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Integrating Low-Cost Rapid Usability Testing into Agile System Development of Healthcare IT: A Methodological Perspective

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Abstract. The development of more usable and effective healthcare information systems has become a critical issue. In the software industry methodologies such as agile and iterative development processes have emerged to lead to more effective and usable systems. These approaches highlight focusing on user needs and promoting iterative and flexible development practices. Evaluation and testing of iterative agile development cycles is considered an important part of the agile methodology and iterative processes for system design and re-design. However, the issue of how to effectively integrate usability testing methods into rapid and flexible agile design cycles has remained to be fully explored. In this paper we describe our application of an approach known as low-cost rapid usability testing as it has been applied within agile system development in healthcare. The advantages of the integrative approach are described, along with current methodological considerations.

Keywords: Agile development; agile testing; usability testing; system evaluation

Introduction

The usability of healthcare information systems has become a major issue, with continued reports of unusable and unsafe health information systems being reported worldwide daily. In response, efforts have been made to improve system design and development processes including the iterative testing and refinement of systems. One development approach that has become popular is known as agile system development. Agile methods focus on rapid and iterative development processes designed to support customer needs coupled with the requirement for flexible software development processes for complex systems [1]. Nowhere are the expected benefits of the approach needed more than in healthcare, where there continues to be reports of unusable healthcare systems which fail to meet user needs [2]. In agile development, rapid iterations or cycles, known as "time boxes" (often of 2-4 weeks in length), are used to reduce the scope of complexity of iterations and thereby speed development [1]. During time boxes key components of a system are designed or implemented. At the end of each such iteration results from that iteration are evaluated and the next iteration begins. Evaluation of results of iterations allows for flexibility in design and the ability

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to be adaptive to changing user requirements. However despite the importance of evaluation during iterative cycles and the often stated need for continual user input into healthcare system design, the issue of how to practically and rapidly incorporate feedback from usability testing into rapid agile development cycles has remained to be fully explored (i.e. how feedback from iterative testing could be used to improve system usability and safety in a rapid away within the agile development process).

In this paper we describe how an approach we have developed known as "low-cost rapid usability testing" [3] can be integrated within agile software development processes, with the objective of improving the effectiveness and usability of healthcare information system design and development. The paper begins with a discussion of agile development processes (including the main principles behind agile development). This is followed by a discussion of low-cost rapid usability testing. We then discuss how low-cost rapid usability testing can be integrated in a practical manner within agile development processes for ultimately improving usability and safety. What is new in this paper is that we describe an approach to agile development that incorporates usability testing (which in the past has often been considered as being too time and resource intensive to be "agile"). We will illustrate how a rapid and low-cost approach can ameliorate such concerns.

1.Rapid Approaches to System Development and Usability Testing

Agile development is a form of rapid system development. It involves iterative and incremental design and implementation of information systems. This method is considered to be change-drive and supports flexible change with a high degree of involvement by stakeholders (clients and end users). The iterations are rapid and may last for as short as two to four weeks in length and are typically fixed regarding resources and time once the iteration begins [1]. Objectives of the iterations are typically fixed within the iterations. An important feature of agile development is continual feedback at the end of iterations with changes driven by input from the clients and users of systems. Therefore, the role of evaluation is key. An important aspect of evaluation in the design and implementation of healthcare information systems is the evaluation and improvement of system design in terms of system usability and safety [4]. However, the type of evaluations needed to ensure usability are often considered to be costly, both in terms of time spent and resources required, which does not well fit with the requirements of the agile approach (i.e. that the cycles of iteration be fast and that change be easily integrated into refined system designs).

Low-cost rapid usability engineering is an approach to conducting usability testing where the testing can be carried out rapidly, at low-cost and in any location [3]. The approach involves recording user interactions with a system component or user interface element (i.e. typically involving computer screen recording or video recording of user interactions). The approach can be applied throughout the systems development life cycle (SDLC) and the type of testing depends on where in the life cycle it is employed [3]. For example, in early system development, it may involve observing a small number of users interacting with a mock-up or partially working prototype and recording their reactions to the mock-up or prototype. Later in the development cycle, user interface components can be tested involving a small number of potential users interacting with the user interface components in carrying out more realistic tasks (so

as the fidelity of the prototype increases, typically, so does the fidelity of the testing). The approach typically involves digital video recording using low-cost as well as freely available screen and audio recording. An important aspect of the method is the application of rapid analysis techniques for determining potential usability and safety problems (from the analysis of the resultant screen, audio and video recordings). The overall approach allows for feedback to be provided to system developers within a short period (e.g. in time frame of several hours to a day or two).

Given the requirements of agile development, we have worked to disseminate low-cost rapid usability testing so that it can be applied within agile processes. There are a number of parallels between agile development approaches and low-cost rapid usability engineering, including an emphasis on providing feedback rapidly and at key points in design and development. In this paper we explore the integration of low-cost rapid usability engineering in agile system development including a description of a methodological approach to its adaptation into agile development in the SDLC.

2. Methodological Approach

Our approach to integrating low-cost rapid usability testing within agile system development is described in this section. The steps involved are the following:

Step 1. *Identification of the iterative cycles where usability testing should be applied:*
This step involves identification of those planned iterations in the design process where low-cost rapid usability testing may be applicable (e.g. iterations where artifacts, such as screen designs, mock-ups or user interface components are the outputs of time-boxed iterations). It should be noted that not all iterations during agile programming require end user input/feedback. However, those iterations that would benefit from the input of users should be considered for inclusion, including any iterations where significant changes may be made to user interface components.

Step 2. *Assessment of testing fidelity required throughout the development process:*
The realism of the type of testing needs to be addressed for each stage at which usability testing will be employed. Earlier iterations may only require low-fidelity testing (e.g. with screen shots or mock-ups shown to end users) while later testing cycles may provide the most useful feedback by testing conducted in-situ (e.g. in clinical settings where the system is being designed for deployment).

Step 3. *Assessment of time to completion of data analysis:*
Agile iterative system development is highly sensitive to speed, and therefore the amount of time required to complete usability testing (including data analysis) needs to be factored in. Generally the time to completion must be in the order of hours or days as developers will not be able to wait for extended periods (i.e. weeks or months) waiting for results before the next iteration begins.

Step 4. *Selection of number and type of participants:*
As usability testing involves observing humans interacting with healthcare systems, early planning for selection and recruitment of subjects for testing is essential. The number and type of subjects will depend on what stage in the SDLC the user interface components being tested are at. This could involve the same pool of participants

throughout all testing cycles, or selection of different types of subjects for different parts of the cycle. This planning needs to be conducted early on to avoid any delays in bringing participants into testing at key points during iterations.

Step 5. *Selection of representative tasks:*
The type of tasks involved in testing will depend on the stage at which user interface components are at. Generally a bank of possible tasks may be prepared well in advance of testing so as not to create delays in the agile development process. Such scenarios should be designed so that they can be flexibly modified to changing requirements.

Step 6. *Creation of a test plan:*
As speed is of the essence in agile development processes, it is recommended that the basis for steps 1-5 be developed early in the iterative process (i.e. as a critical objective an early iteration). The test plan should outline the requirements for integrating usability testing into the agile process. However, as agile methods call for ability for change they should not be hard-wired or rigid, but rather provide a basis for rapidly deploying usability testing that itself is flexible.

Step 7. *Rapid data collection:*
The actual procedure for carrying out usability testing with agile iterations will depend on the stage the product is at (e.g. early mock-ups versus functioning prototype). Testing may take place in setting ranging from a meeting room to testing in-situ, where access may be available to the live setting of potential use (e.g. hospital rooms). Earlier phases may involve rapid testing with mock-ups or prototypes.

Step 8. *Rapid analysis of usability data:*
The analysis of data from usability testing involves transcribing and coding recordings and video/audio recording of user interactions with a prototype or system. Results must be relayed to developers rapidly and that there be a focus on key issues requiring consideration in upcoming iterations. Automated speech recognition software for speeding the transcription process is useful for converting verbal data into text to decrease time to coding. The analysis and coding of the data may also be facilitated by using a number of computer-supported video coding tools (e.g. using the low-cost rapid usability engineering approach, see [3]). Rapid methods for analyzing video data from usability testing, such as the IDA (e.g. instant data analysis approach, see [5]), can also be applied to provide useful feedback from usability tests within a period of one day.

Step 9. *Input into re-design and customization during iterative development cycles:*
The objective of conducting low-cost rapid usability testing is to obtain feedback that can be used to flexibly improve the design of health information systems. The results from step 8 data analysis should be summarized and presented to the relevant design teams and reviewed at the end of the cycle in which it was conducted (this can include an itemized summary of types and frequency of coded usability or workflow problems, with recommended fixes and changes).

3. Experiences to Date

The approach we have described above has been developed based on a wide range of projects that required usability testing and user input into system design and refinement.

Baylis and colleagues [6] have shown that the low-cost rapid usability engineering approach can be applied quickly to lead to large benefits in terms of cost (for not having to re-engineer key user interface components). Using most conservative estimates, the application of low-cost rapid usability testing resulted in 60% to 100% cost savings (as compared to not applying the approach and allowing serious usability problems to propagate throughout the design process). The quick turn-around of results from the analysis was in the order of a few days and coupled with a cost of under $5000 CAD, this project showed the approach was effective within agile cycles. In related work, Hall and colleagues have also shown the method can be used to provide rapid feedback that can lead to significant organizational benefits (a significant increase in efficiency of call handling in a tele-health application being refined for a provincial organization) [7]. We are currently applying the overall approach in a number of other projects that are using agile methods, including the design and testing of a new educational EHR prototype, including continual user input (during time boxing) from educators and students as end users of the product.

4. Discussion and Conclusion

Agile and iterative development has become a popular approach for the development of software. According to its proponents it is effective in that it allows for rapid development and agility to allow for changes. One issue that has remained is how to practically incorporate user-centered input into agile processes, more specifically, how to incorporate usability testing results. To do so requires new approaches to usability testing which allow for both rapid data collection and analysis that can be conducted in many settings. In addition, such testing needs to be flexible and as it will be employed throughout development it should be low-cost (both in terms of resources and time). Furthermore, effectively integrating usability testing into such development requires an understanding of agile processes, where iterations need to be identified where usability testing is relevant and will lead to improved prototype/emerging system. In this paper we have argued this can be done in a way that is both practical and effective, however such an approach requires careful consideration of both modern software development processes (such as agile processes) in parallel with advances in usability engineering, in particular low-cost rapid usability testing and rapid analysis of test data.

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