Using Explorative Simulation to Drive User-Centered Design and IT-Development in Healthcare

Edwards, Kasper; Thommesen, Jacob; Broberg, Ole; Nielsen, Jacob; Alapetite, Alexandre; Andersen, Henning Boje

Published in:
Proceedings from PSAM11 and ESREL 2012. 11th International Probabilistic Safety Assessment and Management Conference and The Annual European Safety and Reliability Conference

Publication date:
2012

Using Explorative Simulation to Drive User-Centered Design and IT-Development in Healthcare

Kasper Edwards[a*], Jacob Thommesen[a], Ole Broberg[a], Jacob Nielsen[b], Alexandre Alapetite[a], Henning Boje[a]

[a]Technical University of Denmark, Lyngby, Denmark
[b]Dansk Inistitut for Medicinsk Simulation, Herlev, Denmark

Abstract: We describe a method involving user-system simulation to drive rapid development and evaluation of layout, organization or information technology in healthcare. The method has been developed, tested and refined in three sub-projects in the Capital Region of Denmark. The overall goal of the project was to validate such a development method in a two-year project (2010-11). Explorative simulation is primarily based on approaches in design and usability engineering and simulation-based training in healthcare, and involves end-users and designers or engineers in a collaborative exploration of design solution. A simulation project consists of a number of discrete simulation events that begin with an observation study of the situation or object in question. This is followed by a Framing workshop where end-users (doctors, nurses, secretaries etc.) are guided through a process that uncovers problems, needs and wishes. This is translated into scripted scenarios that are explored in simulations. The simulations all use end-users to play their normal role in the scripts but different types of props are used depending on purpose. E.g. simulation of layout and organization are done using table-top simulation and mobile devices are simulated on iPads with mock-up screens. We describe and exemplify the chief advantages of the explorative simulation method, summarized briefly as follows: - a surprisingly quick way to set up and test a reasonably complex work setting and task environment - an efficient way in which application developers can gain insight into the healthcare work practice and design applications accordingly - Theories and new ideas can be readily transformed to into the simulated world where they are explored and quickly rejected or used further - A very cost-effective approach to innovation.

Keywords: user-system simulation, user-driven innovation, organization design, IT-development

1. INTRODUCTION

Simulation has been used in many situations to train specific competences and master situations that would be dangerous in real life. Airline and air force pilots use simulation at regular intervals to hone their skills and prepare for such situations. Such simulators were originally focused on the man-machine interface and testing specific reactions e.g. when the plane does this you "the pilot" should do that. Flight simulation also includes cockpit resource management focusing on the collaboration between crewmembers. However, simulation is much broader than flight simulators and has a much broader application. Simulators have been designed for ships and control rooms at nuclear power plants to name a few examples. But simulation need not be a matter of training specific competencies for known situations; simulation can be used for exploration as well.

This paper reports findings from a two year project with the aim of testing and validating explorative simulation as a method for developing new organizational forms, IT-system for delivering blood testing results and tele-medical technology.

This paper is divided into three sections: 1) explorative simulation, 2) cases and 3) conclusion and benefits from using explorative simulation

2. EXPLORATIVE SIMULATION

Explorative simulation is a methodology to develop and test ideas, concepts and organizational forms by using a tested model of the problem or situation to explore specific dimensions and unfold the knowledge gathered. The strength of simulation lies in the use of professionals to play (simulate) their own role in situations where actions, relations, organization, layout and technology etc. are changed.

Although the cases are different the core of the tested explorative simulation remains the same. Explorative simulation relies on intricate knowledge of the situation to be simulated. A situation can be a patient process from the patient arrives to the patient is discharged from an outpatient unit. A situation can also be when a doctor receives diagnostic information which he must then process and take action.

Situations can be very different but from a simulation perspective they must be well understood and the main features described. This is done in a pre-study where the situation is chosen and outsiders such as researchers or technology providers observe the situation and form their own understanding of the situation.

A variety of tools exists to understand situations ranging from observation to participation in the actual situation. Direct observation and interviews are emphasized here as they provide outsiders with two perspectives: 1) Observation provides outsiders with an actual experience of how events unfold in the situation. 2) Interview allows outsiders to question the observed and have the participating professionals explain the reason and logic behind the observed.

Participation may allow outsiders a further level of understanding and experience; however, this may come at the expense of the outsiders' ability to critically access and question the situation. Prolonged participation in a situation result in outsiders becoming embedded in the situations own logic, premises and reason. Having established an understanding of the situation it is possible to begin simulation.

Explorative simulation was carried out as table top simulation and as on-site simulation.
Table-top simulation is a type of simulation where the situation is played out on – as the name indicates – a table. This allows participants to stand around the table and maintain overview of the situation. Props such as pen, paper, cardboard boxes are used to recreate the situation e.g. layout of rooms and equipment. Participants are professionals who play their own role as doctor or whatever the situation requires. The participants control a character such as a LEGO DUPLO® figure and have the figure act as they would normally do in the situation, that is greet the patient, walk to the examination room etc. The situation is the basis for the simulation and a sequence of events must be prepared – this is called a script.

The script details the sequence of events for each of the involved roles and the approximate amount of time for each event. The level of detail must be kept at a Meta-level recognized by the professionals in order for them to unfold their personal role. If the detail level gets too high the professionals will simply perform each activity without unfolding their professional practice. At the Meta-level where events are described as "Interview patient" professionals simply act as they would normally do which is indeed the purpose of the simulation.

Explorative simulation requires a facilitator who can guide the participants through. The facilitator is responsible for the scripts but also for introducing unforeseen events during simulation. While the participants know the scripts an can play their roles, they are not informed about the unforeseen events. The purpose of in traducing unforeseen events is to observe how the participants solve the problem. Naturally there may be a limited number of unforeseen events which prepare the participants. Still the participants are not led through the same situation twice. Although the theme may be the same, changes will be made to the layout, work processes or whatever the focus of the simulation.

After simulating a situation it is the duty of the facilitator to debrief the participants and collect suggestions for improvements to the situation. This is best done on a flip-over or similar to make sure that all participants have a common understanding and contribute their insight.

3. CASES

Two cases are interesting to present: 1) New organization for an outpatient unit and 2) Portable device software for handling blood test result.

3.1. Case 1: New organization for an outpatient unit

The setting is a regional hospital outpatient unit with a mix of doctors, nurses, secretaries etc. totaling little over 300 FTE's. The unit is set to move to a new building in a few years and this provides an interest in developing new forms of organization which can be used as input for the design of the new building. The

ward also feels that the organization is not a smooth running as it could or should be. Secretaries are constantly behind with their work and are frequently interrupted, the reception area is overloaded, timetables are only kept because of no-shows, narrow hallways makes transport difficult, supervision of younger doctors takes too much time and processes do not appear to be consistent. However, the ward had an excellent working climate and collaboration between roles and functions were extremely flexible. The ward functioned well because of the working climate and flexibility not because of well-designed processes.

A small group of 2 doctors, 2 nurses and one secretary participated but not always the same people. The mix of roles was very important as we needed knowledge of all processes present during simulation. Before engaging in simulation four three hour workshops were held. The overall purpose of the workshops was the gain a deep understanding of work in the ward and this was done having different themes for the workshops:

Workshop 1 was themed "Visions, challenges, and breakdowns". The main activity was two sessions in which the users first identified breakdowns in the current work practice and secondly create visions for a better work based on the breakdowns.

Workshop 2 was themed "The dream outpatient ward". The two design games were played focusing on sketching the 'dream outpatient ward'. The first design game revolved around an A1cardboard with a printed figure of three overlapping ovals (see Figure 1). The second design game used a square shape that served to pressure the participants to use the principles just found in a more regular shaped structure.


Fig. 1 User group in workshop 2

Workshop 3 was themed "Consolidating the dream ward" focused on consolidating the conceptual ideas from the previous workshop. Patient scenarios were introduced and played out on the game board representing the future department.

Workshop 4 was themed "The department in 3D" and presented the user group with 3D rendering of the ideas of the future ward developed on workshop 2 and 3. The 3D rendering was used to challenge the participants to refine their perception of the future ward.

The workshops formed a solid foundation for developing a situation and script to be simulated. A regular work situation with a standard patient type was chosen. This was a patient with a common not complicated illness that required a well-defined sequence of activities for which there was an agreed time for the average duration.

Three simulations were carried out and the first focused on developing a rough framework for the organization and layout of the outpatient ward. The second simulation focused on development and test of either multifunctional or function specific rooms. The third simulation was a test and validation of the results using participants from another hospital and speciality. Here we are to focus on the second simulation as this proved to be the most innovative and radical as compared to the existing organization.

The second simulation was to explore how differences in room layout would affect ward performance and collaboration. The simulation began with a baseline that simulated the arrival of two patients in the normal

context to get used to the scripts and simulation in general. The first explorative simulation was done by simulating a simple situation of one doctor who could use an interview room and two examination rooms. Two patients would arrive a couple of minutes apart and taken to the interview room by the nurse. Following the interview the doctor ask the patient to go to the first examination room to undress and prepare for examination. The next patient would then be interviewed in the interview room and subsequent sent to the second examination room to undress and prepare. Two nurses would support the process and each follow a patient through the process.

The simulation revealed that utilization of rooms dropped as both patients had longer lead time and the interview room was not used when the doctor was in the examination room. The simulation further revealed that doctor-nurse collaboration suffered as the doctor would use the time when the patient was getting dressed in the interview room to complete the patient record. Normally this would be in the examination room allowing both patient and nurse the listen in. This made it difficult for the nurse to do the follow-up interview with the patient as the nurse would not have the required knowledge to do so. A significant part of the follow-up interview is explaining to the patient what the doctor said, what it actually meant and what was going to happen.

During the workshops and the observation in the wards it was found the coordination was a problem. Often there was a need for supervision or something unexpected happened that required immediate action. A situation was developed to capture this where a number of patients would arrive as normally but then the scripts would be interrupted by unforeseen events such as an audit, a medical complication or need for supervision. The participants would then have to deal with the situation as they would normally do.

In the normal situation i.e. rooms and business as usual revealed that a number of patients would have their examination interrupted for an inappropriate long time. This was perhaps noted in the day to day work but in simulation it was clear for the participants that such situations should be avoided. The main realization was that some means of coordination should be introduced.

Coordination was introduced as two changes: 1) the layout was changed from the normal rectangular shape to a circle where doctors and nurses would be in the centre when not treating patients. Examination rooms were placed in a circle outside the centre with access both from the outside and the centre. Patients would then arrive from the outside and doctors and nurses from the inside. The person tasked with coordination would be stationed in the middle thus maintaining a visual overview of the work going on. This would allow doctors and nurses to ask the coordinator to provide help. Given the coordinators knowledge of what was going on he/she could ask where it would impose the leas problems such as a doctor who just finished a patient.

The simulation revealed that layout and use of a coordinator role would indeed reduce problems with patients waiting in uncomfortable situations. This organization was much better at handling interruptions and unforeseen events due in part to the circular layout but mostly because of the coordinators ability to maintain overview of what was happening in the ward.

3.2. Case 2: Portable device software for handling blood test result

The second case is completely different and focuses on the situation where a doctor receives results from blood tests and needs to take action. The normal situation is that the results arrive at the computer and the doctor therefore has to be at his desk to process the results. However, doctors are usually not at their desk but doing various patient related activities. There is further the issue that doctors while doing patient related activities would benefit from having immediate access to patient data such as blood results both current and historic but also information regarding current medication etc.

To improve this situation a software company wanted to develop a software application by using explorative simulation. Contact was made to a medical ward and two doctors to participate in a three hour workshop to uncover the situation and needed functionality for a portable device. The process began by outlining the situation and functional needs from the doctors perspective. Then the workshop proceeded to detail the actual screen that would support the situation. Armed with this knowledge the software developers spend a mere day to produce a mock-up prototype of the functionality and screens described by the doctors.

The actual simulation took place at the medical ward where the software developers asked available doctors to use an iPad with mock-up screens (made as PDF's) to go through the described situation. The situation was where the doctor would talk to a patient and receive results from a blood test and change the dose of the medication used. With this little explanation the doctor was presented with the device where the first screen was a list of patients. The doctor would then simply use the device without further instructions and the software developers would observe the simulation. A few doctors would need a key word such as "would it be interesting to know the historical data?" to try out more functionality. The mock-up was also tested on nurses.

The simulation revealed that the application supported the intented situation but that in order to keep the doctors from returning to use their office computers a lot more functionality had to be incorporated. In adjusting dosage and adding new medication doctors routinely use both a drug description and what is called the "interaction database". The interaction database can be used to check if any of the current or suggested medication will have interaction effects when used at the same time. There was further a need for access to detailed patient files etc.

Simulation with the nurses revealed a completely different picture. The software developers assumed that doctors and nurses use the same information and react to the same data. The simulation revealed quite the contrary and the nurses found little use the in mock-up as they were oriented towards care and did not order medicine or changed dosage. From a care perspective the nurses requested a different functionality i.e. nurse records for the patient and tools to support their work such as a medication list or treatment plan that could be checked when completed. This work further allowed doctors and nurses to verify if the actions had actually been performed.

4. CONCLUSION

This paper has reported findings from two cases of explorative simulation that ware part of larger 2 year study. Explorative simulation is a flexible and powerful approach to user drive innovation.

The case of the out-patient ward showed that explorative simulation can be used to test the feasibility of specific changes to room configuration. Explorative simulation reveals not only the simple facts of utilization which could have been found using computer simulation of doctors, nurses and patients. Explorative simulation also uncover changes in collaboration, which in this case was negative as nurses lost access to information which made it difficult to complete their follow-up interviews with patients.

The case of a software application to support doctors handling of blood test results illustrated that it is possible with explorative simulation to gain significant knowledge for the development of the software concept. In just three days the software developers gained an understanding of a situation, implemented a mock-up solution that could help the situation and test it in the ward. The explorative simulation in the ward revealed both human computer interaction issues but also that doctors and nurses had completely different information and application needs. The led the developers to question the wisdom of creating a common application for doctors and nurses.

Explorative simulation is a very dynamic tool where exploration starts with knowledge of a situation and assumptions of how to solve it. However, during simulation the interaction between professional groups quickly creates new possibilities that can be tested either by rearranging the layout or by drawing a new computer screen on a piece of paper for the doctors to simulate and test.

This on the other hand is also what makes traditional project managers weary: You begin in one end assuming you know the direction you are going – but you end up in a completely different situation than imagined. Facilitators of explorative simulation must be able to allow this level of flexibility. If not the creative energy of the participants disappear and in becomes a simple test of a situation where the participants only deliver domain knowledge but not their creative insight.

Explorative simulation allows developers of technology and an organization to shortcut development time. Many avenues to improve a situation can be tested very quickly and with very little cost.