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A Framework for User Involvement and Context in the Design and Development of Safe e-Health Systems

Andre KUSHNIRUK[a,1] and Paul TURNER[b]
[a] *School of Health Information Science, University of Victoria, Victoria, Canada*
[b] *eHealth Services Research Group, University of Tasmania, Tasmania Australia*

Abstract.. Current approaches to health IT research and development emphasize the valuable role of users. However, differences amongst users, in how they are defined, involved and interact with health IT under conditions of varying complexity has received limited attention. Failure to acknowledge these differences makes assessments of the quality, reliability and transferability of results problematic. More importantly, as e-health systems are increasingly opened up to use by health consumers the implications of differences in the context of system use for patient safety require closer investigation. To support the safety of e-Health systems, it is essential that where users are involved we can more accurately differentiate between types of users and their contexts of use and how these factors interact with usability and the risk of unintended consequences from such systems. This paper presents an extended three dimensional user-task-context matrix for considering who users of healthcare applications are, their needs and their requirements under differing contexts of use.

Keywords: User-centered design; system design and evaluation; user analysis; e-health systems; patient safety; user modeling; technology-induced error.

Introduction

There are measurable benefits from involving users in the design and development of information technology (IT). These benefits include improved technology adoption and utilization, increased user satisfaction, trust, and usability [1]. Conversely, failure to understand users and their context of use has long been recognized as one of the biggest points of failure in IT development [2] yet it continues to recur as a 'classic mistake' in IT projects [3]. This paradox suggests that involving users is not as straightforward as it sounds and that despite more than 60 identifiable user approaches [4] the nature and role of users poses challenges for study comparisons. How users are defined, engaged and their use of systems in real settings is understood has the potential to raise questions for analysis and for the extent to which we are prepared to open up genuine dialogue on innovative ways of thinking, designing and empowering users[5].

In the healthcare domain many informatics specialists have advocated strongly for greater user involvement in the design, implementation and evaluation of health IT [6].

[1] Corresponding Author: Professor Andre Kushniruk - Email: <andrek@uvic.ca>.

These approaches have generally been adopted from other disciplinary traditions and applied uncritically to health contexts. Noticeably less attention has been paid in development of approaches to differentiate amongst users of healthcare systems and how different approaches define and describe the impact of systems in a range of complex healthcare settings. More importantly, there has been limited consideration of the implications of how different mechanisms for characterizing user involvement impact on the safety of the e-health systems developed [7]. Failure to acknowledge these differences makes assessments of the quality, reliability and transferability of results problematic. More importantly, as e-health systems are increasingly opened up to use by health consumers the implications of these differences for patient safety require even closer investigation. To support the safety of e-Health systems, it is essential that where users are involved we can more accurately differentiate between types of users and their contexts of use and how these factors interact with usability and the risk of unintended consequences from such systems [8]. In the development of e-health systems through user-centered and related user approaches, this paper argues that there is a need to ensure we are explicit about who our users are, their contextual settings of use as well as the analytical processes used to translate the rich insights generated from them into safe e-health systems [9]. This paper presents an extended three dimensional user-task-context matrix for users of healthcare applications, their needs and their requirements under differing contexts of use, in order to improve the development of safe e-health information systems. This work is part of a larger research program aimed at helping provide aid and assistance to developers and designers of systems when contemplating the selection and role of users in complex healthcare IT projects.

1. Differentiating Users: Who, What, When, Where?

Following Kushniruk and Turner [10] there are a number of different dimensions that can be used to differentiate users and their involvement in the design and development of e-health systems. Firstly, it is essential to be explicit about who the users are and why any user or groups of users are the most appropriate for involvement in any particular development. While conventional usability testing profiles and targets prescribed groups of users [11], in health IT challenges arise because of the larger potential number and classes of users in healthcare (e.g. physicians, pharmacists, nurses). Within each class there may be important subclasses of users to consider (e.g. emergency physicians, attending physicians, residents, surgeons) [12]. Also beyond normal demographic differences (e.g. age, sex, computer literacy) healthcare also brings in variance due to specialty, nature of treatment (e.g. chronic, episodic, acute) and differences in clinical practice across local, regional and national boundaries [13]. Additionally, with the increasing reporting of failed healthcare systems when they are delivered in complex environments, it is becoming increasingly recognized that there is a need to more fully consider the varied contexts of system use, when designing and deploying systems, in particular when considering the complexity of tasks carried out by varied types of users in healthcare. This need to integrate consideration of users, tasks and contexts will form the basis for the framework we have developed, which is described in the next section.

2. The Framework

In this section of the paper we present an extended three dimensional user-task-context matrix for considering who users of healthcare applications are, as well as their needs and requirements under differing contexts of use, in order to improve the development of safe e-Health information systems. The approach, as will be described has been used both in the early part of the System Development Life Cycle (SDLC) (in order to define user classes, tasks and contexts as a basis for system design), as well as late in the SDLC to provide scenarios for testing completed (or near complete) systems to ensure they meet both initial requirements and safety expectations (i.e. do not introduce inadvertent technology-induced errors).

Our work builds from and extends the notion of a two dimensional "user-task" matrix [16], which can provide a detailed summary about frequency that users perform various tasks with a product and what user groups are expected to perform any specific task. Such a matrix helps to conceptualise choices between design features that support a task for efficiency as opposed to ones that support ease of use or learning. Duration, frequency and complexity of task can be examined. Steps we have deployed in developing user-task matrices include the following: (1) assemblage of a group who regularly interact with the users – a "user profile team" – conduct work domain analysis, (2) brainstorming of a preliminary list of users and potential uses (3) creating a user/task matrix or a user/characteristic matrix to serve as an initial model (4) discussion of the characteristics assumed to be typical of the user community, and (5) deciding on how to test user assumptions. This model of users and their tasks (which can be developed early in the SDLC) can also be used later in the development cycle, to drive creation of usability testing goals and scenarios (corresponding to cells of the matrix which correspond to particular tasks that specific types of users would be expected to carry out using the completed health information system – e.g. defining user-task pairings, such as physician user paired with data entry).

Despite the usefulness of the approach, we have found that the complexity of healthcare necessitates addition of an additional dimension to this formalism – namely the inclusion of the context under which the user undertakes to complete a task supported by the system which is, or has been designed. It is argued that in both the development of health system requirements (and the subsequent application of those requirements in developing scenarios for testing of near to completed systems) context should be formally considered and included in models of user interaction with systems such as electronic health records, decision support and patient information systems. We argue this is required in order to lead to adequate system design and testing and to mitigate the chance of a system being considered to be adequately designed, tested and deployed, when in fact it may pose a safety risk under certain conditions of use and under critical contexts of healthcare practice (which were not formally considered). Without consideration of context, it will be unclear under which conditions a particular design will work in a healthcare setting, and under which conditions it would likely fail.

The model we have developed and used to drive both our work in healthcare system design and testing is depicted in Figure 1, which considers the following dimension in the context of healthcare information systems and their evaluation: (1) Users (2) Tasks, and (3) Healthcare Context. The User dimension details aspects of users in terms of experience, expertise, specific profession (e.g. physician, nurses, pharmacists etc.) and can be used to brainstorm a preliminary list of users to drive system design and also to be referred to later in the SDLC when creating validation test

scenarios [16]. The Task dimension details the specific tasks from a detailed functional point of view that different classes of users will be expected to complete using the system (e.g. "tasks" defined by developers and commercial vendors such as entry of medications, scheduling of patients etc.). Together the User and Task dimensions are linked and related together through a two-dimensional User/Task matrix. Although such a model can help to ensure all classes of users are considered in design and testing (by providing a rationale for development of design use cases and test scenarios) the complexity of healthcare software necessitates explicit consideration of a third dimension – namely the healthcare context, when creating design use cases and user test scenarios (as depicted in Figure 1). Aspects that complicate development of real-world applications in complex safety-sensitive work domains include the following, which were derived from empirical study of users in complex domains [17]: (1) ill-structured problems (2) variation in physical location where the system will be used (3) uncertain, dynamic environments (4) time stress (5) high stakes (6) multiple players (i.e. varying number of participants) and (7) shifting organizational goals and norms.

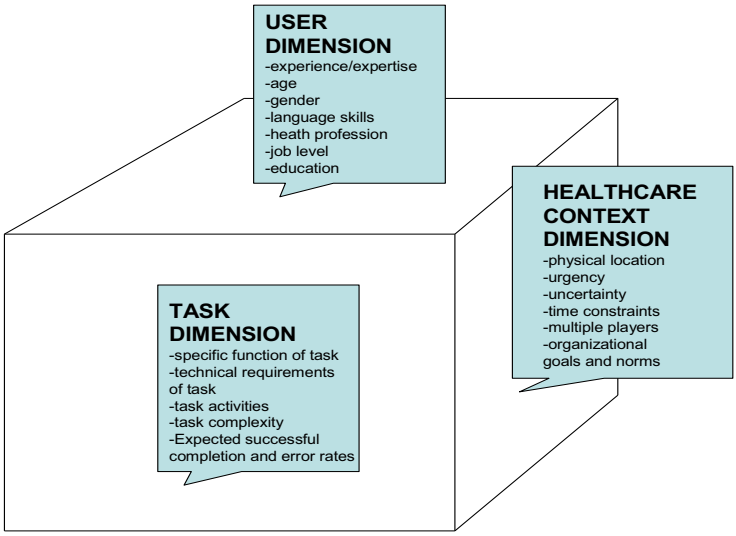

Figure 1. User-task-context matrix for healthcare systems design and evaluation.

3. Experiences to Date and Discussion

Our initial work in applying the user-task-context matrix to drive design and testing of healthcare systems has spanned application that has included design and refinement of a large regional data warehouse, as well as application in the design of test scenarios for evaluating clinical decision support embedded within a large hospital electronic medical record system. The data warehousing example involved intense discussion during participatory design (of the data warehouse structures and capabilities) with a wide range of expected end users of the system to determine what functions and tasks the system would support, along with the contextual aspects of its use. The approach helped to not only determine what were the expected classes of users, but also allowed for explicit discussion of the varied contexts in which the system would be used. In the

example of its application in design and refinement of clinical decision support, the cube in Figure 1 was used to drive creation of a comprehensive test bed of scenarios based on the three dimensions (for example, such as: User: Attending physician; Task: Medication Entry; Context: Emergency Setting). These scenarios were in turn used to drive both laboratory and simulation lab testing that revealed a number of errors and safety issues that only arose under certain conditions of use (e.g. only during an emergency involving an interruption of the user-system interaction when a physician was called away from the computer to the bedside, leading to potential for technology-induced error).

4. Conclusion

The user-task-context matrix described in this paper has helped in clarifying and refining the description of user requirements during early phases of the SDLC as well as supporting the creation of test scenarios that can be used later in the SDLC. It has helped conceptualise choices between design features that support a task for efficiency as opposed one such as ease of use or learning. Duration, frequency and complexity of tasks under differing contexts of use of a system can also be examined.

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