

Participatory Design of Large-Scale Information Systems

A Reconstruction of the Iterative Prototyping Approach

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Abstract

In this article we discuss how to engage in large-scale information systems development by applying a participatory design (PD) approach that acknowledges the unique situated work practices conducted by the domain experts of modern organizations. We reconstruct the iterative prototyping approach into a PD process model that (1) emphasizes PD experiments as transcending traditional prototyping by evaluating fully integrated systems exposed to real work practices; (2) incorporates improvisational change management including anticipated, emergent, and opportunity-based change; and (3) extends initial design and development into a sustained and ongoing stepwise implementation that constitutes an overall technology-driven organizational change. The process model is presented through a large-scale PD experiment in the Danish healthcare sector. We reflect on our experiences from this experiment and discuss three challenges to address when dealing with large-scale systems development.

Keywords

Participatory Design, Large-Scale Information Systems, Improvisational Change Management, Challenges, EPR.

Introduction

Participatory Design (PD) is a diverse collection of principles and practices aimed at making technologies, tools, environments, businesses, and social institutions more responsive to human needs. A central tenet of PD is the direct involvement of people in the co-design of things and technologies they use. Participatory Design Conferences have been held every two years since 1990 and have formed an important venue for international discussion of the collaborative, social, and political dimensions of technology innovation and use.

PD started as a dialogue about user involvement in information systems development between, on the one hand, Scandinavian scholars and promoters and, on the other hand, European and Americans interested in how the Scandinavian experience could be adopted and extended. Since then, the PD agenda have broadened to address participatory approaches in a variety of other arenas, including communications, computer supported cooperative work (CSCW), healthcare, new media, architecture, the arts, and others.

PD has a lot to offer when developing large-scale information systems, for example with regard to clarification of goals, formulation of needs, design of coherent visions for change, combining business-oriented and socially sensitive approaches, initiating participation and partnerships with different stakeholders, using ethnographic analysis as part of the design process, establishing mutual learning processes with users from the work domains in question, conducting iterative experiments aiming at organizational change, managing stepwise implementation based on comprehensive evaluations, and providing a large toolbox of different practical techniques.

The iterative prototyping approach is well-known within PD and information systems development in general (Floyd 1984; Budde, Kautz et al. 1992). Prototyping refers to the process of creating a working model in advance (a prototype) exhibiting essential features of the final product (the information system) in order to test various aspects of a design, illustrate ideas or features and gather early feedback and experiences from using it. The approach is basically rooted in the principles for the scientific experiment that set up an experiment in order to test and evaluate specific hypotheses (Nagel 1961). Traditionally, iterative prototyping have been conducted as the initial part of an overall development process using exploratory and experimental prototypes leading (in commercial settings) to a contractual bid (Bødker, Kensing et al. 2004). And typically, the development process succeeding the contractual bid is based on a thorough requirement document defining the system to be deployed following a traditional sequential waterfall type process (Davis 1990).

In this article we present a reconstruction of the iterative prototyping approach – including large-scale PD experiments as part of the commercial endeavors with information systems. We do this by means of an exemplary reflection: *What are the challenges that PD must face when engaging in design and implementation of large-scale information systems?* We describe and reflect on a Danish PD initiative in the healthcare sector involving a PD experiment with Electronic Patient Record (EPR) systems (Simonsen and Hertzum 2006). The experiment was conducted by the authors in close collaboration with the vendor, CSC Scandihealth (in the following referred to as just 'CSC'), and the customer, the Zealand Region ('Zealand'), in particular Zealand's EPR unit and a neurological stroke unit, treating acute apoplexy at Roskilde Hospital ('the stroke unit'). The experiment represents a breakthrough for PD engagement in large-scale EPR systems in the Danish public sector by leading to a new regional strategy for Zealand driven by PD experiments and by inspiring a new Danish national strategy for healthcare systems. We describe the experiment and our experiences and lessons and present the challenges that the PD paradigm has to cope with to succeed in playing a major role in large-scale information systems projects.

Background and Previous PD Projects

Over the past decades new information systems in the public and private sectors have moved from the 'back office' (systems for accounting, inventory control, handling staff and wages, etc.) to the 'front office' supporting knowledgeable and often also quite powerful users (caseworker, clinicians, etc.) who are in direct contact with the 'customer' (citizen, patient, etc.). While back-office systems have automated and supported many routine operations and transactions, front-office systems (like EPR systems and other types of electronic document repositories) to a large degree aim at supporting ongoing communication, coordination, collaboration, and decision-making. Such work practices may primarily consist of situated action (Suchman 1987). Technological changes introduced into these relatively autonomous front-office users' work practices are known to be unpredictable and characterized by having an uncertain, open-ended, complex and flexible nature (Orlikowski and Hofman 1997). The overall change process is constituted by an ongoing process made up of opportunities and challenges that continue to evolve when using the system (Markus 2001; Markus 2004).

There is a need for a design process that allows the organization to experiment and learn as it uses the technology over time. Such an overall design process that includes – and transcends – the technical implementation of the technology has been described by Markus (Markus 2004) as a technochange prototyping approach. This approach combines large IT projects with organizational change programs to produce technology-driven organizational change: "Here what is to be prototyped is not just a technical solution *or* just an organizational change, but both together" (Markus 2004, p. 17). This technochange prototyping approach may thus be considered as using the traditional iterative prototyping approach as an overall model for organizational change.

Iterative PD experiments using various sorts of mock-ups and prototypes have been conducted for decades. But a review of the PD literature reveals that most PD experiments have been restricted to small scale systems (often driven by researchers) (Clement and Besselaar 1993; Oostveen and Besselaar 2004) or to the initial parts of larger scale information-systems development followed by a conventional contractual bid (Kensing 2000; Bødker, Kensing et al. 2004). Recently, however, a growing number of PD experiments include both initial design and real-use evaluations (Pipek and Wulf 1999; Bødker and Buur 2002; Büscher, Eriksen et al. 2004; Bardram, Hansen et al. 2006; Hansen 2006; Hansen, Bardram et al. 2006)

In the Florence project (Bjerknes and Bratteteig 1988) researchers succeeded in supporting nursing work through a PD approach that dominated the entire development and implementation process. The developed information system was, however, small-scale. Conversely, the UTOPIA project (Ehn 1988) concerned a large-scale information system but included initial design only. Large-scale information systems have also been undertaken in the Danish Radio (Kensing, Simonsen et al. 1998) and Maersk shipping (Christensen, Crabtree et al. 1998) projects. In these projects the PD approach included initial design and prototyping but was followed by a contractual bid and a conventional procurement and implementation process. In another large-scale project the aim was to develop an internet and smartcard-based system for European citizens (Oostveen and Besselaar 2004). This project combined a PD approach to the initial design with technology assessment of case studies of other smartcard technologies. Furthermore, PD approaches have proven successful in identifying and resolving work-practice problems occurring after the initial implementation of new technologies. This was for example the case with a study of automatic drug-dispensing machines and keyboard trays at a Canadian hospital (Balka and Kahnamoui 2004; Balka 2006).

Arguments for conducting PD experiments that transcend initial design have been raised in relation to usability laboratories (e.g., the design collaboratorium (Bødker and Buur 2002)) and systems development methodologies (e.g., cooperative experimental systems development (CESD) (Grønbæk, Kyng et al. 1995)). CESD has, for example, been used in the Great Belt project (Grønbæk, Kyng et al. 1993) where researchers developed a generic CSCW prototype for a large engineering company. However, the prototype was, apparently, not evaluated in real use as part of its development and refinement. Other recent projects include socio-technical experiments with so-called pervasive-computing devices exposed to real-life testing in hospital settings (Hansen 2006). In these projects researchers have experimented with patient records deployed on tablet PCs and awareness information on mobile phones (Hansen 2006) as well as with coordination support for operations by means of large interactive displays (Bardram, Hansen et al. 2006; Hansen, Bardram et al. 2006). The WorkSpace project (Büscher, Eriksen et al. 2004) may be an exception among PD projects by realizing a commercial software product for landscape architects – institutionalized in a company owned by the researchers (www.43d.com).

Improvisational Change Management

If iterative PD approaches are to transcend initial design and product development and play a role in the organizational implementation of new large-scale information systems then an improvisational approach appears to be required (Ciborra 1996). Orlikowski and Hofman (Orlikowski and Hofman 1997) characterize improvisational change management by distinguishing between three kinds of change: anticipated, emergent, and opportunity-based. *Anticipated change* is planned ahead and occurs as intended by the originators of the change. *Emergent change* is defined as local and spontaneous changes, not originally anticipated or intended. Such changes do not involve deliberate actions but grow out of practice. *Opportunity-based changes* are purposefully introduced changes resulting from unexpected opportunities, events, or breakdowns that might arise after the introduction of a new information system: "While there is no predefined sequence in which the different types of change occur, the deployment of new

technology often entails an initial anticipated organizational change [...]. Over time, however, use of the new technology will typically involve a series of opportunity-based, emergent, and further anticipated changes, the order of which cannot be determined in advance because the changes interact with each other in response to outcomes, events, and conditions arising through experimentation and use” (Orlikowski and Hofman 1997, p. 13).

Orlikowski and Hofman (Orlikowski and Hofman 1997) suggest adopting an improvisational change model that incorporates the evolving capabilities, emerging practices, and unanticipated outcomes and allows for learning from practical experience, responding to unexpected outcomes and capabilities, and adapting both the technology and the organization as appropriate.

Emergent and opportunity-based changes are widely noted in PD projects (e.g., (Bjerknes and Brateteig 1988; Ehn 1988; Bødker and Buur 2002)), but there has been surprisingly little focus on managing and learning from such changes over longer periods of time. Change management has, however, been studied in relation to tailoring in the AT project (Trigg and Bødker 1994; Bødker 1996). While the planned change involved that inspectors at the studied labor inspection service were introduced to text processing and thereby took over many typing tasks from the secretaries, tailoring and standardization evolved in emergent and opportunity-based ways. Some inspectors started developing templates of standard forms. Initially, these forms were merely for personal use but they quickly spread to other inspectors. This emergent change made it apparent that more robust templates were needed if they were to be sharable. Thus, an opportunity-based change was triggered, during which a number of templates and button panels were developed and distributed among the inspectors. While this improvisational process is acknowledged, it remains unclear how PD may actively embrace and manage such a process in a manner where emergent changes are nurtured, identified, and gradually turned into opportunity-based, organization-wide changes.

In the POLITeam project (Pipek and Wulf 1999), the main improvement of the work process of vote preparation was the parallelization of a previously sequential process. Neither project members nor interviewed users had, however, recognized this improvement opportunity prior to installation of the system. It was realized, “rather accidentally” (Pipek and Wulf 1999, p. 207), several months after installation and led to an opportunity-based change in the workflow. In spite of its large scale and long duration the POLITeam project does not appear to systematically facilitate improvisational change management. Instead, the occurrence of emergent changes is explained partly by uncertainty about the extent of planned changes. If planned changes are adopted at a large scale they may occasion emergent changes that would not otherwise be feasible. Thus, success at managing planned changes may increase, rather than decrease, improvisational change.

Finally, the extensive PD work on BSCW illustrates how the organizational consequences of introducing such a generic system may differ radically depending on whether the involved work is distributed co-authoring (Horstmann and Bentley 1997), educational courses (Sikkel, Gommer et al. 2001), or community building among Iranian NGOs (Rohde 2004). Today, large-scale information systems have changed from being standard, one-size-fits-all systems to the ‘era of configurability’ (Balka, Wagner et al. 2005) offering much more flexible and generic systems (Bansler and Havn 1994) that can be configured to support individual needs. This way new information systems incorporate some of the properties known from groupware and CSCW (Grudin 1994; Grudin 1994; Ciborra 1996). This emphasizes the diversity of change that may emerge and the impossibility of anticipating all of them.

The PD Experiment

The improvisational model for change management (Orlikowski and Hofman 1997) entails that to engage in large-scale information systems projects PD approaches will have to integrate design and development with organizational implementation. This is necessary to obtain data and experiences from real use during design and development and thereby iteratively (1) evaluate progress on planned changes, (2) become aware of emergent changes, and (3) turn selected emergent changes into opportunity-based or new planned changes. While progress on planned changes is a means to ensure that system possibilities get incorporated in actual work practices, turning emergent changes into opportunity-based changes is a means to ensure that work practices are changed in relevant ways. The resulting process model is illustrated in Figure 1 and gives the overall structure of the following description of our EPR experiment.

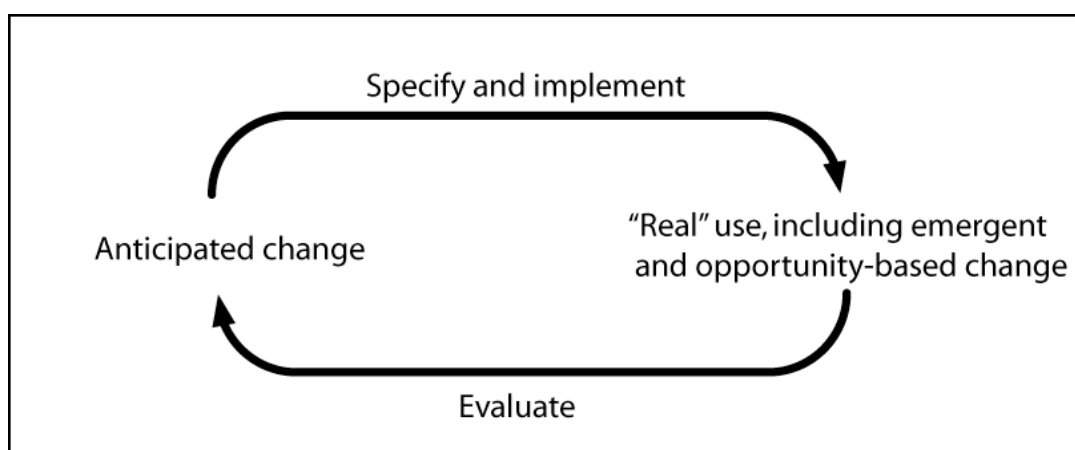


Figure 1: A reconstruction of the iterative prototyping approach into a process model for PD. The model emphasizes PD experiments as evaluating systems exposed to real situated work practices and reflects a sustained and ongoing stepwise implementation constituting an overall technology-driven organizational change.

The model is depicted as the task-artifact cycle (Carroll, Kellog et al. 1991) and outlines a reconstruction of the iterative prototyping approach where the starting point of an iteration is the changes that are anticipated and aimed for. The anticipated changes are further specified, for example in terms of effects of using the system. The system (or a part/prototype of it) is then implemented and tried out for a period under conditions as close to a real use as possible. Actual use of the system allows for emergent and opportunity-based changes to occur. Finally, evaluation of using the system informs subsequent iterations. This includes that selected emergent changes are turned into opportunity-based and new anticipated changes.

Context and involved partners

Denmark is divided into five geographical regions, each responsible for running the hospitals in the region. This includes each hospital's EPR system. The development and implementation of Danish EPR systems has been dominated by traditional top-down strategies starting from high-level goals not directly related to the concrete clinical work. As mentioned above, the Zealand region recently adopted a different strategy, where the development and implementation of EPR systems is done through a bottom-up process informed by PD experiments.

The background for Zealand's choice of a PD strategy was their recent experiences from implementing an EPR module for managing the prescription and use of drugs ('OPUS'). OPUS has about 2500 users and runs on approximately 1000 PCs, mostly laptops. OPUS was developed by CSC with a traditional

top-down strategy and was taken into use by all hospitals in the region during a relatively short period of time (5 months in 2003-2004). The EPR unit was surprised by the high number of problems that arose during the organizational implementation of the system. There were long-standing technical problems related to poor performance, usability problems leading to unsophisticated and erroneous use of the system, and enormous efforts were required to make the clinicians comply with the workflows and procedures related to the new ways of managing drug administration. The EPR unit had produced and distributed new procedures for how to administrate drugs with the new system. When the system was introduced at a ward these procedures were supplemented by a training course and for two weeks EPR-staff was present as support personnel. The experience, however, was that this was far from sufficient to bring about the intended changes in work practices.

To analyze the implementation of OPUS, the EPR unit started to collaborate with the authors in Fall 2004. Based on these analyses, the EPR unit developed a new strategy for their next EPR module, the clinical process module. This EPR module supports clinical documentation and decision making and comprises the ongoing documentation of medical patient information made by the clinical staff (physicians, nurses, therapists). Today, this clinical documentation is (throughout Denmark) mainly paper-based. The EPR unit decided that a clinical process EPR module could not be successfully implemented unless it was positively welcomed by the clinicians – especially the physicians who are the most powerful group of clinicians. The result was a PD strategy for a stepwise change and implementation with a focus on the effects of using the system and on the clinical staff's satisfaction with the system.

To initiate the deployment of the regional PD strategy a large-scale PD experiment was conducted, involving a close collaboration between CSC, Zealand, the stroke unit at Roskilde Hospital, and the authors:

CSC constitutes the vendor organization in charge of developing, implementing, and testing EPR solutions in terms of IT infrastructure and applications as well as critical clinical processes. CSC provided – free of charge – Zealand with access to their newly released EPR platform. The platform is based on the Oracle[®] Healthcare Transaction Base which is highly configurable and suited for prototyping. CSC was responsible for system development, installation, configuration, data migration, and extensive support during the experiment where the system was in use. CSC's interest was to experience how to configure a clinical process EPR module in participation with clinicians and to test how their solution would work in a real clinical process. In particular, CSC's interest was to get a real-life reference installation of their system for use in a bid with another Danish region. Due to this interest CSC invested considerable resources in the experiment and demanded that the experiment was completed in 2005.

Zealand constitutes the customer organization defining the needs and desired outcomes from using the system as well as providing access to a clinical department for evaluating the EPR system. Zealand was responsible for preparing the clinical department for participation in the experiment, including training of the clinical staff. Zealand's general interest was to start the deployment of their new PD strategy and assess how to document clinical utility value. In particular, Zealand's interest was to evaluate whether CSC's EPR solution could perform satisfactorily, be integrated with other clinical systems, and meet the expectations of the clinicians. Zealand demanded that the system was evaluated at a critical care unit (the stroke unit) where malfunctions and inconveniences cannot be tolerated. Based on experiences from the OPUS system they also demanded that bed-side registrations was supported by portable PDAs.

The stroke unit at Roskilde Hospital constitutes the test site. Stroke is a leading cause of death and chronic disability in most industrialized countries. Roskilde Hospital is a medium-sized Danish hospital with a neurological ward that includes an in-patient stroke unit with nine beds. The stroke unit treats

approximately 650 acute-stroke patients a year, plus approximately 200 patients that turn out not to have suffered a stroke. The stroke unit was chosen as representing a critical care unit with well-documented patient trajectories of high quality. This was regarded an asset for the experiment because an initial design of the clinical process EPR module could partly be based on this documentation. The experiment required that all paper-based patient records in the stroke unit were replaced with the EPR system for a five-day period. This necessitated thorough planning, including development of new EPR-supported patient trajectories, and training the clinical staff in using the system and working according to the revised patient trajectories.

We (the authors and participating researchers) were responsible for evaluating the experiment. We facilitated the collaboration, participated in developing and refining the PD approach, and investigated its initial use. Our interest was to use the case as empirical input to a research program on 'Effects-driven IT development'. The experiment should provide empirical input to two related research questions: How can desirable effects be identified and specified in collaboration with the clinical staff, and how can realistic experiments be conducted using EPR systems during real clinical work? In particular, we were responsible for identifying and specifying the desired effects in participation with the clinicians, for developing methods for measuring these effects, and for designing, managing, and facilitating the experiment in order to evaluate usage effects.

Process and results

The PD experiment was completed during Fall 2005. Referring to Figure 1 we describe the process, main results, and factors driving the experiment.

Anticipated changes: specify and implement

The overall anticipated change that the experiment aimed for was to implement a fully IT integrated EPR that included support for the clinical process and replaced all paper-based patient records. The clinicians at the stroke unit specifically requested improvements in obtaining patient overview and in their mutual coordination. Stroke is one of the diseases included in the Danish National Indicator Project (NIP) (NIP 2008). NIP is a national database providing a scientific basis for monitoring and improving medical care. The management of the stroke unit voiced a need for improving the quality of the unit's NIP reportings. On a national level it is also a long-term aim to increase the structuring and standardization of the content of patient records as part of the development of EPR (Bossen 2006). In response to this overall political objective, the EPR unit wanted to introduce an initial limited structuring of the nursing record.

The anticipated changes were specified in the first part of the experiment (August to October) through five full-day PD workshops where clinical staff in cooperation with designers from CSC and project managers from the EPR unit designed and configured the EPR system. Main parts of the system were designed through up to three iterative events: At one workshop, mock-ups were drawn on flip-over charts. At the following workshop, a preliminary non-interactive PowerPoint prototype was discussed. Finally, at a third workshop, a running prototype was demonstrated, discussed, and evaluated.

Our role at the workshops was to facilitate in defining the clinicians' needs for support stated in terms of the effects they wanted from using the system. The clinical staff comprises physicians, nurses, and therapists. Physicians and nurses were from the beginning represented at the workshops because they are the core clinicians at the stroke unit. On any shift one physician is in charge of the medical treatment of the patients and one nurse is the leader of a team of 2-4 nurses and auxiliary nurses. At the third workshop, the therapists were included but (partly due to their late involvement) this staff groups' influence on the design remained marginal.

In their requirements the physicians and nurses focused on two aspects central to their work, namely their continual creation and recreation of an overview of the status of the individual patients and the coordination among the clinicians, within as well as across staff groups. Overview and coordination are particularly prominent in relation to three clinical activities:

- Team conferences. Every morning on weekdays physicians, nurses, and therapists meet for about 15 minutes to walk through the admitted patients.
- Ward rounds. After the team conference the chief physician starts his or her ward round, which consists of medically assessing each patient and adjusting the treatment and care accordingly.
- Nursing handovers. At the start of every nursing shift the nurses meet for about 45 minutes to walk through the admitted patients and coordinate activities.

Through the PD workshops a number of desired effects were specified by the clinicians. What the clinicians wanted from the EPR system was essentially support during the three activities mentioned above. All clinicians requested coordination support. The chief physician wanted, for example, to be able to complete the daily ward rounds as a “one-man show” (without an escorting nurse), where all information and coordination with other clinical staff was done through the EPR system. This effect was given high priority because the nurses are busy and have little time left for escorting the chief physician during the long-lasting ward round. An additional reason for giving this effect high priority was that a main motivation for CSC was to obtain a reference with a satisfied chief physician in relation to their bid with another region. Improved patient overview was defined as a desired effect especially in relation to the team conferences and nursing handovers. As requested by the EPR unit additional requirements were an increase in the structuring of the nurses’ recordings by introducing the 13 Virginia Henderson categories (Henderson 2006) and a requirement for prompt response times to evaluate the performance capabilities of CSC’s new development platform. Finally, the quality of the NIP reportings was to be improved, as requested by the stroke unit’s management. The clinicians’ often forgot to record NIP data and a medical secretary spent considerable time obtaining them from the clinicians after the patients were discharged.

In November through December, CSC undertook the technical implementation of the EPR system, along with interfaces to various systems currently used at the hospital (laboratory systems, patient administrative system, OPUS, etc.). A number of tests and reconfigurations of the system (using sample patient data) were made in parallel with training the clinical staff in the use of the system. By the end of November five years of patient data (in total more than 26 million data records from more than 300,000 patients) were migrated to the system. This allowed access to patient records even for patients that would be hospitalized during the experiment. It also provided a data load that enabled a realistic evaluation of system performance.

Real use: evaluate

The trial period, where the EPR system was in real use, took place in December and lasted five days. During this trial period all clinicians at the stroke unit used the EPR system 24 hours a day, and the system replaced all paper records for all patients. The system involved stationary and portable PCs, PDAs for bedside measurement of patient parameters (temperature, blood pressure, etc.). Furthermore, the team conferences and nursing handovers took place in a dedicated room where the EPR was displayed by projecting a PC screen onto the wall using a ceiling projector.

The system simulated a fully integrated EPR system, not expected to be in operational use in Denmark until years from today. Transactions involving other wards not included in the experiment were simulated by a Wizard of Oz process (Maulsby, Greenberg et al. 1993). A back office was established and staffed 24 hours a day. Patient-record entries that involved paper transactions with other wards were

initiated in the EPR system by the clinicians. The back office continuously monitored the system, identified such entries, mailed them in the conventional fashion, waited for the results to arrive, and immediately typed them into the EPR system. Thus, all clinicians experienced the EPR system as if all transactions were fully IT supported.

To safeguard against troubles and misunderstandings, which might have entailed risk to patient health, the clinicians were supported by ‘shadows’, who were present 24 hours a day. The shadows were CSC employees and persons from Zealand’s EPR unit, all with a clinical background and detailed knowledge of the EPR system.

During the trial period we observed 5 team conferences and 9 nursing handovers, all performed using the EPR system. Prior to the trial period we had observed 7 team conferences and 6 nursing handovers to get acquainted with these work situations. In total, the observations comprised 16 hours of clinical work involving 35 patients and more than 20 clinicians. Each observation was done by one researcher acting as an observer participant (Blomberg, Giacomi et al. 1993), i.e. sitting in the room, where the handover or team conference took place, while being as unobtrusive as possible. All observations were documented by the authors in written notes. Selected sessions were audio and video recorded, in parallel with a recording of the full-motion screen interaction with the EPR system. Seven clinicians were interviewed in relation to the observations, including interviews immediately after an observation to clarify and elaborate key issues, and interviews after the trial period to verify details and interpretations. Finally, all participating clinicians received a small diary booklet and were encouraged to note any observations, proposals, and remarks they deemed relevant.

The five-day trial period made it possible to test the EPR in real use enabling emergent and opportunity-based change. Though the trial period was short we observed both emergent and opportunity-based changes. Emergent changes included that the traditional oral way of informing about patient status changed to collectively reading the information on the large shared display used for team conferences and nursing handovers. As a result of being able to collectively read the patient record on the shared display, we further observed that the clinicians initiated collective investigations of the patient record during these activities. At the nursing handovers we observed before the trial period, the patient record was only seen by the nurse team leader, who held the patient record in her or his hand and conveyed the status of the patient by reading key information; the other nurses listened to this oral presentation. During the trial period the patient record was projected on the wall and repeatedly inspected by all nurses present at the handovers, and they collectively participated in interpreting the status of the patient. As an example of an opportunity-based change the nurses managed to make their observations more visible at the team conferences: Halfway through the trial period the nurses initiated a change in the team conference screen – adding a panel specifying their observations relevant for the conference. In this way, the nurses’ observations became more salient to the clinicians as they were forming their overview of the status of the patients. The observations shown in the new panel was entered by the nurses at the handovers preceding the team conference.

The evaluation included analysis of response time, questionnaires and diaries completed by the clinicians during the trial period, follow-up interviews, a full-day seminar, and the writing of a comprehensive report with contributions from all involved parties – the stroke unit, CSC, the EPR unit, and us. Overall, the chief physician and the nurses were positive and satisfied with the EPR system. For example, the chief physician managed to complete his ward round as a “one-man show”, and the nurses experienced that their observations became part of the shared agenda at team conferences. After the experiment the nurses furthermore requested the addition of more structure to the nursing record. This came as a surprise to the EPR unit who expected that the nurses would resist rather than request increased structure of their documentation.

The quality of the NIP reportings did not change: This turned out to be a far more complex task than anticipated. CSC had considered the inclusion of the NIP reportings in the experiment an easy target to meet, merely requiring entry fields for capturing the relevant data at the source. Now they realized that the process of capturing such data involves that specific clinicians attend to these data at the right time. This entails a need for sophisticated support in terms of notifications.

To CSC, the major result of the experiment was the implementation of a fully integrated EPR that worked throughout the trial period without technical breakdowns. Hereby CSC got a valuable reference proving that they have a highly configurable EPR platform that can deliver satisfying response times. As a direct consequence of the clinicians' strong focus on coordination at the workshops, CSC initiated the design of a completely new EPR module supporting task allocation and management.

Wider results of the experiment

The PD experiment was a success in so far as it demonstrated that it is possible to design, configure, and evaluate a fully functional large-scale EPR solution in close collaboration with the clinical staff. CSC managed to develop a state-of-the-art clinical process EPR solution that three months later led them to win the bid for the clinical process EPR in the North Jutland region of Denmark.

After the trial period the EPR system was removed and the stroke unit went back to their paper-based patient records. At the same time national political concern was raised with regard to whether the five Danish regions were giving sufficient weight to integration across regions in their ongoing EPR projects. As a result, a new national EPR organization has been established. The manager of the Zealand region's EPR unit during the experiment has been appointed head of this new national EPR organization and is now in charge of the national EPR strategy. The PD strategy initiated in Zealand has hereby inspired the new national strategy which (as opposed to previous national strategies) now is based on a stepwise implementation process, driven by experiments (so-called pathfinder projects), and where attempts to standardization must be based on a bottom-up principle (Pedersen 2007).

Challenges for PD

The PD experiment described in this article consumed relatively many resources. A total of 4249.5 hours were spent by the four partners in the course of the experiment, which lasted five months. A prime reason for this was the sophistication required from the EPR system because it was to be evaluated during real use, affected all groups of clinicians at the stroke unit, was used repeatedly by the clinicians during their shifts, handled information pertinent to their work, and concerned a domain in which mistakes may have severe consequences. Relative to the budget of a full future development and deployment of an EPR system in Zealand (expected to be beyond US\$ 20 million), the experiment was, however, a minor expense.

Large-scale PD projects call for a *focus* with regard to which parts of the system and its use context should be subject to thorough analysis and several iterations and experiments using different configurations of the system. In our experiment the majority of the screens in the EPR system (87% of the total 243 screens) were remarkably stable. The clinicians did not need any changes to the initial configuration of these screens. Relatively few screens (13%) were subject to ongoing experimentation and several re-configurations. All these screens were in parts of the EPR system that involved new ways of working, such as information sharing and coordination support (Barlach and Simonsen 2007).

Important *conditions* must also be present in order for PD to gain a main role in large-scale projects. In our experiment the customer (the EPR unit) had become ready for a PD approach through their earlier experiences with the drug administration module OPUS. The manager of the EPR unit (with his back-

ground as a physician) was further aware that the clinical process EPR could not (as in the case of OPUS) be designed as a one-size-fits-all standard system. The vendor (CSC) on the other hand had a new and highly configurable EPR platform and an urgent need to prove its ability and obtain a satisfied reference. Finally, the customer and the vendor knew each other from the development and deployment of OPUS. This mutual knowledge laid the ground for the close partnership and collaboration required by the experiment.

An ambitious and focused PD approach that meets the appropriate conditions will face at least three major challenges: the different interests of a multitude of stakeholders, an ongoing and stepwise implementation process guided by a series of large-scale PD experiments, and the conduct of PD experiments with the system in real use as part of the overall design process. These three challenges are further discussed below.

Large-scale information systems projects are characterized by involving a number of different actors spanning different organizations and different organizational levels. Thus, the first major challenge is to *manage and align the motivations and interests of this multitude of stakeholders*. Traditionally, PD projects undertake a focus narrowed to the relation between designer and end-users (Clement and Besselaar 1993; Oostveen and Besselaar 2004). In our experiment we can identify the following different stakeholders: a national and political level (requesting increased structure and standardization of the EPR content), the vendor (needing a reference for another contractual bid), the EPR unit (requesting an initial structuring of the nursing record and proof of system performance), the management of the stroke unit (requesting improved quality of NIP reportings), the physicians (wanting to complete the ward rounds as a “one-man show”), and the nurses (wanting improved overview and coordination during nursing handovers). The challenge is to comply with the premises set at the national and political levels and by high-level organizational strategies, align with the different lower levels, and argue how PD with its direct involvement of end-users is an effective means to manage, mesh, and meet these different interests.

Navigating and managing this complex set of multiple stakeholders in a political environment is a major challenge to PD approaches as noted in other large-scale PD projects (Kensing, Simonsen et al. 1998; Oostveen and Besselaar 2004). We are experimenting with using means-end hierarchies, known from cognitive systems engineering (Rasmussen, Pejtersen et al. 1994; Vicente 1999) as part of a strategic analysis (Bødker, Kensing et al. 2004, pp. 117-137) to identify and relate different stakeholders’ interests. Using such means-end hierarchies we might, for example, argue that: (1) a national and political demand for increased structure in the EPR can (2) be met by a stepwise change and incremental increase of the EPR structure, which again (3) can be initiated by introducing structure to the narrative part of nursing records (4) by categorizing the record according to the Virginia Henderson categories, which (5) will only succeed if the categories fit the nurses’ documentation practice; all of which ultimately (6) is calling for a PD approach focusing on the nurses’ work practices.

A second major challenge is to effectively *manage sustained large-scale iterative PD experiments forming an overall stepwise implementation process*. This includes managing individual PD experiments as well as an overall stepwise implementation process that involves a series of PD experiments. The latter introduces an important problem of representation: Our experiment was, for example, carried out in close collaboration with one clinical speciality. It remains an open question how well the our results are transferable to similar specialities at other hospitals.

The challenge involves transcending beyond classic prototyping experiments focusing on evaluations of user interfaces and interaction based on prototypes with limited functionality and small data samples. Our process model is reconstructed to reflect the change processes described by Orlikowski and Hofman (Orlikowski and Hofman 1997): anticipated, emergent, and opportunity-based change. This

entails conducting a series of experiments where functional prototypes are evaluated during real use. The model thus supports both the initial design and the stepwise implementation process suggested by Markus (Markus 2004). The stepwise implementation process faces the traditional way of managing large IT projects as ‘design first then implement’ (Markus 2004, p. 17): Implementing as a sequence of steps with no iterations or improvisation reflected in the prevailing way of conducting competitive bids and deeply institutionalized by the common IT contract form. The argument for a stepwise process may notice both the problems related to the traditional implementation process and the much less risky process of ongoing incremental implementation. This introduces, however, the challenge of managing an implementation process that acknowledge the need for improvisation – which constitute exactly the complexity that the traditional approach (the ‘myth of the methodology’, (Markus 2004, p. 18)) is blind for.

There is no final answer regarding how PD can manage this challenge. In our research we investigate how to manage a stepwise design and implementation process on the basis of identifying and measuring the effects of using the system. Our model facilitates an iterative process managed by means of effects of using the system: Overall anticipated change might be specified in terms of usage effects focusing on the work domain in question (e.g., to be able to complete the ward rounds as a “one-man show”). We have been successful in convincing managers from both the customer and the vendor that such a sustained focus on effects is a promising idea, which might potentially lead to an effects-based commercial contract model where the customer’s payments are dependent on effects arising by using the vendor’s system. However, this research is only in progress and many questions are still unresolved.

A third major challenge concerns the *methodological question of how to conduct realistic large-scale PD experiments* to evaluate prototype systems during real work. Our experiment raises two issues in respect to this challenge: the restricted timeframe for evaluations and the need for precautions against errors.

The timing of real-life experiments is a trade-off between, on the one hand, evaluating early and quickly to acknowledge project deadlines, save resources, and curtail diffusion of ineffective systems and, on the other hand, evaluating after a longer period of time to allow system errors to be corrected, users to gain proficiency, work practices to stabilize, use situations to reach their true level of heterogeneity, emergent and opportunity-based changes to develop, and long-term outcomes to emerge. If a PD experiment is biased toward early and brief evaluation to honor the realities of IT projects, the consequences of various learning effects become critical to the interpretation of the experiment.

In our experiment the trial period was five days. In this short period of time none of the clinicians gained proficiency in using the EPR system and their ways of working were thus in flux, whereas their prior use of paper records was facilitated by long-standing work practices. It is encouraging that some improvements could be identified after using the EPR system for only five days (Hertzum and Simonsen 2008). However, longer trial periods are highly desirable, also as a means of getting beyond the goodwill that can be invested in trying something new for a restricted period of time.

Special precautions against errors may be necessary to evaluate systems during real use. PD experiments involve a balancing of the benefits of evaluating prototype systems during real use against the confounds introduced by the necessity of special precautions to safeguard against unacceptable errors. While experiments with real use increases validity and the possibility of unanticipated discoveries, special precautions may reduce validity. For safety-critical systems it may not be acceptable to leave users to trial and error when they encounter situations not covered by training. The project context will often preclude that evaluations are postponed until special precautions are no longer necessary. Thus, either users must have ready access to support or evaluations must move to laboratory settings. Apart from more control over possible confounds laboratory settings provide for a simplified organizational setup

and may in a number of situations be an alternative, yet not as convincing, way of performing narrowly focused evaluations.

In our experiment the clinicians were supported by shadows and certain parts of the EPR system were simulated by a back office using Wizard of Oz techniques. These precautions were necessary as troubles and misunderstandings in using the system might entail risk to patient health. But with these precautions in place the EPR system could replace paper records for the duration of the trial period.

Conclusion

We have reflected on our experiences leveraging PD in the Danish healthcare sector and reviewed the important lessons we can identify. An ambitious and focused PD approach that meets the appropriate conditions will face at least three major challenges: the different interests of a multitude of stakeholders, an ongoing and stepwise implementation process guided by a series of large-scale PD experiments, and the conduct of experiments during which the system is in real use, though it is still being designed as opposed to deployed.

We have reconstructed the traditional iterative PD experimental design approach in an attempt to create a basis for a PD approach that leverages design and deployment of large-scale information systems. The process model we suggest incorporates anticipated as well as emerging and opportunity-based change as identified by Orlikowski and Hofman's improvisational change management (Orlikowski and Hofman 1997). It emphasizes PD experiments transcending traditional prototyping tests by evaluating fully integrated systems exposed to real work situations. Thus, the model enables an alternative PD strategy extending initial design and development into a sustained and ongoing stepwise implementation defined by Markus (Markus 2004) as a technochange prototyping approach.

So far, this alternative PD strategy has yielded promising results in the Danish healthcare sector. Applying it, however, forces us to meet the challenges described. It hereby raises a number of how-to questions that cannot be satisfactorily answered with general methodological guidelines. What we need is research, preferably conducted as action research, that refines this strategy by applying it in a number of cases and thereby stimulates the mutual creation and sharing of knowledge and experiences.

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