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Evaluating interactive computer-based scenarios designed for learning medical technology

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ABSTRACT

The use of medical equipment is growing in healthcare, resulting in an increased need for resources to educate users in how to manage the various devices. Learning the practical operation of a device is one thing, but learning how to work with the device in the actual clinical context is more challenging. This paper presents a computer-based simulation prototype for learning medical technology in the context of critical care. Properties from simulation and computer games have been adopted to create a visualization-based, interactive and contextually bound tool for learning. A participatory design process, including three researchers and three practitioners from a clinic for infectious diseases, was adopted to adjust the form and content of the prototype to the needs of the clinical practice and to create a situated learning experience. An evaluation with 18 practitioners showed that practitioners were positive to this type of tool for learning and that it served as a good platform for eliciting and sharing knowledge. Our conclusion is that this type of tools can be a complement to traditional learning resources to situate the learning in a context without requiring advanced technology or being resource-demanding.

Introduction

Medical technology is rapidly developing and an increasing number of devices are being incorporated into clinical work. Learning the practical operation of these devices, such as the function of each control, recognizing the alarms, or how to connect and disconnect the machine is one thing, but in the actual clinical context, with a patient connected to the machine, the cognitive pressure is higher and operating these devices may be more error prone.

This paper presents a computer-based simulation prototype for learning medical technology in the context of critical care. Properties from simulation and computer games have been adopted to create a visualization-based, interactive and contextually bound tool for learning. This tool is one example of how to expand the resources for professional training beyond the more traditional educational material, such as text-based material, case descriptions and product manuals, without moving to technically advanced and resource-demanding simulation-based training, such as full-scale team training or virtual reality-based skills simulators. A prototype was designed and implemented in a participatory design process with staff from a clinic for infectious diseases, and was evaluated to better understand how this type of tool can be used for continuing professional education. The purpose of the study was to provide an example of how available information and communication technology (ICT) can be used to create motivating and easily accessible educational tools situated in the local contexts of nursing practice.

Background

Simulation has for a long time been known to bridge the gap between theory and practice and will continue to do so in various forms in the future (Nehring and Lashley, 2009). Many of today's simulation exercises focus on full-scale team simulations (Flin and Maran, 2004; Wallin et al., 2007) or part-task skill training (Johannesson et al., 2013; McCloy and Stone, 2001), available to students and staff at dedicated simulation centres. With the introduction of ICT in healthcare, such as managing patient records, preparing medication and supporting continuous professional

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development, the benefits of simulation for training can be transferred to the clinic and adapted to the specific learning objectives in that workplace. Simulated virtual patients (Bergin and Fors, 2003), online virtual worlds (Rogers, 2011), desktop simulation systems (Schwid et al., 2001) and game-based simulations (Kato, 2010; Stanley and Latimer, 2010) are examples of innovations making use of ICT for continuous professional development. These systems make use of the engaging, interactive and context-based properties of simulation and gaming to encourage learning and help retain the knowledge.

While many applications are being developed in this field, there are still areas that could benefit from these types of tools for training. One such area is the use of advanced medical equipment, such as medical ventilators. The interaction with medical equipment results in incidents in healthcare every year (Medicines and Healthcare Products Regulatory Agency, 2011). There are several underlying reasons for this that relate to the design of the devices themselves and to the education and experience of the nursing staff operating the devices (Hyman, 1994). Regulations state that practitioners must know the functionality of a device, know how to operate it, be aware of potential risks for the patient, and know how to act if an incident occurs (The Swedish National Board of Health and Welfare (2008a)). This places responsibility on the staff to be well prepared for all types of scenarios and well trained on the technical equipment. It also places responsibility on hospital management and work organizations to provide time and resources for training, and on the developers of technical devices to design them with high usability and to provide appropriate training. This is not an easy task to achieve with the constant influx of new technical devices, frequent software updates, and patients coming in with equipment from homecare.

Not many studies have examined continuing education for practitioners in the use of medical equipment and it has recently been reported to be a neglected area of research (Brand, 2012). One small study from 2001 found that the dominant source for learning was still to read product literature and product manuals, suggesting that there is room for novel educational strategies (Douglas et al., 2001). The respondents in this study also emphasized the increased stress in their work environment related to medical devices, due to “unnecessary alarms and nurses being unsure if they were using equipment correctly” (Douglas et al., 2001, p. 91). Furthermore, Rystedt and Lindström (2001) have shown that observing and evaluating the course of events and being able to predict the progress of situations are elements in nursing that are considered difficult to learn and that could benefit from simulation-based training. This further motivates continued development of new interactive, visualization-based tools for learning in this area.

Research design

The design process was participatory in the sense that a team consisting of three researchers and three practitioners from the clinic for infectious diseases worked hands-on with all the steps in the design process. Participatory design processes have proven to work well in projects where new technical solutions are developed for healthcare to design for the social and cultural context in which the solution is to be used (Hasvold and Scholl, 2011; Sjöberg and Timpka, 1998). The participating practitioners were two senior nurses and one assistant nurse. They contributed with knowledge from the clinical context that was used to guide the decisions about the form and content of the prototype. The researchers supported with knowledge about design in theory and practice, and about using digital tools for learning.

The design process has moved forward in iterative cycles, each reflecting experience from previous ones (Clemensen et al., 2007; Hayes, 2011). It started with a discussion about possible issues in the work environment combined with workplace observations (*problem formulation phase*), continued with a process to progressively concretize the ideas, from low- to high-fidelity prototypes (*prototyping phase*), and ended up in an evaluation in which the high-fidelity prototype was evaluated by a larger group of users (*evaluation phase*). The activities in the study are visualized in Fig. 1.

Problem formulation phase

The work in this phase consisted of discussions in the project team on the local work context alternated with clinical observations for the researchers to learn more about the workplace. Once the area of interest was settled the discussions were enhanced by exploring visualization, simulation and gaming approaches for educational purposes, through lectures, simulation centre visits and literature reviews.

Prototyping phase

Prototyping is a way to concretize and evaluate the ideas that come up in a design process. This is especially important in a participatory design process where the people involved often have different frames of references and different terminology for expressing themselves. The prototype is a means to reach a common understanding on the user requirements. The division into low- and high-fidelity prototypes is well established and the pros and cons of these have been discussed over time (Rudd et al., 1996). In short, low-fidelity prototypes can be good for testing design concepts without a time consuming development phase. It is easier for the user to understand that the design is under construction and still possible to influence when the prototype does not look like a finished product. High-fidelity prototypes, on the other hand, are useful for presenting a more complete user interface and to evaluate it in a realistic context. In this research we used low-fidelity prototyping to identify and sort among design concepts, and continued with high-fidelity prototyping, where a fully interactive representation of the application was created.

Prototyping encompasses numerous hands-on methods, such as sketching, scenarios, paper mock-ups and computer-based tools. These “design-by-doing” methods are an aid in supporting the communication between participants from different domains and encourage the participants to take a more active role in the design process by using their practical skills (Ehn, 1993). Two techniques were used in the low-fidelity prototyping phase: storyboards and paper mock-ups. The storyboards enabled the participants to visualize scenarios in their work that could be of interest for this type of educational tool and paper mock-ups where used to evaluate different design concepts in the work group, providing input to the high-fidelity prototyping phase. The computer-based, high-fidelity prototype went through a number of iterations as well before reaching a version that was ready for evaluation.

Evaluation phase

A more comprehensive evaluation was performed to involve more potential users in the participatory process and gain a broader understanding of the role of this type of tool for learning. Groups of two participants were asked to use the prototype and encouraged to simultaneously talk aloud to each other about the usage and the content (Rogers et al., 2011). The sessions lasted approximately 30 min and were video recorded. This was followed by a questionnaire with 15 statements on which the users were asked to indicate on a five point Likert scale the extent to which they agreed or disagreed. Ten of these statements were from the *System*

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