

A Framework for Contextual Design and Evaluation of Health Information Technology

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Abstract. Poor contextual fit is a significant cause of health information technology (HIT) implementation issues. While the need for better fit of HIT and context has been well described there is a shortcoming of approaches for how to do it. While the diversity of the contexts where HIT is used prevents us from designing HIT to fit all contexts, if we had better ways of understanding and modelling contexts we could design and evaluate HIT to better fit contexts of use. This paper addresses the above need by developing a framework consisting of a set of terminology and concepts for modelling contextual structures and behaviours to support HIT design. The framework provides a way of binding contextual considerations to allow us to better model contexts as part of HIT design and evaluation.

Keywords. Context, health information technology, modelling, structure, behaviour

Introduction

Enhanced reporting of the impacts of context has been described as one of most significant improvements we can make in the evaluation of health information technology HIT [1]. While the importance of context in HIT design and evaluation has been well described [2, 3], there is a shortage of methodological guidance on how to do it. A foremost challenge in understanding context is that contextual factors can vary considerably in scope and complexity. While the task that people are doing defines their immediate context, a task will be influenced by various contexts including organizational, informational and temporal factors [4].

A key consideration in understanding context is that it is a dynamic entity. The conversations that people have and the interactions that they engage in have to be considered as part of the context of how HIT is used [5]. Smith and Koppel describe how the manner in which users interact with HIT can vary due to several factors including the real world and mental model of the clinician and the way in which HIT re-shapes a clinician's perception of reality [2]. Understanding the impacts of context is particularly important in collaborative healthcare delivery and the relationship between individual and group contexts [6]. Lack of understanding of context can result in over- or under- engineering HIT, which leads to post implementation issues. We can address

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that problem by being more explicit about the HIT related contexts that need to be considered in a situation.

While modelling languages such as ContextUML have been developed to model contexts [7] a shortcoming with these languages is a focus on structural contexts such as mobile versus fixed HIT usage rather than behavioural contexts such as the interplay between individual and group needs.

A systematic review on HIT implementation has stated that the single most important need is better reporting of the effects of implementation and context [8]. However, contexts can be varied and there is a need to bind the modelling of them to ensure that we do not over or under engineer HIT and instead are able to better position the system within the context of use. A first step to achieving contextual 'binding' is to develop an approach for understanding and modelling contexts. This paper draws upon previous research of ours and develops a framework for modelling contextual structures and behaviours to support HIT design and evaluation.

1. Methodological Framework

The authors draw upon their prior research looking at different contexts of use of HIT [9, 10] as well as a study that looked at contextual variation in usability testing across the perioperative spectrum [11]. We also draw upon modelling representations that show changes in states and how processes or information flows in different contexts [12].

We expand upon our previous work by proposing a framework for considering context in HIT design and evaluation. The framework identifies structural as the primary binding context and actor and behavioural contexts as the internal bounding contexts within the structure. We describe each of those below.

1.1. Structure

The structure is what bounds the context where HIT is used. Structures include physical structures, such as buildings or clinical areas, as well as virtual structures such as software infrastructure. Physical and virtual structures both introduce structural sequences that influence how people perform their work. A key part of structural contexts is recognizing that a structure may be comprised of several sub-structures. Sub-structures introduce various levels of integration between them. Each sub-structure is modelled as the various actors, HIT and information flows involved in care delivery and while each sub-structure is modelled individually, there is integration between the actors and information flows and across other substructures.

Fig 1 illustrates how structure is modelled. It shows a contextual system with three sub-structures. We have shown the details for sub-structure 2, which has three actors (physician, nurse and pharmacist), two different HIT systems, and information flows in and out of the system. Sub-structure 2 is also the middle sub-structure. Therefore any activities and data from sub-structure 1 will be inherited by sub-structure 2 and activities and data from sub-section 2 will be inherited by sub-structure 3. Increased connectivity provides implications such as the need for data sharing agreements across structures and for collaborative protocols to govern how cross-structure tasks are done.

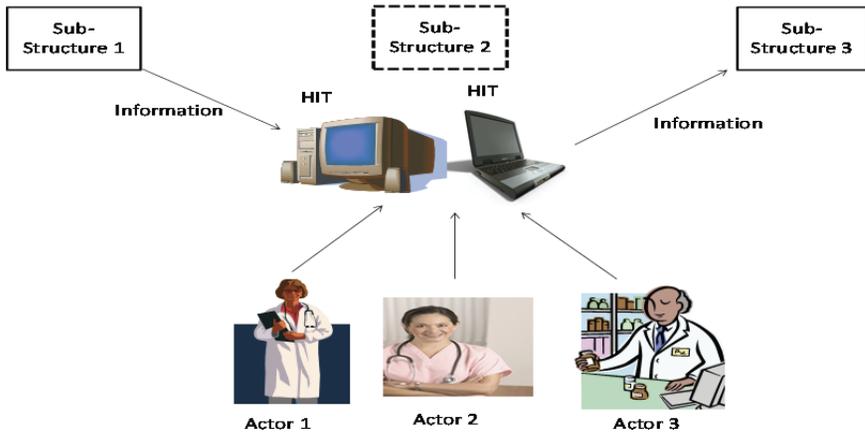


Figure 1. Modeling structural contexts

1.2. Actors

An integral part of the contextual model we are proposing are the actors or agents that operate within the healthcare structure(s) which are being modelled. These agents need to be explicitly described in the context of both their physical and virtual structures, as well as in terms of their behaviours, as described in the next section. The essential components of actor modelling are their individual roles (e.g. nurse, physician), granularity of their role (e.g. individual versus team), how a role interacts with the physical and digital structures from section 1.1 as part of task completion (e.g. data entry/retrieval or decision making), and the cultural context where the role takes place

1.3. Behaviour

Behavioural contexts define how the structural and actor models from sections 1.1 and 1.2 operate. Specifically, it defines the rules of engagement for how the actors, HIT, information, processes and workflows will interact. Behavioural contexts have to be defined at individual and collaborative levels. Individual contexts include how HIT impact tasks such as information retrieval and entry and decision making [9]. Individual contexts also consider the granularity of how an actor uses HIT. For example, interacting with one HIT is a one to one relationship, while multiple HIT would be a one to many relationship. Individual behaviours also need to look at whether a task is stationary or requires mobility.

Collaborative contexts look at the relationship between individual and group tasks. A process like a handover, which are done by multiple actors, must be modelled as a collaborative process as several different actors may contribute to the process through a single HIT. If an individual has trouble with a task (e.g. data entry) then it may have impacts at the group level (i.e. inability to find the data). A key contextual aspect of collaborative processes is that individual and group behaviour may require trade-offs that need to be reconciled by ensuring that all users have common ground about HIT behaviour.

1.4. A Framework for Contextual HIT Design

Fig. 2 shows summarizes sections 1.1-1.3 as an overarching framework for contextual HIT design. The framework serves as a framework for ensuring context is considered when designing healthcare systems to ensure that structures, actors and behaviours have all been explicitly considered and defined during the requirements and analysis phases of HIT design.

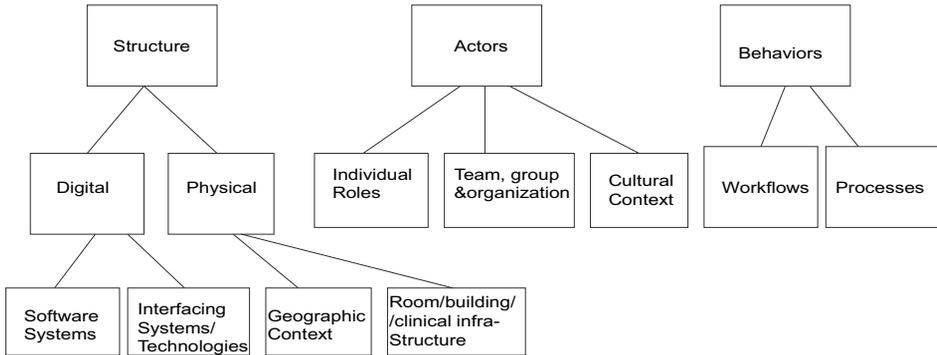


Figure 2. A framework for considering context in HIT design

In modelling context we start with the digital and physical structure. We then model the actors, their roles, and tasks, emphasizing the relationship between the actors and the structural aspects. Finally, the behaviour is modelled to define how the structure and actors will actually work within differing structures. This entails detailing the work activities of each of the actors within each of the digital and physical structures. The more pieces of structure that are connected, the greater the implications with respect to the need to have common ground about information and processes, as well as having to understand and reconcile individual and group needs.

2. Discussion

Contextual factors play a key role in how HIT is implemented and used in specific settings. Numerous studies have described how poor contextual fit leads to issues post HIT implementation [2, 3, 6]. However, there is a lack of studies that have looked at how to define different contexts as a precursor to modeling contexts. This paper presented a framework that provides a way to bind the modeling of context according to the structure, actors and behavior where an HIT will be used. The framework also helps articulate contextual considerations including the type of task (i.e. data entry vs. retrieval), mobility of the task, and the need to consider trade-offs as part of reconciling individual and collaborative HIT behavior. Overall, the framework identifies contextual considerations for designing HIT (i.e. for ensuring that structure, actors and behaviours have all been explicitly considered and defined during requirements and analysis phases of new health information technologies). We are currently extending the

framework to assess the ability of different modelling languages (e.g. Business Process Model and Notation) to model context in order to allow for explicit modelling of what-if scenarios when considering the impact of changes in context (e.g. structure, actors or behaviours) on system design and usage. Future work will also entail defining specific contextual patterns.

The paper makes an important distinction between structural and behavioral contexts of HIT usage. While the structure bounds what we do it is the system behavior that drives the outcomes. While we have made good progress at designing the structure, we have made less progress at understanding the behaviors within the structure. Many HIT implementation initiatives such as Meaningful Use in the United States or the unsuccessful National Health Services Connecting for Health initiative in the United Kingdom struggled because they focused on structure while not understanding the contextual behaviors of the HIT being implemented. Our framework can start defining the rules of engagement to support individual and group contexts.

Acknowledgements

We acknowledge funding support from the Natural Sciences and Engineering Research Council of Canada and a Research Fellowship from the Telfer School of Management.

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