Participative Design and the Challenges of Large-Scale Systems: Extending the Iterative PD Approach

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ABSTRACT
With its 10th biannual anniversary conference, Participatory Design (PD) is leaving its teens and must now be considered ready to join the adult world. In this article we encourage the PD community to *think big*: PD should engage in large-scale information-systems development and opt for a PD approach applied throughout design and organizational implementation. To pursue this aim we extend the iterative PD prototyping approach by (1) emphasizing PD experiments as transcending traditional prototyping by evaluating fully integrated systems exposed to real work practices; (2) incorporating improvisational change management including anticipated, emergent, and opportunity-based change; and (3) extending initial design and development into a sustained and ongoing stepwise implementation that constitutes an overall technology-driven organizational change. The extended approach is exemplified through a large-scale PD experiment in the Danish healthcare sector. We reflect on our experiences from this experiment and discuss four challenges PD must address in dealing with large-scale systems development.

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

INTRODUCTION
Three years ago Dan Shapiro wrote an intriguing article entitled ”Participatory design: the will to succeed” [40]. His message was to encourage the Participatory Design community to make a collective effort to place itself at the centre of the design of large-scale information systems, especially in the public sector. Referring to UK cases, Shapiro argued that many large-scale systems-development projects are highly troubled. Attempts to introduce ambitious information systems in the public sector have been especially notorious with regard to being late, over budget, or functionally inadequate. He further noted that ”the situation in the private industry may be no better but commercial confidentiality and the lack of public accountability may make it less visible” [40, p. 30]. We can add that the situation looks no better in Denmark where the public sector has suffered a number of so-called ’IT scandals’ [13].

The intriguing part of Shapiro’s article is not only his argument that the failures can be explained from a PD perspective (other perspectives could probably also produce plausible explanations) but rather that PD ”would do much better if its paradigm is given a serious chance” [40, p. 29]. If we believe that PD approaches are not only right (whatever that may mean) but also powerful by leading to the best and most effective systems, with regard to support of the work they are used for, then: ”Participatory Design as a community of practitioners should seriously consider claiming an engagement in the development of large-scale systems, and more particularly an engagement with the procurement and development of systems in the public sector, and should devise a collective strategy for doing so” [40, p. 32].

There is no doubt that PD has a lot to offer, 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.

Active engagement in – and documentation of results with – large-scale information systems would represent a major goal and challenge for PD. Ellen Balka has characterized it as “PD coming in from the cold” and “working inside the belly of the beast” [1]. In this article we pursue Shapiro’s call for a collective PD strategy by extending the iterative prototyping approach into a sustained PD approach including large-scale PD experiments. 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 a Electronic Patient Record (EPR) system. 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, one of Denmark's five healthcare regions, the Zealand Region ('Zealand'), in particular Zealand's EPR unit and the neurological stroke unit at Roskilde Hospital ('the stroke unit'). 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

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 (caseworkers, 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. 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 [36]. The overall change process is constituted by an ongoing process made up of opportunities and challenges that continue to evolve when using the system [31, 32].

PD is characterized by the aim of establishing mutual learning situations between 'users' and 'designers' [9]. There is a need for a sustained PD approach that allows the organization to experiment and learn – not only as part of the initial design but also as part of the organizational implementation and use of the technology. Such an overall design process that includes, and transcends, the technical implementation of the technology has been described by Markus [31] as technochange management and (in particular) as a technochange prototyping approach. Technochange 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" [31, p. 17]. The technochange prototyping approach may be considered as using the traditional iterative prototyping approach as an overall model for organizational change.

PREVIOUS PD PROJECTS

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) [19, 35] or to the initial parts of larger-scale information-systems development followed by a conventional contractual bid [9, 29]. Recently, however, a growing number of PD experiments include both initial design and real-use evaluations [5, 12, 15, 25, 26, 37]

In the Florence project [7] researchers succeeded in supporting nursing work through a PD approach that covered the entire development and implementation process. The developed information system was, however, small-scale. Conversely, the UTOPIA project [20] concerned a large-scale information system but included initial design only. Large-scale information systems have also been undertaken in the Danish Radio [30] and Maersk shipping [17] 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 [35]. 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 [2].

Arguments for conducting PD experiments that transcend initial design have been raised in relation to usability laboratories (e.g., the design collaboratorium [12]) and systems development methodologies (e.g., cooperative experimental systems development (CESD) [22]). CESD has, for example, been used in the Great Belt project [23] where researchers developed a generic CSCW prototype for a large engineering company. However, the prototype was, apparently, not evaluated in real use. Other recent projects include socio-technical experiments with so-called pervasive-computing devices exposed to real-life testing in hospital settings [25]. In these projects researchers have experimented with patient records deployed on tablet PCs and awareness information on mobile phones [25] as well as with coordination support for operations by means of large interactive displays [5, 26]. The WorkSpace project [15] 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 PD is to transcend initial design and product development and play a role in the organizational implementation of new large-scale information systems then an improvisational strategy appears to be required [10, 18]. Orlikowski and Hofman [36] 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: ”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” [36, p. 13].

Orlikowski and Hofman [36] suggest adopting an improvisational change model that incorporates the evolving capabilities, emerging practices, and unanticipated outcomes and establish mutual learning situations based on 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., [7, 12, 20]), 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 [11, 44]. 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 [37], 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” [37, 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 the BSCW system illustrates how the organizational consequences of introducing such a generic system may differ radically depending on whether the involved work is distributed co-authoring [28], educational courses [41], or community building among Iranian NGOs [39]. Today, large-scale information systems have changed from being standard, one-size-fits-all systems to an ‘era of configurability’ [3] offering flexible, generic systems [4] that can be configured to support individual needs in a manner comparable to the ongoing configuration of BSCW. This emphasizes the diversity of change that may emerge and the impossibility of anticipating all of them.

A SUSTAINED PD APPROACH

The improvisational model for change management [36] 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. Our proposed PD approach is illustrated in Figure 1. The sustained PD approach is an extension of the iterative prototyping approach. It emphasizes evaluation of systems through exposing them to real situated work practices [43] and consists of stepwise implementation of technology-driven organizational change.

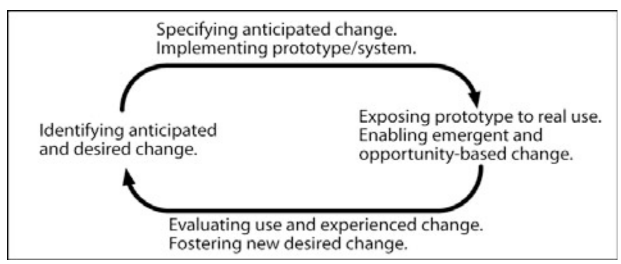

Figure 1: Outline of a sustained PD approach.

The PD approach outlined in Figure 1 resembles the task-artifact cycle [16] 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 under conditions as close as possible to real use. 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.

In the following we describe our proposed PD approach by presenting a large-scale PD experiment that exemplifies the four elements depicted in Figure 1.

THE PD EXPERIMENT

The background for Zealand's involvement in the PD experiment was recent experiences from implementing an EPR module for managing the prescription and use of drugs ('OPUS'). OPUS has about 10000 users and runs on more than 1000 PCs, mostly laptops. OPUS was developed by CSC with a traditional top-down strategy and was implemented at all hospitals in the region during 2003-2006. 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 clinicians were reluctant to comply with the workflows and procedures related to the new ways of managing drug administration [21]. 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 decided to apply the sustained PD approach 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.

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

CSC constituted 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 healthcare region. Due to this interest CSC invested considerable resources in the experiment and also demanded that the experiment was completed in 2005.

Zealand constituted 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 the PD approach and gain experience with documenting 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 were supported by portable PDAs.

The stroke unit at Roskilde Hospital constituted 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 our ongoing 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 capturing these effects, and for designing, managing, and facilitating the experiment in order to evaluate usage effects.

The PD experiment was completed during Fall 2005. Referring to Figure 1 we describe the process of applying the PD approach.

Identifying anticipated and desired change

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 [34] providing a national scientific database for monitoring and improving medical care (the NIP database). The management of the stroke unit voiced a need for improving the quality of the unit's reportings to the NIP database. 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 [14]. In response to this overall political objective, the EPR unit wanted to introduce an initial limited structure of the nursing record.

Specifying anticipated change

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 group's 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 one of CSC's a main motivations: 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. In addition, the EPR unit required an increase in the structuring of the nurses' recordings and required 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 had been discharged.

Implementing prototype/system

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 previous 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.

Exposing prototype to real use

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 provided as a large shared display by projecting a PC screen onto the wall using a ceilingprojector.

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 [33]. 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, the clinicians at the stroke unit 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 staff 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 [8], 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 during the trial period 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 record any observations, proposals, and remarks they deemed relevant.

Enabling emergent and opportunity-based change

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 out loud; 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.

Evaluating use and experienced change

The evaluation included analysis of our observations, interviews, and questionnaires along with diaries completed by the clinicians during the trial period, follow-up interviews, analysis of system response times, 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. The evaluation of the anticipated changes included a quantitative analysis that verified a number of positive effects [27]. For example, the chief physician did manage to complete his ward round as a "one-man show".

The quality of the reportings to the NIP database 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 performed well 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. Three months later CSC won the bid for the clinical process EPR in the North Jutland region of Denmark.

Fostering new desired change

CSC's EPR platform had been under development for years and subjected to numerous usability tests. The configured EPR system had been iteratively evaluated during the workshops and as part of the training sessions prior to the trial period. Even though the trial period lasted only five days, 183 out of in total 482 requests for changes and improvements to the EPR system were recorded during this period where the system was for the first time exposed to real clinical work. While the EPR system tended to focus on provision of information about patients (e.g., in order to provide clinicians with an overview of patient status), the trial period revealed additional needs for support of the clinicians' coordination of their activities.

Using the large shared display during the team conferences and nursing handovers resulted in various unanticipated changes (and related requests for further support) including (as described above): The change from oral presentation to collective reading of patient records; initiation of collective investigations of patient records; and that nurses' observations became a prominent part of the shared agenda during team conferences. As a direct consequence of the clinicians' requests for coordination support, CSC initiated the design of a completely new EPR module supporting task allocation and management.

After the experiment the nurses furthermore requested the addition of more structure to the nursing record. This was a direct result of their experiences of how structured nursing observations became part of the agenda during team conferences. This request came as a surprise to the EPR unit who expected that the nurses would resist rather than request increased structure in their documentation.

CHALLENGES FOR PD

THINK BIG was the slogan with which Michael Hammer [24] introduced the business process reengineering revolution. We argue that the PD community should think big by applying a sustained PD approach to large information systems. 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.

Extending an iterative PD approach beyond initial design (as outlined in Figure 1) raises the overall challenge of how to manage this improvisational and relatively open-ended process. We can identify at least four major challenges in managing such a sustained iterative process. These challenges are further discussed below.

Obtaining appropriate conditions and focus for PD

Important *conditions* must 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 a background 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.

Large-scale PD projects also 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 request any changes to the initial configuration of these screens. Relatively few screens (13%) were subject to ongoing experimentation and several reconfigurations. All these screens were in parts of the EPR system that involved new ways of working, such as information sharing and coordination support [6].

Managing a multitude of stakeholders

Large-scale information-systems projects are characterized by involving a number of different actors spanning different organizations and different organizational levels. Thus, a second 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 [19, 35]. 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 reportings to the NIP database), 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, to align with the different lower levels, and to 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 [30, 35]. We are experimenting with using means-end hierarchies, known from cognitive systems engineering [38, 45] as part of a strategic analysis [9, 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, which (4) will only succeed if the categories fit the nurses' documentation practice; all of which ultimately (5) calling for a PD approach focusing on the nurses' work practices.

Managing a stepwise implementation process

A third 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 results are transferable to similar specialities at other hospitals.

Our PD approach entails conducting a series of experiments where functional prototypes are evaluated during real use comprising a stepwise implementation process as suggested by Markus [31]. The stepwise implementation process stands in contrast to the traditional way of managing large IT projects as 'design first then implement' [31, p. 17]: Implementing as a sequence of steps with no iterations or improvisation reflected in the prevailing way of conducting competitive bids and in the common IT contract form. The argument for a stepwise process includes both the problems related to the traditional implementation process and the less risky process of ongoing incremental implementation. This introduces, however, the challenge of managing an implementation process that acknowledge the need for improvisation – the very complexity to which the traditional approach is blind (the 'myth of the methodology', [31, p. 18]).

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 a system. The sustained PD approach facilitates an iterative process managed by means of the effects of using a system: The anticipated changes can 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 from using the vendor's system [42]. However, this research is only in progress and many questions are still unresolved.

Conducting realistic large-scale PD experiments

A fourth 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. 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

The 10th biannual anniversary PDC marks a milestone in the history of participatory design. PD has obtained international reputation and widespread application. Yet, as Shapiro [40] notes, PD still seems reluctant to become engaged in the development of large-scale information systems. He calls for devising a collective strategy for doing so. There is no doubt that PD has a lot to offer but also that PD approaches will face considerable challenges if claiming a serious influence in the design and implementation of large-scale information systems.

We have suggested a collective PD strategy by means of an ambitious and sustained PD approach, emphasizing that mutual learning situations should be provided throughout the organizational implementation and use of large-scale systems. This acknowledges the uncertainties of technology-driven organizational change and at the same time poses the challenge of treating the entire design and implementation process as a process of genuine development. Our PD approach incorporates anticipated as well as emerging and opportunity-based change, as identified by Orlikowski and Hofman [36]. We argue for large-scale PD experiments transcending traditional prototyping tests by evaluating fully integrated systems exposed to real work situations. Thus, our PD approach extends initial design and development into a sustained and ongoing stepwise implementation, defined by Markus [31] as a technochange prototyping approach.

We have reflected on our experiences leveraging PD in the Danish healthcare sector and reviewed the important lessons we can identify. Four major challenges have been discussed: The establishment of appropriate conditions and focus for PD, handling the different interests of a multitude of stakeholders, management of 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.

So far, this PD approach 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 action research, that refines this PD approach by applying it in a number of cases and thereby stimulates the mutual creation and sharing of knowledge and experiences. We encourage the PD community to join forces, think big, and strive for success also in the case of large-scale information systems.

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