Quality of Life through Quality of Information
J. Mantas et al. (Eds.)
IOS Press, 2012

doi:10.3233/978-1-61499-101-4-363

Low-Cost Rapid Usability Testing for Health Information Systems: Is it Worth the Effort?

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Abstract. Usability testing is a step of the usability engineering process that focuses on analyzing and improving user interactions with computer systems. This study was designed to determine if an approach known as Low-Cost Rapid Usability Testing can be introduced as a standard part of the system development lifecycle (SDLC) for health information systems in a cost effective manner by completing a full cost-benefit analysis of this testing technique. It was found that by introducing this technique into the system development lifecycle to allow for earlier detection of errors in a health information system it is possible for a health organization to achieve an estimated 36.5% to 78.5% cost savings compared to the impact of errors going undetected and potentially causing a technology-induced error. Overall it was found that Low-Cost Rapid Usability Testing can be implemented in a cost effective manner to develop health information systems, and computer systems in general, which will have a lower incidence of technology-induced errors

Keywords. health informatics, cost-benefit analysis, usability engineering, low-cost rapid usability testing, technology-induced error, health information systems safety

Introduction

The development of new health information systems is advancing faster than legislation and industry can keep up. Health information systems are being developed by companies with limited medical or clinical background and put into use without being thoroughly tested by the software provider or the end user of the application. This has led to the introduction of errors in the workflow of medical environments causing serious complications and even deaths in some cases [1]. Errors of this type caused by the introduction of new systems are referred to as technology-induced errors [2] or technology-facilitated errors [3].

A possible solution to deal with the growing issue of technology induced error comes from the field of usability engineering [4]. Usability engineering refers to human- computer interaction and specifically with making human-computer interfaces that have

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high usability or user friendliness; this involves assessing the usability of a interface and recommending ways to improve it. Usability testing is a subset of usability engineering involving observing representative users of a system carrying out representative tasks and has been used in many cases to identify usability problems, and to validate and improve the functionality of health information systems [4]. Low-cost rapid usability engineering has been developed and applied in the area of health informatics to provide a rapid and cost effective approach to assessing both usability problems and technology-induced error in healthcare systems before they are released for general use [5]. The approach describes methods of video and audio recording user interaction data and details specific methods for conducting computer-supported video analysis of coding of resultant usability data [5].

However, despite its potential importance to date usability testing has not gained mainstream acceptance in the health sector for the testing of all applications [5] even though a number of studies have demonstrated the usefulness of this technique [5, 6, 7, 8]. Additionally even though a few of these studies have shown the cost effectiveness of usability engineering in mainstream industry most of these studies of costs and benefits have dealt with usability inspection methods (involving trained analysts analyzing and inspecting applications) rather than usability testing involving recording and analyzing end users interacting with systems. Furthermore no studies have been reported demonstrating the cost effectiveness of video-based usability testing methods such as Low-Cost Rapid Usability Testing [5] for health information systems. This leads to the objective of this study which was to perform a cost-benefit analysis of Low-Cost Rapid Usability Testing in validating a health information system.

1. Methods

Completing a full cost benefit analysis of Low-Cost Rapid usability testing involved several key steps. The application tested was the Chronic Disease Management (CDM) Toolkit developed by the British Columbia Ministry of Health to provide health professionals with decision support for the treatment and management of patients with chronic diseases.

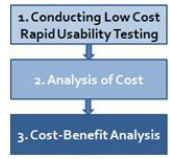

Figure 1. Methods

1. Low Cost Rapid Usability Testing: Low-cost Rapid Usability Testing [5] was performed using the CDM Toolkit which was under development. A total of 8 subjects were recruited. The subjects fell into 4 main categories physicians, nurses, medical office assistants, and administrators. Subjects were asked to perform a predefined set of test scenarios while verbalizing their thoughts (or "thinking aloud") as they worked through the test scenarios. Once the test scenarios were complete subjects also completed both an oral and written questionnaire to further document any issues they may have encountered with the system and to get their overall impressions of the testing process. When testing was complete the results of the testing were fully analyzed to determine any issues with the application. The log files created for each testing session were then coded for specific categories of usability problems [2] and assigned a severity rating [9]. This aided in determining which errors should be fixed and in what order

2. Analysis of Costs: To accurately perform a cost-benefit analysis all the related costs of the testing process were tracked (e.g. materials such as cost of the computer

used in testing, recording equipment, travel, time provided by subjects and testers). These costs were then reviewed to determine what percent of usability testing costs were attributed to which category.

3. Cost-Benefit Analysis: Once the usability testing was completed and costs for the testing process tracked and summarized the next step was to perform a detailed cost- benefit analysis of the usability testing. This was performed by comparing the cost of performing Low-Cost Rapid Usability Testing directly to the estimated benefits of testing. The benefits of the testing were assessed in terms of costs that were estimated to be incurred if the errors that were found in the testing were found later in the SDLC. This analysis was completed calculating the possible costs in 3 different ways:

- *Direct Measurable Savings:* The most basic calculation (ignoring evidence about when in development an error is introduced [10]) was done by finding the number of application errors and estimating the costs associated with having to do multiple migrations of the application to a production environment to resolve the errors.
- *Cost of Errors Relative to When Resolved in the SDLC:* This calculation took into account that when an error occurs in the SDLC which can directly affect the cost of resolving that error [11]. If an error is not found until after an application is in production it can cost as much 100 times more to fix.
- *Cost of Medical Error:* A cost-benefit analysis was then performed to determine the cost of medical errors that could have been caused by errors that were detected from usability testing. The errors detected from usability testing were categorized and rated (and the subjects' testing logs examined) and they were then reviewed by an expert physician to determine if any of them could have lead to a medical error (e.g. wrong dosage prescribed based on incorrect body mass calculations that was detected from the testing). The possible medical errors were then analyzed from two different perspectives:
    - *Measurable Cost of Medical Error:* The measurable cost of a medical error was found by creating a list of the possible medical issues for each medical error that the application could have caused and determining the related costs.
    - *Complete Costs of Medical Errors:* The cost of a potential medical error was determined by reviewing the existing healthcare literature to find the total cost of a medical error once all factors were taken into account including everything from associated medical to legal costs

2. Results

Low-Cost Rapid Usability Testing: A total of 73 errors were found as a result of conducting usability testing (see Figure 2). The errors discovered were not just strictly usability errors, several errors were identified as programming errors that were not

Distinct Usability Errors

Error Description	# of Occurrences	% of Total Errors	Severity Rating
1. Applications Speed Issues	25	34.25%	2
2. Body Mass Indicator (BMI) did not calculate	3	4.11%	4
3. Entering Height is Confusing	3	4.11%	3
4. Entering Observation date when Navigating to Flowsheet	9	12.33%	3
5. General Data Entry Issues	9	12.33%	2
6. General Layout Issues	5	6.85%	1
7. Invalid Application Certificate	8	10.96%	3
8. Influenza Vaccine entered on Asthma did not show on Diabetes Flowsheet	1	1.37%	4
9. Locating Flowsheet Links	3	4.11%	2
10. No Error for Incorrect Blood Pressure	1	1.37%	4
11. Populating Other Meds Field	1	1.37%	3
12. Populating the Peak Flow Fields	2	2.74%	3
13. Popup window for Reports is Confusing	3	4.11%	3

Figure 2. Distinct Usability Errors

identified in the initial testing of the application. It was also determined that 3 of the errors (Figure 2 in red) could have potentially caused a technology induced medical error.

Testing Costs: The first step of completing the cost-benefit analysis was to determine the total cost of the usability testing. It was found that one round of Low-Cost Rapid usability testing for the CDM Toolkit cost a total of $8,362.91. This included the cost of all testing materials (e.g. recording equipment.), hourly wages and travel costs for all research analysts and the hourly wages for all research participants. This did not include the cost required for developers to resolve any issues that were found.

Cost-Benefit Analysis: Once the full cost of the usability testing was determined it was then possible to complete a full cost benefit analysis form the three different perspectives outlined in the Methods sections.

Once the full analysis of all proposed cost-benefit scenarios was complete it was found that a cost savings could be achieved in all cases, as indicated in Figure 3, when Low-Cost Rapid Usability testing was applied.

Cost-Benefit Analysis Summary

Cost-Benefit Analysis	Savings	% Savings
Direct Measurable Savings	$14,247.09	63.0%
Cost of Errors related to when resolved in the SDLC	$13,397.09	61.6%
Cost of Medical Error		
• Measurable Cost of Medical Error	$4,816.51	36.5%
• Complete Costs of Medical Errors	$30,637.09	78.5%
Average Savings	**$15,774.45**	**59.9%**

Figure 3. Cost-Benefit Analysis Summary

3. Discussion

It has been decades since usability testing was first introduced, since then it has been used in a wide range of industries from basic software development to the engineering of new airplane designs [4]. However, even though it has been shown that it could have potential in finding life threatening errors in health information systems it has still not gained widespread main stream acceptance in the healthcare industry [5], with one of the major barriers being the impression that usability testing is too expensive to implement on a regular basis. Previous studies [6] have shown that usability engineering techniques such as usability inspection could cost effectively be introduced into the system development lifecycle allowing developers the opportunity to identify application errors much earlier in the development process (which leads to a definite overall cost-benefit). The goal of this study was to determine if usability testing could be cost effectively applied in evaluating health information systems. To accomplish this, a cost-benefit analysis of Low-Cost Rapid Usability Testing was performed,considering the costs related to correcting problems detected during usability testing (including those that may result in technology-induced error) in a health information system from three viewpoints: (1) Direct Measurable Savings, (2) Cost of Errors related to when they are resolved in the SDLC, (3) Cost of Potential Medical Error.

It was found that by introducing Low-Cost Rapid Usability Testing into the system development lifecycle errors could be detected prior to system release. Early detection of errors (i.e. prior to release) would allow health organizations to achieve a 61-63% cost saving compared to the impact of errors going undetected. Furthermore, the cost savings increased to 78% when the detection of potential technology-induced error was also considered. Additionally, this study was designed to determine if users and stakeholders involved in the development of health information systems viewed Low-

Cost Rapid Usability Testing as a useful process. In general, from post-scenario interviews subjects involved in this testing process indicated that they perceived usability testing as a useful tool for improving health information systems. Subjects also indicated that they appreciated the opportunity to have input into the development of a system before it was implemented as part of their everyday workflow.

Overall, Low-Cost Rapid Usability Testing was found to be an effective testing technique that can be implemented in conjunction with other testing techniques (e.g. unit testing, black box testing, white box testing, clinical simulations) in a cost effective manner to develop health information systems which will also have a lower potential for causing medical error. Additionally, the results of this study also indicated that Low-Cost Rapid Usability Testing could lead to a cost savings even when not considering its potential to detect and prevent medical error.

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