovations for Sustainable Health Care Systems
J. Mantas et al. (Eds.)

doi:10.3233/SHTI240439

Success Factors for Usability Testing of Digital Health Solutions

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Abstract. Background: The design and development of patient-centered digital health solutions requires user involvement, for example through usability testing. Although there are guidelines for conducting usability tests, there is a lack of knowledge about the technical, human, and organizational factors that influence the success of the tests. Objective: To summarize the success factors of usability testing in the context of patient-centered digital health solutions. Method: We considered three case studies and collected experiences related to time management, relevance of results and challenges encountered. Results: Success factors relate to participant privacy and data protection, test environment setup, device and application readiness, user comfort and accessibility, test tools and procedures, and adaptability to user limitations. Conclusions: Small organizational and technical details can have a big impact on the outcome of a usability test. Considering the aspects mentioned in this paper will not only save resources but also the trust of the participating patients.

Keywords. Usability, testing, user-centered design, user experience, digital health intervention, user involvement

1. Introduction

Patient-centered design "focuses on needs, wants and skills of the product's primary user [ergo, patients] and implies involving end-users in the decision-making and development process" [1]. One method of achieving this involvement is usability testing, which aims to identify any confusing design decisions that might impair the interaction with a digital health solution. Usability tests can be moderated by a facilitator or unmoderated, managed by an automated software solution. Unmoderated testing usually requires less time, although not being suitable for testing of early prototypes. Moreover, participants "tend to be less engaged" [2]. On the contrary, moderated testing requires moderation by a facilitator. While qualitative studies reach the maximum benefit-cost ratio with only five participants, quantitative research requires at least twenty participants for achieving a reasonably small margin of error [3]. Testing cannot be parallelized, resulting in high personnel costs, in addition to the time needed for development of the testing procedure

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and analysis of results. While there exist various methodological guidelines for usability testing of digital health solutions (see [4], [5], [6]), there is a lack of recommendations regarding technical, human and organizational success factors. With this paper, we present an overview of applied strategies and best-practices to maximize the return-on-investment of moderated usability testing of digital health solutions.

2. Methods

We conducted a multi-case study to explore the processes and experiences of usability testing of digital health solutions. Specifically, we aimed at obtaining a rich understanding of experiences regarding usability tests, including technical, human, and organizational success factors. We included three cases of usability tests, varying in location, application development phase, target group and number of participants. However, all three cases aimed at assessing a digital health solution and required the participants to enter or retrieve information. Feedback was obtained from each of the test facilitators based on the following questions: 1) Were the results of the usability workshop useful for the further development of the digital health solution? 2) How was the time management? 3) Which threats or challenges did you recognize during usability testing? 4) Which potentials for improvements do you see?

3. Results

3.1. Case 1: Digital Medical Interview Assistant for Mammography

For this case, we tested a previously developed digital medical interview assistant (DMIA) for mammography [7]. Patients interact with the DMIA using a chat interface on a tablet device. The system collects the medical history of a patient and provides this information to the responsible radiologist. A question answering system is included that enables patients to ask questions regarding an upcoming mammography. The system is based on predefined content, where the patient question is mapped to the most similar predefined question and the corresponding answer is returned. A usability test was carried out with 35 patients (mostly women before undergoing a mammography) using a tablet device. To ensure compliance with the General Data Protection Regulation (GDPR) and allow for de-indentification, a random identifier was assigned to each person and all persons entered the same provided dummy data into the system instead of their real names. As test facilitators have no access to accumulated data and researchers are not in contact with test persons, their identity remains unknown. Furthermore, the DMIA communicates with another system to fetch anamnesis questions and patient data. At the time of usability testing, this system was not implemented yet, leading to increased effort for implementing a test mode. Due to little time and resources available, the test mode required careful interaction with the system in order not to lose logging data, which could not be omitted in one test case due to insufficient training of facilitators. Below, we describe further best practices that were iteratively discovered and improved with each test:

- Ensure that the test device’s battery is fully charged.
- Set display luminosity to 100 %.

- Consider activation of kiosk-mode (locking the application to be tested in place).
- Turn off automatic rotation of display if not foreseen by the application.
- Ensure that the keyboard layout corresponds to country standard.
- Turn off automatic correction and automatic completion.
- Disinfect device after each usage.
- Offer test persons a touch pen.
- Turn off display timeout and automatic display lock.
- Ensure a quiet test environment.

3.2. Case 2: Mobile App for Cancer Survivors

In this case study, we designed a digital solution to support cancer survivors. Potential users were involved in gathering requirements and providing feedback on design prototypes. The latter were created using Figma (https://www.figma.com). The solution tested in the usability test was a non-functional but clickable prototype. The designed features are related to sports and nutrition and include an overview of exercises, group activities or access to recipes and nutritional advice. A total of five people were involved in the test. The test was divided into three parts: 1) interaction with the application using Maze, 2) free exploration of the application on a mobile phone, 3) post-test interview. Maze (https://maze.co) allows the definition of tasks for usability testing. The tool then guides the participant through the tasks and automatically collects interaction data. The analyses contain information about wrong click rates, direct success, incomplete tasks and the average duration of each task. As Maze was assumed to be unknown to the participants, a short introduction was given before the actual test began.

During the usability test, we received valuable feedback showing us that our initial assumptions did not always meet the needs of patients. These insights were essential to make targeted adjustments and better adapt the application to the real needs. Several challenges arose. The subjects had significant problems interacting with Maze. Due to technical issues, it was not possible to use Maze in a mobile phone which would have been the targeted device for the final solution. Instead, a laptop was used. However, the user interface on a laptop is very different from the interface on a mobile device, resulting in interaction difficulties. The setting was stressful for the participants because two people were doing the test at the same time in the same room, but with different devices which produced additional noise. Some of the subjects suffered from chronic fatigue. As a result, they had to stop and could not continue with the test as planned. Best practices resulting from this test are:

- When using a testing tool, schedule a testing period to get familiar with it.
- Use the device for testing for which the application has been designed.
- Consider the cognitive capabilities and health limitations of the participants and adapt the testing protocol in a way to plan for breaks.
- Conduct the test in a quiet environment.

3.3. Case 3: Mobile App for Monitoring Multiple Sclerosis-Related Symptoms

This case study presents the experience gained in the development of a mobile app to support research conducted in the MSF-PHIA project. The main objective of the MSF-PHIA app was to collect patient-generated health data on possible Multiple Sclerosis

(MS)-related symptoms, such as perceived fatigue, including cognitive fatigue, emotional state, etc. This app implemented several mandatory as well as voluntary questionnaires used by the participants for self-reporting their health status. Reminders were also implemented in the app to prompt participants to complete the questionnaires requested in the study. The app design process was user-centered and involved the participation of healthcare professionals. The app was developed with Flutter. An initial usability test was performed with a limited sample of persons with MS (n=3). This test was conducted in a room of the hospital after their clinical visits. Some tasks were predefined: opening the app; accessing and completing the perceived fatigue questionnaire; accessing and setting the user's preferences; accessing and completing the cognitive activity questionnaire; and closing the app. A researcher asked participants to perform these tasks independently during the test session. Information regarding errors, incomplete tasks, and any potential doubts was collected, as well as participants' comments. The second test was conducted after participants (n=9) used the app at least three times per day for 14 consecutive days. An individual interview was conducted at the patient's home to identify any potential issue affecting technology acceptance, including usability issues.

As a result of the initial usability testing, we gathered valuable information to anticipate and resolve any problems in the next phases of the research. We also identified several challenges during both usability tests. Most of these challenges were related to MS-associated fatigue, particularly cognitive fatigue. Persons with MS who experience fatigue may feel exhausted when concentrating on a task for a period of time. Most of the participants reported fatigue after performing the proposed tasks. This fact influenced the time needed to perform the tasks and, therefore, their perceptions of ease of use. The number of proposed tasks, their difficulty, in particular the number of options and questions to be completed in the questionnaires, were pointed out as relevant factors affecting perceived usability. In addition, transportation to the clinic and attendance to their scheduled visits, including some clinical tests, also influenced their perceived fatigue and the usability test results. The following additional best practices were identified:

- Consider the characteristics of the target population when planning the usability test.
- Use measurement tools such as questionnaires to detect the participant's current status in terms of symptoms or capabilities that could influence usability test results.
    - These tools should be simple but accurate to allow defining the participant's status without impacting his or her fatigue level.
    - Schedule a new appointment when the participant's situation is not suitable.
- Establish adequate breaks during the usability test session.
- Define an alternative plan to be followed when the level of fatigue or other limiting symptom is high.
- Select an appropriate location that avoids worsening of the patient's conditions/symptoms.
- Ensure that tasks and explanations are adapted to the participant's capabilities, especially cognitive, and current state of the participant.

4. Discussion and Conclusions

Experiences from the three included cases differ widely, although demonstrating that especially consideration of participating patients' needs and sufficient preparation have a positive impact on the outcome of a usability test. First, it is important to consider the resilience and peculiarities or limitations of the participants, as recently shown by Maqbool and Herold [8]. For example, a test could be split up into smaller units to allow for breaks. Only one person should conduct a test in one room to avoid distraction and noise. It is important to consider factors that might impact the experience of the testing participants: Stress, overwhelm, lack of trust or similar aspects might all have an impact on the usability test results. It is thus important to ensure user comfort and accessibility when conducting the test.

Second, test facilitators should undergo a structured briefing about the testing procedure and should perform the test themselves as well with another person to identify and improve potential issues as early as possible.

Third, a technical preparation checklist standardizes the set-up of the testing device and ensures that no technical difficulties arise during the procedure. This also includes ensuring that the test can be conducted on the same device for the test as the solution is developed for. Usability testing should be considered as early as upon definition of the system requirements, including a test mode of the system without depending on external systems. Technical tests should be performed at the location where the usability tests will be conducted to check that the necessary technical resources and conditions, such as internet connection, lighting, and noise conditions, are appropriate. Adhering to the above-mentioned recommendations fosters optimization of resource allocation and, most important, patient trust.

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