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Chapter 2: Iterative Participatory Design

By Simonsen and Hertzum

In this chapter, the theoretical background is information systems development in an organizational context. This includes theories from participatory design, human-computer interaction, and ethnographically inspired studies of work practices.

The concept of design is defined as an experimental iterative process of mutual learning by designers and domain experts (users), who aim at changing the users' work practices through the introduction of information systems.

We provide an illustrative case example in terms of an ethnographic study of clinicians experimenting with a new and fully integrated electronic patient record system. The case study focuses on emergent and opportunity-based change enabled by exposing the system to real work practices.

The contribution to a general core of design research is a reconstruction of the iterative prototyping approach into a model for sustained participatory design and implementation. The model incorporates improvisational change management comprising anticipated, emergent, and opportunity-based change. The model outlines a process that enables mutual learning, including collective reflection-in-action, through the use of information systems in real work practices.

INTRODUCTION

Experimentation, reflection, and learning are inherent aspects of design. A design process carried out by an experienced and reflective design-practitioner can be characterized as 'reflection-in-action' (Schön 1983):

> 'The practitioner allows himself to experience surprise, puzzlement, or confusion in a situation which he finds uncertain or unique. He reflects on the phenomenon before him, and on the prior understandings which have been implicit in his behaviour. He carries out an experiment which serves to generate both a new understanding of the phenomenon and a change in the situation' (ibid, p. 68).

In this chapter we apply Schön's reflection-in-action to participatory design and implementation of information systems in a work-oriented organizational context. The traditional iterative prototyping approach is reconstructed into a process model that (1) emphasizes experimenting by evaluating fully integrated information 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 change process driven by sustained participatory design.

Participatory design 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 participatory design is the direct involvement of (representatives of) the future users in the design process. This involves collective

'reflection-in-action' through the establishment of a process of mutual learning between designers and users from the work domains in question.

We draw on theories from participatory design and human-computer interaction. The design traditions in these research fields emphasize information-technology designs that emerge from a solid analysis of the intended use context. Appreciating the realities of a work-oriented organizational context implies viewing work as a socially organized and situated activity, where the actual behaviour differs from how it is planned, described, and prescribed (Suchman 1987). In such a context, design benefits from being informed by the use of ethnography to develop a thorough understanding of work practices as a basis for the specification of information systems (Simonsen and Kensing 1997; 1998).

Most approaches to technology design include iterative prototyping as part of the early design of information systems. We argue for an extension of prototyping into participatory-design experiments where you – as part of an overall design and implementation process – evaluate fully integrated information system by exposing them to real work practices. In the following, we present a process model for practice-based participatory design of information systems to be used in an organizational context. The model outlines a process that enables mutual learning, including collective reflection-in-action, through trial use of information systems for real work. The potential and impact of the model is illustrated by an ethnographic study of emergent and opportunity-based changes resulting from clinicians' trial use of a new electronic patient record (EPR) system.

This chapter is part of our research program on 'effects-driven IT development' (Hertzum and Simonsen 2008; Simonsen and Hertzum 2008). The program's aim is to establish sustained participatory design processes through an effects-driven, participatory, and experimental strategy for managing large, long-term design and implementation projects. This includes strategic partnerships based on trust, mutual learning, and close collaboration between vendor and customer. Effects-driven IT development focuses on (a) effects of using information systems instead of products and processes; (b) measurement and evaluations instead of expectations and estimates; and (c) specifications of the anticipated effects of system use instead of specifications of system functionality. The vendor and the customer should, based on these three characteristics, design and implement information systems that demonstrate utility value and measurable effects on the work they support. Measurement of anticipated effects and identification and evaluation of unanticipated effects are important means to manage the general design and implementation process: Thus, the process is driven by several iterations of formative evaluation.

A MODEL FOR SUSTAINED PARTICIPATORY DESIGN

The iterative prototyping approach is well-known within information systems in general (Floyd 1984; Budde et al. 1992). Prototyping is the process of creating, in advance of the completion of the final product, a working model (the prototype) that exhibits essential features of the final product and using this prototype to test aspects of the design, illustrate ideas or features, and gather early feedback and experiences from usage. The prototyping approach is most often illustrated as an iterative process reflecting a hermeneutic circle as in the task-artefact cycle by Carroll et al. (1991), see

Figure 1. The task-artefact cycle shows how a new system (artefact) and the task it is developed to support interact and mutually define each other: ‘A task implicitly sets the requirements for the development of artefacts to support it; an artefact suggests possibilities and introduces constraints that often radically redefine the task for which the artefact was originally developed’ (ibid, p. 79).

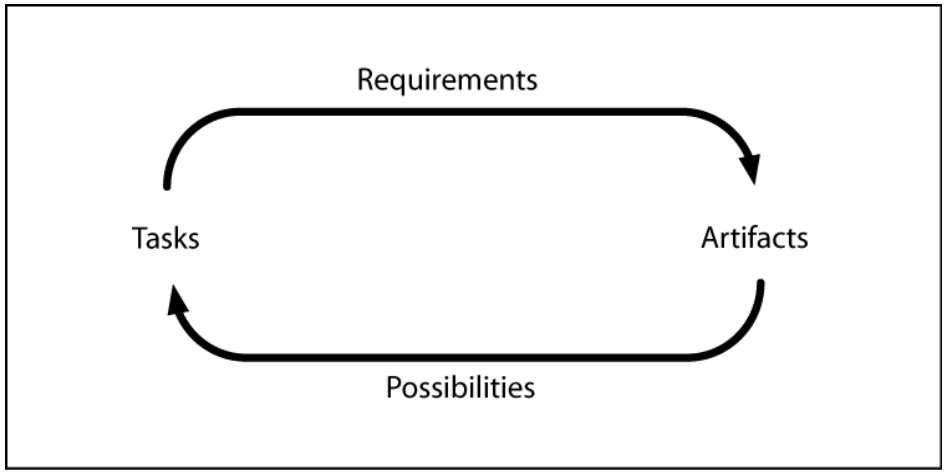

Figure 1: The Task-Artefact Cycle by Carroll et al. (1991)

Studies of small information systems (including groupware applications) that allow for quick iterations of design, use, and redesign have stressed the importance of using the system for real work in order to learn about the possibilities and constraints imposed by the artefact. Orlikowski and Hofman (1997) have characterized this as ‘improvisational change management’ and made a distinction between anticipated and unanticipated change. Anticipated change denotes the desired change that is planned ahead and occurs as intended by the originators of the change. As indicated in Figure 1, it is impossible to plan and predict all changes that occur when introducing new artefacts such as information systems to a work context. The nature of work itself is characterized by being ‘situated’ (Suchman 2007) where the course of the work process depends of the material and social circumstances at hand. Thus ‘[u]nanticipated use of computer artefacts reflects the fact that work itself is undetermined until realised in situ’ (Robinson 1993, p. 189). Unanticipated change can, according to Orlikowski and Hofman (1997), be divided into ‘emergent’ or ‘opportunity-based’ change. Emergent change is defined as local and spontaneous change, not originally anticipated nor intended. Such change does not involve deliberate actions but grows out of practice. Opportunity-based change is purposefully introduced to take advantage of unexpected opportunities, events, or breakdowns that have occurred 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’ (Orlikowski and Hofman 1997, p. 13).

Traditionally, iterative prototyping has been conducted in the initial phase of the development process and led (in commercial settings) to a contractual bid (Kensing 2000; Bødker et al. 2004). And typically, the development process succeeding the

contractual bid is based on a traditional sequential waterfall-type process, where the system is eventually 'rolled out' in the organization (Davis 1990).

Today, standard, one-size-fits-all systems are, however, increasingly giving way to an 'era of configurability' (Balka et al. 2005), where information systems are based on flexible, generic frameworks (Bansler and Havn 1994). Configurable frameworks include high-level configuration tools (often XML based) and embed standard interfaces for other systems as well as general business logic for specific domains. One example is the Oracle Healthcare Transaction Base (HTB)™, which constitutes a development framework that enables agile modelling of processes and objects native to the healthcare domain. Such generic frameworks substantially ease the creation of individual applications because much of the work is transformed from development of functionality from scratch to configuration of domain-specific building blocks.

The 'era of configurability' introduces increasingly mature technological means for an iterative, real-life experimentation-based participatory design approach, comprising design as well as organizational implementation of information systems. Configurable information systems may be implemented, used, and evaluated as part of an overall iterative design process. This opens for an important aspect of the design process since only real and situated use of the system enables emergent and opportunity-based change. During the period where a system is exposed to real use, ethnographic evaluation studies can be conducted to investigate how the system affects the users' work practices. Ethnographic evaluation studies provide an opportunity to become aware of unanticipated changes. Such evaluations might identify and analyze emergent and opportunity-based changes, hereby informing the subsequent design and implementation of the system. This reconstruction of the iterative prototyping approach is outlined in Figure 2.

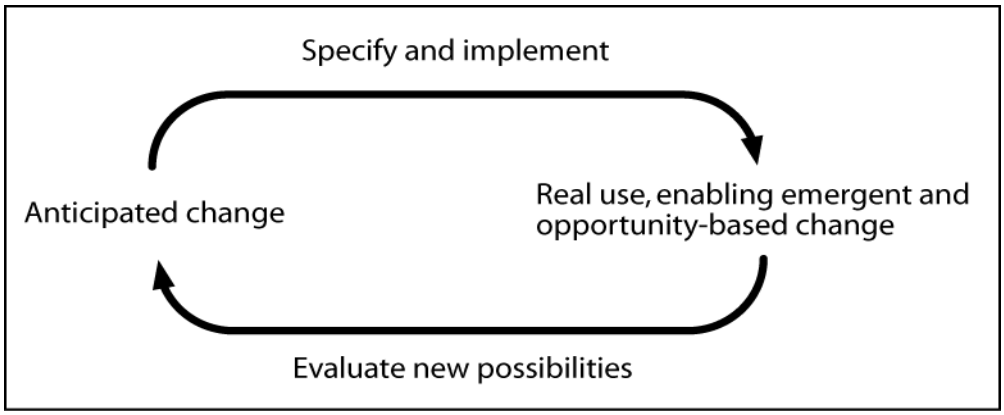

Figure 2: An iterative model for sustained participatory design.

The sustained participatory design process outlined in Figure 2 is adopted from Simonsen and Hertzum (2008) and emphasizes the evaluation of systems through exposing them to real work. 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 what effects are expected from 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 – a process which sometimes is referred to as a pilot study (Glass 1997; Turner 2005). Actual use of the system allows for emergent and opportunity-based changes to occur and inform subsequent design iterations. The model in Figure 2 outlines a process of long-term engagement of both the designers and the users of the proposed and evauated information systems. This has also been described as a process of 'co-realisation' (Hartswood et al. 2002).

THE CASE

The hospital in Roskilde, Denmark, is in the process of replacing paper-based patient records with electronic patient records. The case below concerns a neurological stroke unit that treats patients with acute apoplexy. The case is described in detail by Hertzum and Simonsen (2008) and Simonsen and Hertzum (2008). An advanced prototype of a fully functional EPR system was designed, implemented, used for real work, and subjected to an ethnographically based evaluation. During the period of trial use, the EPR supported the clinical process and replaced all paper-based patient records.

The period of trial use was the culmination of five months of preparations, during which clinical personnel in cooperation with the vendor (CSC Scandihealth), the hospital's EPR unit, and two researchers (the authors of this article) configured the EPR system to support the stroke units' patient trajectories. The clinicians used the system 24 hours a day throughout the five-day period of trial use.

Anticipated changes were specified in the first part of the project during five full-day participatory-design workshops. The clinicians at the stroke unit specifically requested anticipated change in terms of support for obtaining an overview of patients' condition and for mutual coordination. A major activity during the workshops was the design and configuration of the system. Main parts of the system were designed and configured in three steps: At one workshop, mock-ups were drawn on flip-over charts. At the following workshop, a preliminary non-interactive PowerPoint prototype was discussed. At a third workshop, a running prototype was demonstrated and discussed.

The vendor undertook the technical development of the EPR system. The system was based on Oracle's HTB, comprised a total of 243 screens, and included real-time integration with the hospital's patient-administrative system, its medication system, and several of its laboratory systems. The system involved stationary and portable PCs and PDAs for bedside measurement of patient parameters such as temperature and blood pressure. Data from the hospital's patients from the previous five years (in total more than 26 million records from 330,000 patients) were migrated to the system prior to the trial period in order to have access to past information about patients and to obtain a realistic data load.

A back-office was established and staffed 24 hours a day, and Wizard-of-Oz techniques (Maulsby et al. 1993) were used to simulate a fully integrated system. If the clinicians initiated transactions that included other wards at the hospital (other wards that were not included in the experiment), this would be captured in the back-office, mailed in the conventional fashion, and when the results came back they would be entered into the EPR system. In this way the clinicians experienced the EPR system as if it supported all transactions (except for maybe a slight temporal delay).

METHOD

During the five days of the trial period, we investigated the clinicians' work when using the EPR system. Our observations focused on the clinicians' use of a large shared EPR display during two highly collaborative situations: the nursing handover and the team conference.

The nursing handover happens three times a day at the beginning of each nursing shift (7am, 3pm, and 11pm) and lasts an hour. During nursing handovers, one nurse is designated as the team leader. This nurse reviews the patient records immediately prior to the handover and then, during the handover, orally informs the other nurses about patient status and plans for the upcoming shift.

The team conference lasts approximately 15 minutes and involves all clinicians. It takes place on weekdays within an hour after the nursing handover at 7am. The current status of each patient is given orally by a the team leader from the preceding nursing handover, and an interdisciplinary assessment ensues. On this basis plans are revised. An overview of the current plans is available on a large whiteboard or, during the trial period, on a shared EPR display projected on the wall.

The nursing handovers and team conferences took place in a designated room where the EPR was displayed by projecting a PC screen onto the wall using a standard projector mounted in the ceiling. We observed nine nursing handovers and five team conferences, all performed using the EPR system. Prior to the trial period, we got acquainted with these situations by observing six nursing handovers and seven team conferences. Each observation was done by one researcher acting as an observing participant (Blomberg et al. 1993), i.e. sitting in the room where the handover or team conference took place, while being as unobtrusive as possible. The observations informing the ethnography in this chapter were focused and thorough: They focused on nursing handovers and team conferences (only), yet they are thorough by aggregating 27 of these recurrent events. We documented all observations by writing notes. In addition, selected observation sessions were audio and video recorded, and the full-motion screen interaction with the EPR system was recorded.

During the trial period, the researchers were present at the ward during the day shift (7am through 4pm). This allowed us to ask clarifying questions when the clinicians were not busy as well as to arrange follow-up interviews. We conducted five interviews with three nurses, one physical therapist, and one speech therapist. These interviews elaborated details from our observations and clarified our immediate interpretations. A few days after the trial period we conducted a group interview with three nurses about their experience of using the EPR system. Finally, we interviewed the nurse acting as the team leader and presented our results from our ethnographic records, for verification. We audio-recorded all interviews and later wrote extended summaries.

The evaluation and the anonymous involvement of patients were authorized by the hospital. Our observations, interviews, audio-, video-, and screen-recordings were authorized by the stroke unit and approved by the participating clinicians.

ETHNOGRAPHIC RECORD

Our observations of the traditional paper-based nursing handovers and team conferences (prior to the trial period) showed a common characteristic regarding the nurse who acted as team leader. This nurse would hold the paper record in her hand and read out key status information prepared before the meeting, while the others would listen to her presentation. This oral reporting is a common practice for nursing handovers (Strange 1996) where the team leader as the chair of the handover disseminating the information in the patient record.

In the trial period, the EPR was displayed on the wall during nursing handovers and team conferences. By using such a large shared EPR display the content of the patient record is available to all participants, see Figure 3. We observed an emergent change in the way of informing about patient status as the traditional oral reporting by the team leader changed to collectively reading the shared display. This was followed by observations of additional unanticipated changes to the collaboration among the clinicians during nursing handovers and team conferences. Along with continuous negotiation about how to navigate the patient record, a process of collective inspection, interpretation, and learning unfolded, during which the clinicians assessed the status and condition of the patients. A similar process was not observed during any of the nursing handovers and team conferences observed prior to the trial period.

Figure 3: Team leader orally presenting the information in the paper record (left) and shared EPR display with patient information visible to all participants (right).

The nurses experienced how the shared display designed for the team conferences formed the agenda for these conferences. During the trial period, the nurses had the opportunity to initiate a change of this screen – influencing the agenda of the team conferences. The change consisted of adding a panel specifying selected nursing observations of relevance to the team conference. These observations, selected and promoted by the nurses, became more salient to the clinicians as they were forming their overview of the status of the patients. In addition, the panel also involved a change in the nurses' recordings as the panel required that selected information was extracted from the nursing documentation and recorded on the panel in a condensed format. Thus, the panel introduced more structure compared to the traditional chronological and narrative nursing report (Strange 1996).

Below we present a detailed ethnographic record, which describes the collective investigation that emerged and the nurses' opportunity-based change of the team

conference. The investigation involves a patient who has been admitted on suspicion of acute apoplexy, but the collective investigation causes the clinicians to realize that the patient actually suffers from acute kidney failure. Immediate action is then taken to treat this life-threatening situation. Follow-up interviews with clinicians indicated that this might have saved the patient's life.

Collective Investigation of the Patient Record at the Nursing Handover

The collective investigation was initiated when reviewing the patient during the nursing handover at seven am on the last day of the trial period. The handover was attended by five nurses: the team leader and nurses A, B, C, and D. The patient record concerned an elderly woman from Pakistan who did not speak Danish. The review of this patient lasted 12:30 minutes and started with the team leader reading aloud information from the preceding shifts. In the beginning the team leader managed the review by navigating through the record, marking text as she read it out loud with no interruptions from the other participants:

Team leader: '... blood pressure is fine; had eaten yoghurt this morning; drinks well; feels thirst; urination in toilet; dry diaper; bladder scanned to 250 [millilitres], but the patient does not feel any need for urination.'

The team leader opens a window with a note from the preceding evening shift: 'Son informs that at home the patient urinated frequently, which points to a usual flow of urine. We continue to control after each urination and observe the need for SIP [a scoring system for Stroke Intervention Parameters that indicates the scope and level of severity from an acute apoplexy].'

The team leader continues opening the window with notes from the preceding night shift: 'Patient still had low blood pressure at the beginning of the shift; she has been given [drug] that increases the blood pressure; physician in attendance will inspect patient; sodium chloride is installed for slow infusion over night; fluid control started ... because of increasing creatinine the infusion of sodium chloride is increased.'

Team leader now opens a note specifying a problem with catheterization: 'Fluid control attempted because patient at 2100 hours had over 325 [millilitres] when bladder was scanned, but control failed; unknown when patient urinated; diaper was wet; physician in attendance attempts a catheterization, but without success … contact made to Gyn [the gynaecological department] … they will come and make a catheterization.'

At this point a discussion starts about the fluid control and the problems with catheterization. Patients with acute apoplexy are routinely observed for bladder dysfunction, because a stroke often affects the nerve paths controlling urination.

Nurse A makes the remark that the patient is very hard to scan: 'I would say that it is difficult to scan the patient because [her tissue] is a bit adipose and I find it difficult to assess what it really is [that I am scanning]: Is it the stomach that I scan or what it is –

and what way it [the scanner] should turn – well I must say I had troubles scanning her, so maybe we are scanning her wrongly?'

Nurse B adds: 'But the frequency? It could, of course, be a bit of a bladder dysfunction when she does urinate frequently, but it might also be that she is intolerant to this?' ... Team leader: '[You mean the] catheterization?'

Observing that the patient is hard to scan and that the infrequent urinations might be due to the apoplexy or a side effect caused by the catheter, the team leader continues to investigate this matter by looking into the fluid intake and output notes: 'Catheterization done by physician at 1200 hours; at 1330 urine in the bag; a little urine in the tube; bladder scanned several times with different results: From 13 millilitres to 400 millilitres; awaits urine in the bag … And this morning; one new liter of sodium chloride has been set up as ordered by the physician in attendance because there is suspicion of possible dehydration. Only 100 millilitres in the bag at 600 hours; complains about pain in stomach and bladder region; bladder scanned to eight millilitres…'

Nurse D interrupts by saying: 'That sounds suspicious', but the team leader appears not to notice the interruption and continues: '… and the sodium chloride has entered, physician in attendance informed, agrees on giving one gram of 'Pinex' on day shift, awaits further planning...' Then the team leader is interrupted again, this time by nurse B: 'Honestly ...' Nurse D adds: 'Where is she depositing it? – That's insane.' Nurse B continues: 'That's really a lot of hours with that catheter. Well I don't know if it works but it did work - a little came out.' Nurse D: 'Can we read if there was something [in the bag] when she was catheterized [the second time]?'

The team leader opens a window on the screen and checks for this but there is no further information on this in the EPR system.

Nurse B asks: 'Are any blood tests ordered for this morning?' The team leader responds 'Let's see...' and opens a window. Looking at the laboratory results nurse C remarks: 'And the creatinine is on its way up.' Nurse B says in a low voice 'There is something wrong.'

They continue to study the laboratory results. Team leader: '...it's here, fluid and lymphocyte balances this morning...' Nurse D requests the team leader to open another window with graphs showing the fluid balances: 'Could you try to look at ... no that one ... the one you had up there ... can you click at the answer ... up there ... try making a right-click on the result up there ... what does it say?' They investigate the graphs and the numbers presented when they pause the mouse over the graphs. They note that one of the fluid controls has been recorded wrongly.

After investigating the recent laboratory results and the fluid balances they investigate the SIP scores. This investigation is done to examine whether the observed bladder dysfunction can be due to a stroke. They notice that the SIP scores might be misleading due to the language barrier (a language rating is part of the SIP score because apoplexy patients often suffer from aphasia).

Team leader: ‘She is scoring two on legs and she has top scores on the others, except language where she gets a three. She has a blood pressure measured to 108 over 82 and a heart rate of 118, and her temperature rose to 37.6 [celsius] this morning.’ Nurse D continues: ‘... the language, I mean you might question if [the score is due to] they couldn’t do otherwise. Without mobility [one of the SIP scores] it adds up to six.’ Team leader: ‘I did score her and I got a [language] score reading of six because the son told me that she had problems pronouncing words.’ Nurse D: ‘Then it’s a question whether she got three because they were in a night shift [where the son was not there] and they could not do anything else?’

They end the investigation by looking for the patient’s weight measurements to see whether they show signs of a congestion of fluids but find that the patient’s weight has not been recorded during the past 24 hours. They decided to control the patient’s fluid balance (measuring all fluids getting in and out) every second hour.

The hypothesis resulting from the investigation was that the patient possibly suffered from acute kidney failure, which is not caused by her apoplexy. This hypothesis was brought forward at the subsequent team conference (further described below).

Sharing Nursing Observations at the Team Conference

As a result of having experienced how the shared display (designed primarily by participation of the chief physician) determined the agenda and discussion during the team conference, the nurses proposed the addition of a panel with nursing observations in the upper right corner of the shared display. The chief physician agreed to this change, and it was implemented during the third day of the trial period. Consequently, important observations made by nurses during their shifts were instantly visible – with no need for a nurse to orally introduce an observation into the discussion of a patient. During the last three days of the trial period, we observed how the nurses’ entries at the team conference were advocated in parallel with those of the chief physician. The impact was that the nurses’ observations affected the agenda of the discussion and that they got a more peer-like voice and role.

The transcript below is from the team conference following the nursing handover described in the above section with the Pakistani woman. Prior to the team conference, the team leader from the nursing handover added their observation about the urine problem to the panel, which then contained three nursing observations (the first two from the day before):

- Fluid balances
- Apparently reduced strength in right arm
- Urine retention, catheter [new problem added by team leader]

At the team conference the patient was reviewed for 2:20 minutes. The conference was attended by 10 clinicians: two physicians (including the chief physician), three nurses (the team leader and nurse D from the earlier handover as well as the administrative

head nurse), a neuropsychologist, three therapists (physio-, occupational-, and speech therapist), and a medical secretary. The following transcript of the conversation demonstrates how the nurses' observations impact the discussion.

Team leader (right after bringing the patient up on the shared display): 'There is something wrong [with regard to this patient] because there is not coming anything out at the other end...' Nurse D adds '...of urine.' Team leader continues: 'Attempts were made to SIP-score her yesterday; she has been catheterized and SIP-scored again. So, there is a lot [to do] during the ward round, and we are a bit ... [concerned] ...When we are [SIP] scoring her then it is hard to assess ….' Nurse D interrupts [addressing the new problem added to the panel with nursing observations]: 'What's new is the urine retention that we are not able to take action on.'

The physiotherapist now points to the second observation in the panel (reduced strength in right arm) bringing this up as a new issue: 'When we [the therapists] assess her [we observe that] she is generally weakened but it is the right arm that's the problem. She can hold a glass but she has reduced functionality from the shoulder – that's where the immediate symptoms were...'

The physiotherapist continues to explain these observations but is after a little while interrupted by the the chief physician who returns to the issue brought forward by the nurses: 'There is apparently something wrong with her [fluid] system. Do we know anything about her past [diagnoses]?' The team leader opens a window with a list giving an overview of the patient's hospitalizations in the past five years. The chief physician looks at the shared display and continues 'She did previously have an infarct...' Nurse D adds: 'It's one year old.' Chief physician: '... And a little hypertension – but that does not explain the issue of her [fluid] system.' Nurse D: 'I am quite concerned since she is not producing urine – as far as we can...' Team leader: 'So she might have to be prioritized so that eeh...' Chief physician: 'Yes, she must be highly prioritized.'

There is no detailed summary of the discussion from the nursing handover. The nurses seem confident in their analysis and introduce the patient by pointing to their new observation. All three observations in the nursing-observation panel are touched upon while the nurses emphasize the new problem of urine detention. The chief physician recognizes this as an urgent problem, checks for earlier diagnoses (which do not provide an explanation), and ends by assigning the patient high priority. The other physician present at the team conference went to the patient on her ward round immediately after the team conference, and in less than an hour the patient was moved to a nefrological ward (the medical specialty concerning kidney diseases) on suspicion of an acute kidney failure.

Summary

The above analysis shows three important changes resulting from the use of the EPR system. While the first of these changes was partly anticipated, the two others were genuine examples of emergent and opportunity-based change. The three changes were: First, the collaboratively available patient records supported the clinicians in getting a more instant and efficient overview, enabled collective investigation, and, thereby,

strengthened clinicians' possibilities for gaining thorough insight into patients' conditions.

Second, the team leader's role changed from being in charge of a (mainly) one-way oral handover of information to participating in a handover characterized by peer-review, second opinions, and the establishment of a professional confidence based on collaboratively developing an understanding of the patients. The collective investigations fostered a mutual learning process where the nurses shared their observations and interpretations and, thereby, stimulated clarification of open issues and a pursuit of hypotheses about the patient's status and condition.

Third, the nurses had confidence in their observations and quickly recognized an opportunity to impact the agenda of the team conference by having selected nursing observations presented on the shared display. The inclusion of the nursing observations on the shared display increased the visibility and prominence of the nurses' work at the team conferences and thereby promoted the cross-disciplinary element of clinical work.

Interventions (I) made by physicians as recorded in the EPR	Issues and hypotheses (H) investigated by the nurses
• I-1: Sodium chloride was installed for slow infusion over night	• Observe little urine out
• I-2: Infusion increased because of increasing creatinine	• Discuss catheter problems (H-1)
• I-3: Attempts catheterization, but without success.	• Discuss blatter dysfunction (H-2)
• I-4: Catheterization made by physicians from the Gynaecological ward	• Investigates stroke scores (challenges H-2)
• I-5: More sodium chloride installed because of possible dehydration	• Doubts H-1 and H-2 and suspect a new H-3 (kidney failure)
	• H-3 presented and confirmed at the following team conference

Table 1: Summary of the mutual learning process conducted by the nurses during their investigation of the patient. Left side represents the physicians' interventions as recorded in the EPR. Right side represents the main issues and hypotheses discussed.

All three changes had a profound impact on how the clinicians' work unfolded during nursing handovers and team conferences, as exemplified by the ethnographic record. Table 1 summarizes the ethnographic record by listing the physicians' main interventions, as recorded in the EPR system, and the nurses' investigations during the nursing handover. The nurses chronologically review the patient by walking through the EPR entries from the preceding shifts and look up additional measurements and data when requested during their discussion. They first observe that sodium chlorine is set up for slow infusion, which is later increased. They notice that only little urine has been observed and discuss several reasons for this: The patient is hard to scan for blatter content; the catheter might not be in the right position; the patient might be

hypersensitive (intolerant) to the catheter; and it might be a case of blatter dysfunction due to the stroke. The catheterization is then redone by specialists from the Gynaecological ward. This moves the focus to the possibility of a blatter dysfunction and whether this could be stroke related. They investigate the SIP scores that indicate a stroke, and they start to question whether they are right: Some measurements (a language score) might be biased because the patient has problems pronouncing words, which the nurse at the night shift might have been unaware of. Taking this bias is into account the nurses reach the conclusion that the patient might suffer from an acute kidney malfunction, which is not related to the apoplexy. They forward this hypothesis to the upcoming team conference by means of the new panel for nursing observations. During the team conference the chief physician recognizes their observations, inspects the EPR system for other possible explanations, and concludes by assigning the patient a high priority. The patient is soon after moved to a nefrological ward on suspicion of severe kidney failure.

CONCLUSION

We have described design as a process that aims at anticipated and desired outcomes while acknowledging the emergent characteristics of introducing new information systems to real work practices. Design thus involves a continual relation between achieving planned goals and learning from real-use evaluation. Design is constituted by mutual learning and by reflecting on this relation – as a collective 'reflection-in-action'. We have presented a reconstruction of the iterative prototyping approach into a model for sustained participatory design and implementation (Figure 2). This model outlines a very specific suggestion regarding how to manage design processes.

Our reconstruction of the traditional iterative prototyping approaches emphasizes evaluations based on real use of the designed artefact – in our case an EPR system. Only through real use is emergent and opportunity-based change enabled. We have demonstrated how such unanticipated change can be identified and analysed with ethnographic techniques hereby informing subsequent iterations. The EPR system had – prior to the trial period – been evaluated through several usability tests conducted in laboratory settings using test data simulating real patients. Although the trial period in our experiment lasted only five days, 183 (38%) of the clinicians' ideas and requests were recorded in this period, where the system was for the first time exposed to real clinical work. This emphasizes the importance of conducting real-life evaluations as part of a general design strategy.

The ethnographic analysis presented in this chapter describes how emergent and opportunity-based change might evolve during real use of a new information system. The unanticipated changes were triggered by making EPR information available on a large, shared display in two situations that demand a high level of coordination: nursing handovers and team conferences. The analysis showed how the clinicians adapted their ways of working as they experienced and incorporated the shared EPR display into their collaborative work practice. We found that the clinicians reduced the amount of oral presentation of patient records in favour of collective reading and assessment of the electronic patient record, which was projected on the wall in the meeting room. The clinicians spontaneously started to engage in collective investigation of patient records. At the nursing handovers this resulted in the nurses jointly interpreting the status and

condition of patients, hereby stimulating a mutual learning situation. The nurses also recognized the opportunity of offering their observations as a prominent, shared resource during team conferences. By having a panel with selected nursing observations added to the EPR display, these observations became part of the shared agenda, resulting in what might be labelled an empowerment of the nurses (Murnane 2005).

These findings provide valuable insights regarding new possibilities for anticipated change in subsequent iterations of the design and organizational implementation of the EPR system, as indicated in our model for sustained participatory design. Based on our case example, new anticipated changes could include:

- Enabling a different role for the nurse team leader because there is less oral presentation, possibly also reducing preparation time.

- Enhancing cross-disciplinary information exchange and coordination during team conferences.

- Designing the user interface to provide specific support for collective investigation of patient records during handovers and team conferences.

- Making recordings more structured and thereby improving the possibilities for the different groups of clinician to benefit from each others' recordings, for example by means of panels with selected observations.

The model for sustained participatory design highlights the importance of exposing prototype versions of information systems to real-work conditions in order to capture hitherto unanticipated possibilities – and constraints – and incorporate them in the design process.

With respect to design research, we suggest that:

- Design research includes a design process based on mutual learning and on the collective reflection-in-action of multiple actors – including the users' of the envisioned design artefacts.

- The improvisational change approach with its notions of emergent and opportunity-based change seems to be applicable beyond configuration of information systems for use in an organizational context.

- Sustained participatory design with its focus on iterative real-life evaluation may be applicable to a variety of large, experimental, and practice-oriented design projects.

As a contribution to a general core of design research we propose our model for sustained participatory design as an inspiration for a general experimental and iterative approach to design.

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