

Agile eHealth Usability Evaluation: A Triangulative Approach to Promoting the Usability of eHealth Systems

Irina SINABELL^{a,1} and Elske AMMENWERTH^a

^a *UMIT TIROL – Private University for Health Sciences and Health Technology, Hall
in Tirol, Austria*

Abstract. Background: Usability evaluation is difficult to reconcile with agile software development for eHealth systems, because traditional usability evaluation is often complex and cumbersome to implement. However, obtaining prospective users' feedback during agile software development is crucial for improving the usability of eHealth systems, which is why there is an increasing need for agile eHealth usability evaluation. Objective: This study investigates whether agile usability evaluations are suitable to evaluate patient-centered eHealth systems being agile developed in health care and are applicable for prospective users, such as older persons suffering from age-related declines. Methods: A triangulation study was conducted combining iterative expert interviews with an exploratory case study. Results: The triangulation study revealed that the implementation of an agile eHealth usability evaluation with prospective users such as older persons proved to be possible. Conclusion: Established eHealth usability evaluation methods must be further evolved to address age-related impairments of older persons.

Keywords. telemedicine, user-centered design, medical informatics applications, consumer health informatics

1. Introduction

Information and communication technologies (ICT) are developing rapidly [1] as well as new health care innovations, particularly in the field of eHealth [2]. eHealth systems that promote a healthy lifestyle could improve the ability to recognize, monitor, and manage the own health condition [3]. ICT, such as eHealth systems, can thus contribute to improving the quality of life [4]. Besides the rapid development of eHealth systems, the population is ageing, leading to a digital divide between older and younger people in terms of the use of ICT [5]. eHealth systems can help older people to live independently [6], but rapid technological progress is leading to an ever-increasing variety of eHealth systems. Older people are willing to embrace new ICT [4] but sometimes have limited IT knowledge. Ensuring the quality of life of older people has become a priority of modern society [7], which demonstrates the need to improve the usability of eHealth systems.

¹ Corresponding Author: Irina Sinabell, UMIT TIROL – Private University for Health Sciences and Health Technology, Hall in Tirol, Austria, E-Mail: irina.sinabell@edu.umat-tirol.at

Expert- or user-based usability evaluation methods can be utilized for a usability evaluation of eHealth systems. During expert-based usability evaluation methods, the experts put themselves in the role of prospective users [8]. In user-based usability evaluation methods, prospective users are involved in the usability evaluation, which is usually carried out through usability tests in a usability laboratory [9]. eHealth systems are being developed using agile software development to incorporate user feedback obtained from usability evaluation early. However, traditional expert- or user-based evaluation methods are difficult to reconcile with agile software development [10], because they require a lot of time and resources [11].

Agile development requires the application of usability evaluation methods that are easy to implement. In order to keep up with the rapid development of eHealth systems and to obtain prospective users' feedback during agile software development, which is crucial for improving the usability of eHealth systems, there is an increasing need for agile eHealth usability evaluation.

2. Methods

In this study, a triangulation approach was chosen because several research methods were applied that are subject to qualitative research [12].

Figure 1 shows the chosen triangulative research design. Overall, the triangulation study comprised of step 1 to step 6 including two systematic literature reviews, phone-based as well as paper-based expert interviews, a formalization of the eHealth usability evaluation methods, and an explorative case study. In research phase 1, a systematic review was conducted complementary to the expert-based validation of eHealth usability evaluation methods. Research phase 2 encompassed the formalization of the eHealth usability evaluation methods. Research phase 3 comprised the context-based selection of appropriate eHealth usability evaluation methods and an explorative case study. In research phase 4 a second systematic literature review was carried out (in addition to the case study) to strengthen the results triangulatively.

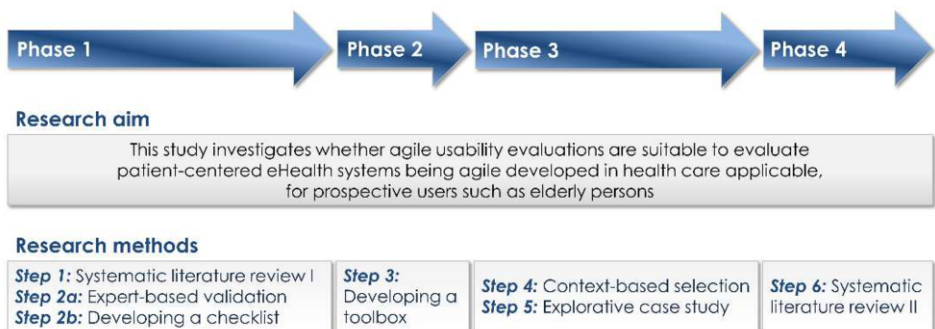


Figure 1. Triangulative research design: research methods applied (presented in steps 1 to 6), in relation to the research phases (phases 1 to 4). The present study is based on three publications that deal with the research design of research phase 1 [13,14], research phase 2 [14], and research phases 3 as well as 4 [15].

2.1. Research phase 1

Research phase 1 comprised the systematic identification and expert-validation of rapidly deployable eHealth usability evaluation methods to support agile eHealth usability evaluations.

Step 1 - Systematic literature review I: This review considered 3,981 peer-reviewed and non-peer-reviewed articles [13]. These articles report on eHealth usability evaluation methods, the rapid deployment of eHealth usability evaluations, and the relationship with the applicability of eHealth usability evaluation methods. Following a systematic process, in the course of which the abstracts and then the full texts were analyzed, a list of 29 eHealth usability evaluation methods was extracted that were potentially useful to conduct an agile eHealth usability evaluation.

Step 2a - Expert-based validation: The second step involved the iterative expert-validation of the extracted list of 29 eHealth usability evaluation methods. These interviews aimed to prioritize the identified eHealth usability evaluation methods into recommended, potentially useful, or not recommended for use in agile eHealth usability evaluations [13]. These interviews included usability experts with at least 10 years of professional experience in field of user research. A total of 10 experts were interviewed. The transcribed text material originating from the expert-based validation was analyzed using inductive and deductive content analysis.

Step 2b - Developing a checklist: To strengthen the expert recommendations for conducting an agile eHealth usability evaluation, two additional expert interviews were performed. These additional paper-based expert interviews aimed at obtaining expert opinions on key aspects (e.g., number of test participants, documentation, hardware or software used, time required to conduct an agile eHealth usability evaluation) that may influence the deployment of an agile eHealth usability evaluation [14]. The paper-based interviews were analyzed via inductive content analysis.

2.2. Research phase 2

Research phase 2 comprised the development of a toolbox for agile eHealth usability evaluation.

Step 3 - Developing a toolbox: Based on step 1 and step 2, all identified eHealth usability evaluation methods were formalized by creating method cards [14]. The method cards include the name of the eHealth usability evaluation method, the number of the method card, a method description, any notes on related method cards, if applicable, and references. The described eHealth usability evaluation methods are complemented by information on strengths, weaknesses, similarities, as well as coherence to other eHealth usability evaluation methods presented in the toolbox.

2.3. Research phase 3

Research phase 3 involved investigating the applicability of eHealth usability evaluation methods to older persons and the feasibility of conducting an agile eHealth usability evaluation with older persons.

Step 4 - Context-based selection: Three appropriate eHealth usability evaluation methods were selected to implement the explorative case study: (1) co-discovery learning, (2) cooperative usability testing, and (3) remote user testing combined with think aloud. These eHealth usability evaluation methods were chosen from the previously developed toolbox for eHealth usability evaluations (step 3) [14].

Step 5 - Explorative case study: The aim of the explorative case study was to examine whether an agile eHealth usability evaluation can be conducted with older persons ($n=7$) who met the inclusion criteria. The inclusion criteria comprised criteria such as an age of at least 60 years, a basic computer literacy, and an e-mail account [15]. The older participants were selected regardless of their socioeconomic status. The case study was conducted using a web-based eHealth system that allows patients to retrieve diagnostics reports in a decentralized manner. Qualitative notes from the agile eHealth usability evaluation were systematically analyzed and the number of usability issues was systematically counted.

2.4. Research phase 4

Research phase 4 comprised the identification, dealing with, and how to overcome challenges that might be countered prior to, during, and after carrying out an eHealth usability evaluation with older persons.

Step 6 - Systematic literature review II: The review considered 300 scientific papers that report on the use of eHealth usability evaluation methods with older persons [15]. The titles and abstracts of the papers were systematically reviewed. Twenty papers were identified that met the inclusion criteria. Three additional papers were identified through hand search that reported especially on challenges of evaluating the usability of eHealth among older persons.

3. Results

3.1. Research phase 1

Step 1 - Systematic literature review on eHealth usability evaluation methods: Following the systematic literature review, a list of 29 eHealth usability evaluation methods consisting of eHealth usability evaluation methods was identified [13]. Most of the identified eHealth usability evaluation methods represent established eHealth usability evaluation methods that were used in the literature to accomplish rapidly deployable eHealth usability evaluations (e.g., expert review or feature inspection).

Step 2a - Expert-based iterative validation of eHealth usability evaluation methods to contrast expert knowledge with findings from literature to prioritize the identified eHealth usability evaluation methods (during step 1): Figure 2 shows that a total of 43 eHealth usability evaluation methods were prioritized into ten recommended eHealth usability evaluation methods, 22 potentially useful eHealth usability evaluation methods, and 11 not recommended eHealth usability evaluation methods. The potentially useful eHealth usability evaluation methods refer to eHealth

usability evaluation methods that were neither recommended nor not recommended by experts. The three most frequently recommended eHealth usability evaluation methods are remote user testing, expert review, and the rapid iterative testing and evaluation method.

Step 2b - Developing of a checklist for conducting an agile, easily applicable, and useful eHealth usability evaluation: Based on the experts’ opinion from the supplementary paper-based expert interviews, a checklist for implementing an agile eHealth usability evaluation was formulated. The checklist comprises a total of five categories: data collection, location and number of test sessions, prospective user group, test participants, and test performance [14]. The checklist is intended for use by software developers or medical informaticians when conducting an agile eHealth usability evaluation.

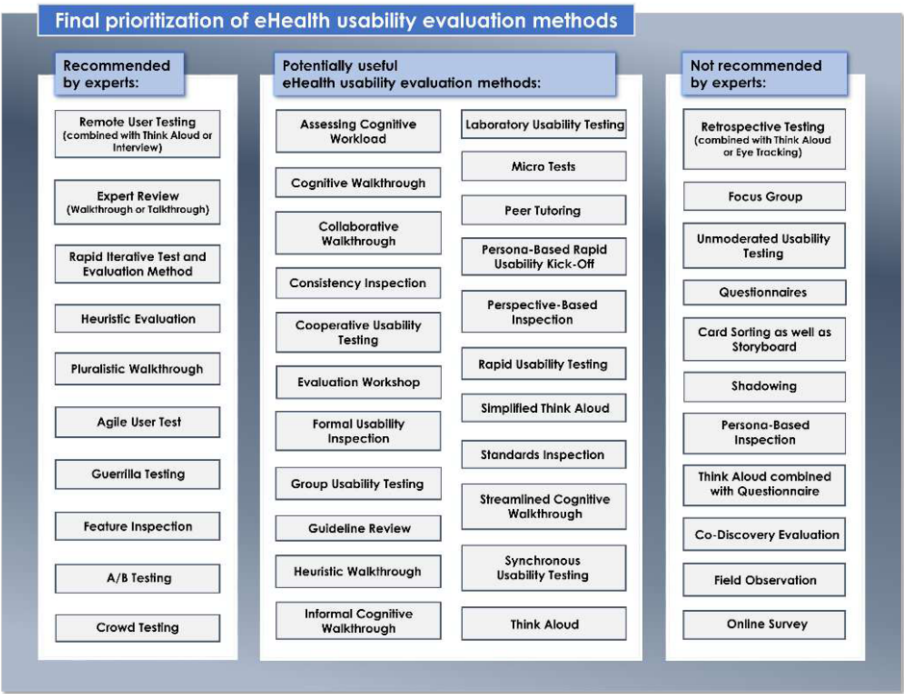


Figure 2. Final prioritization of eHealth usability evaluation methods [13]. Recommended eHealth usability evaluation methods and not recommended eHealth usability methods are ordered by the number of experts’ choice. Potentially useful eHealth usability evaluation methods are arranged alphabetically.

3.2. Research phase 2

Step 3 - Based on the findings of step 1 and step 2 a toolbox consisting of rapidly deployable and useful eHealth usability evaluation methods was developed: A toolbox called ToUsE (“Toolbox for eHealth Usability Evaluations”) was developed that comprises all 43 identified eHealth usability evaluation methods (step 1 and 2). ToUsE consists of eHealth usability evaluation methods that are useful for implementing agile eHealth usability evaluations. All eHealth usability evaluation

methods are listed on method cards with method descriptions [14]. The toolbox is intended for consideration by software developers, medical informaticians, usability experts, or medical professionals who aim to perform an eHealth usability evaluation.

3.3. Research phase 3

Step 4 - Context-based selection of appropriate eHealth usability evaluation methods to implement the case study: To accomplish the explorative case study three eHealth usability evaluation methods were chosen from ToUsE [15]. Co-discovery evaluation was selected to give older persons the opportunity to complete tasks together. Cooperative usability testing was chosen to jointly reflect with the older persons on their task processing by means of a video recording. Remote user testing combined with think aloud was used in order to accomplish the case study at older persons' homes and virtually involve the software developers of the eHealth system. Tasks were defined based on a fictitious scenario and explained to the older persons prior to the start of the case study.

Step 5 - Examination if the implementation of an agile eHealth usability evaluation is achievable with older persons: Remote user testing combined with think aloud could be successfully applied to evaluate the eHealth system with the older persons. The rationale is that the older persons felt comfortable in their familiar environment and were open-minded about using the new eHealth system. However, not all established eHealth usability evaluation methods are suitable for conducting an agile eHealth usability evaluation with older persons (e.g., cooperative usability testing and co-discovery evaluation) [15]. Cooperative usability testing failed because older persons preferred on completing the tasks alone. Co-discovery evaluation failed as well because the older participants did not agreed to a video recording due to privacy concerns.

3.4. Research phase 4

Step 6 - Systematic literature review on challenges of conducting agile eHealth usability evaluations with older persons and how these challenges can be overcome: From the case study and the systematic literature review, 24 recommendations were derived to address challenges prior to, during, and after the eHealth usability evaluation with older participants [15]. The recommendations were equally derived from the findings of the case study and the systematic review. Most of the recommendations addressed motivation, while the second largest number of recommendations was associated with cognition, and the third largest number of recommendations dealt with physical abilities.

4. Discussion

The results of the triangulation study revealed that the implementation of an agile eHealth usability evaluation in the specific context of the explorative case study and older persons as prospective users is possible. In total, 43 eHealth usability evaluation methods were identified as suitable for agile eHealth usability evaluations. Of these, ten were recommended by the experts based on their usefulness for agile eHealth

usability evaluations. The explorative case study revealed that remote user testing combined with think aloud could successfully be applied to evaluate the eHealth system with older persons. The recommendations for conducting an agile eHealth usability evaluation with older persons highlight the need to consider the challenges of this age group, as eHealth systems should be tested with prospective users who represent the intended users [15,16]. Although weak health conditions often prevent older persons from using eHealth systems [17], the exploratory case study showed that age-related health complaints are not a barrier to use. However, the established eHealth usability evaluation methods must be further evolved to address the specific needs of older persons that may be caused by age-related declines. This study contributed to the development of improved eHealth systems tailored to older users.

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