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Original Research

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Abstract

The user role in the design of information systems is increasingly portrayed as active and complex, and the relationships between users and developers are portrayed as blurry. Information systems have become ubiquitous in most work processes, and users typically rely on several large scale information systems tightly integrated into other information systems, machines and work practices. In this paper we propose the notion of generativity as a framework to assess generative socio-technical characteristics of such systems, conceptualized as information infrastructures. Further, the paper will discuss the role these characteristics play in users' involvement by exploring the ways in which users can contribute as designers and thereby expand on the conceptual views of users and design processes of generative information infrastructures.

Empirically, this paper presents the evolution of an information system for cooperation between general practice and hospital laboratories, where users in both settings participated in the design process. The system was designed using agile methods, and design and implementation were continuous and iterative co-existing processes. The case showed that a high degree of generativity in the system itself is a necessary condition for users to make changes. However, in an integrated and complex setting the flexibility of the existing and integrated systems will heavily influence the possibility to make changes. The paper also provides an in-depth illustration of how user and designer roles evolve together with circumstances and relationships. However, we argue that this type of evolvement requires dedicating a considerable amount of time and effort to achieve a climate in which such evolvement can take place. Finally, design is more than just the development of technology. It is also the development of work practices in which users' contributions are decisive. Designing work practices alongside the design of the technology has given rise to insights that feed directly into the design process. Acknowledging users' substantial contributions in design processes can aid in refining conceptualizations of users and developers along with bolstering efforts to facilitate appropriate user involvement.

Keywords: Participation, IS development, inter-organizational systems

INTRODUCTION

The importance of user involvement in the design of information systems (IS) has been recognized for decades, and the user concept has been thoroughly analyzed (e.g., Grudin, 1991, Lamb and Kling, 2003). Despite the wealth of literature, the user concept is still criticized for being too narrow (Lamb and Kling, 2003; Millerand and Baker, 2010). For instance, most portrayals of user involvement in design implicitly contain a clear distinction between those who design a system and those who use it. In contrast, a current trend in IS is that of End-User Development (Markus and Mao, 2004) which allows users to tailor software to their own needs, thus implying that users are also developers.

Among the challenges of user involvement is that users today rely increasingly on complex IS that are integrated with other IS, machines and work practices. These socio-technical systems (Mumford, 2006) often involve software and hardware, work practices, organizations, standards and regulations that are integrated and shared. Such systems are often conceptualized as information infrastructures (Hanseth and Monteiro, 1998). This is a new context for IS research (Markus and Mao, 2004), implying that the opportunities users have to design technology or work practice are limited because this involvement might also require changes in integrated systems and work practices of others. Design and user participation in such contexts have not been widely studied, as research on participation has largely been preoccupied with small scale products and projects (Oostveen and van den Besselaar, 2004). This trend has resulted in a call for more research on participation in large-scale projects (Oostveen and van den Besselaar, 2004), particularly when integrating many systems from different practices (Titlestad et al., 2009). A key question here has to do with identifying the users' actual contributions to the design of IS (Bergvall-Kåreborn and Ståhlbrost, 2008).

Research on participation and user-centeredness has traditionally focused on the political aspects of user participation and methods for participation (Beck, 2002; Iivari and Iivari, 2011), while others have focused on the conditions of participation, such as internal resources and conflicts (Bødker, 1996) and motivational factors (Hirchheim, 1989; Johannessen and Gammon, 2010). In this paper we draw attention to the characteristics of the actual system to be designed, and examine how they influence the user role and the users' ability to design. We propose the notion of generativity (Zittrain, 2006) as a framework to assess generative socio-technical characteristics of large integrated systems. The generativity concept denotes how a system leverages work or may be used in unanticipated ways, as well as the possibilities for changing a system. Based on this framework, we discuss the role these characteristics play in users' involvement in changing a system. Using a case study to illustrate, this study aims to: firstly, explore a large-scale integrated IS in terms of flexibility to make changes and flexible use of the system, secondly, explore ways in which users can contribute as designers in large-scale integrated IS, and finally, expand on the conceptualization of users by examining the roles and relations of users and designers in such change processes. Empirically, this paper presents the evolution of an IS for cooperation between general practice and hospital laboratories. The system was designed using agile methods, and development and implementation were continuous iterative processes that occurred parallel to each other. Users both in the hospital and in general practice participated in the development and implementation processes, and were important contributors for the vendor. Based on experiences from this case and the perspectives on users as designers described above, this paper argues that users may act as designers in different ways during the evolution of socio-technical IS. The conditions for this are partly determined by the flexibility of the system to be designed and partly by the measures taken to involve users in work practice design. The paper is further organized in the following way: first, there is a theory section elaborating on generative information infrastructures, design and the user role in design. This is followed by a description of the methods used in this research. Then the case is presented, followed by a discussion of the findings. Finally, the conclusions from the research are presented.

THEORY AND RELATED RESEARCH

This section outlines the theoretical background and former research which has informed the case analysis in this paper. The notion of generativity (Zittrain, 2006), which denotes a system's ability to create change, is used as the overarching concept in this section. First, we will conceptualize healthcare IS as information infrastructures and use the generativity concept to denote the flexibility of such infrastructures. Further, the generativity concept links the systems' flexibility and the changing work practices that have implications for design. The close relation between changing technology and changing work practices also gives rise to new ways of conceptualizing design. Finally, conceptualizing design as changes in both work practices and technology also leads to a new understanding of the user concept and the user role in design processes.

Generative Information Infrastructures

IS for healthcare today are increasingly part of an integrated portfolio of IS supporting many different cross-organizational practices, and thus a heterogeneous array of users. The notion of information infrastructure has been used as a framework for analyzing such large-scale systems. Information infrastructures are heterogeneous networks consisting of a wide range of physical artifacts, information, software, standards and people that are integrated. This implies that information infrastructures are socio-technical systems (Mumford, 2006). Star and Ruhleder (1995, p.68) underscore how an information infrastructure shapes and is shaped by work practices, and also how the tension between local, customized, intimate and flexible use on the one hand, and the need for standards and continuity on the other hand shapes the infrastructure: "An infrastructure occurs when the tension between local and global is resolved." Hence, an infrastructure exists when local practices are enabled by larger scale technology. Information infrastructures are always in the process of design and have an evolving nature: "the emergence of the infrastructure...is thus an "organic" one, evolving in response to the community evolution and adoption of infrastructure as natural, involving new forms and conventions that we cannot yet imagine" (Star and Ruhleder, 1995, p.132). The verb 'to infrastructure' (Star and Bowker, 2002) denotes the activities and processes of integrating materials, tools, methods and practices that make up and change an infrastructure. These processes are incremental, iterative and long term (Karasti et al., 2010). Infrastructuring implies that processes or components will be changed or added to the infrastructure continuously. This also implies that information infrastructures will never evolve from scratch and new components or changes will always have to be integrated into existing systems or work practices, which are known as the installed base (Hanseth and Braa, 2000). The installed base is conservative due to rigid work practices, technological lock-ins and economy of scale on the demand side (i.e. the number of users) (Hanseth and Lyytinen, 2004). New parts will struggle and inherit strengths and limitations from this installed base (Star and Ruhleder, 1995), which implies that new features have to fit the existing portfolio of IS, old practices and users, and also means that these factors will influence how new parts can evolve.

To allow for such evolution, Hanseth and Lyytinen (2004) suggest technological solutions to avoid lock-ins, while Star and Bowker (2002) argue that infrastructuring requires a modifiable infrastructure on an individual and social level. These arguments indicate that there are both technical and social aspects determining the possibility of making changes to an information infrastructure. The concept of generativity, as coined by Zittrain (2006) and used to describe the Internet, also seems promising for information infrastructures, offering a framework for assessing both technical and social aspects related to the opportunity for flexibility. The term generativity can generally be understood as the ability or power to create something. In a pure technological context it has been used to describe the automatic generation of code (Czarnecki and Eisenecker, 1999) and also to describe how information technology has the power to enable changes in work practices (Berg, 1999). Zittrain (2006) has taken the concept further by giving it a wider socio-technical definition in which the ability to create something in a system depends on both technical design and social behavior and the degree of generativity characterizes a technology's capacity to produce unanticipated change. According to Zittrain, five factors will, to a varying degree, be present in a generative system:

- How the system leverages possible tasks by making them easier; the more the system can do, the more change it may produce.
- How the system can be adapted to a range of tasks that were not anticipated at the time of development.
- How easily new contributors or audiences can master both adoption and adaption.
- How accessible it is to those able to build on it in terms of barriers, etc.
- To what extent any changes can be transferred to other users (Zittrain, 2006).

As Zittrain points out, however, it is not an aim in itself to make the technology as generative as possible in all cases; rather, it is a characteristic of the technology's potential to generate new patterns of use and thus further innovations. For an information infrastructure, a certain degree of generativity could promote local practices.

Conceptualizing Design of Information Infrastructures

Generativity, as defined by Zittrain (2006), includes both use and change aspects and points to the close link between the opportunity to change a technology and the work to be performed and changed. Recognizing the close link between technology and work practice should also influence the way researchers talk about the design of information infrastructures. Design can be understood as any motivated, transformational activity that is performed. However, the traditional interpretation of what should be designed tends to focus only on the artifact (Pipek and Wolf, 2009). According to Pipek and Wolf (2009), the distinction between the design of the artifact and its surroundings (i.e., the use of the artifact) is one of the core problems of IS design. However, such ideas are not new and the inclusion of work practices in design has been a research topic for a long time. The concept of work-oriented design denotes a setting in which researchers study work practices and represent these processes in such a way that developers can create products that fit with the users' needs (Blomberg et al., 1996). Although this concept depicts work practices as being important for the design, we still think it represents a way of viewing work practices as something stable into which the technology should fit nicely. We argue that this represents an artificial separation between technology and

work practices, and we want to address the inclusion of work practice design (Pentland and Feldman, 2008) in the conceptualization of IS design. This would lead to a view of technology design and the design of work practices as inseparable. Orlikowski (1995, p.2) coined the term 'technologies-in-use' to refer to the concept of: "situated and patterned interactions of technological artifact and human action." With this concept, Orlikowski suggests that actors develop knowledge and understanding about the artifact itself as well as its potential use from the use situation. This knowledge of how the technology affects and is affected by the work practice must also be reflected in the development processes: "the substance of development is expanded to include social and organizational concerns" (Hirschheim, 1989, p.196).

Changing a generative system in new and unexpected ways requires that the users appropriate, or take possession of, the technology. Appropriation is not restricted to the users' technical interactions with artifacts, but includes complex cultural dynamics including social, cultural and economic aspects (Oudshoorn and Pinch, 2003). When appropriating the technology, they will reshape its features and use it in unanticipated ways, and also shape their own practices according to the technology. In this way, the users can be said to finish the design process through their appropriation of a technology (Carroll, 2004). The Technology Appropriation Cycle suggests that design is the combination of two processes: the design process that is completed during appropriation, and the appropriation process that is the basis of design. In this way, Carroll draws attention to the way in which technologies should be redesigned based on experiences from the technology in use, and how these two processes of use and redesign should continue.

While Carroll suggests an iterative process, Suchman (2002, p.142) goes even further by arguing that design phases should not be discrete, but: "complex, densely structured courses of articulation work, without clearly distinguishable boundaries between them." By blurring the boundaries between use and design, the users' perspectives on use, training and design can be taken into account; this allows for the continued development of the core activities while the technology development takes place (Karasti and Syrjänen, 2004). The blurring of these boundaries and the suggestion that an information infrastructure is always in the process of design (Star and Ruhleder, 1995) implies that it is proper to abolish the design-redesign distinction.

The Blurry User Concept in IS Research

Zittrain's (2006) definition of generativity also directs attention toward those using and building (on) the technology. Lately, we have seen a wide range of design processes in which end users play a major role as user-designers, act as actual developers, or take responsibility for design activities within their everyday settings. Examples are Lay Participatory Design (Syrjänen, 2007) which depicts non-IT-professional user-designers that develop IT systems through their field of practice, and End User Development which is a set of methods, techniques, and tools that allow users to act as non-professional developers to create, modify or extend a software artifact (Lieberman et al., 2006). Still, the traditional dichotomy prevails in that users and designers are depicted as two different groups, where designers develop systems and users provide input to this process, thereby giving the developer the most prominent role in the design process (Pipek and Wolf, 2009). This view has been evident in, for example, several public procurement and design projects within Norwegian healthcare (Norwegian Directorate of Health, 2004). The traditional roles attributed to users in design have been based on functional roles or interest groups (Lamb and Kling, 2003), and include end-users, super users, and user managers, although it is well recognized that one actor may assume several roles at the same time (Millerand and Baker, 2010). Along the same lines, developer roles are usually assumed to be those belonging to a development team (Grudin, 1991).

In contrast to such distinctions are those focusing on infrastructuring and arguments for new user-designer concepts that have less distinct boundaries. Mackay et al. (2000) criticize some of the existing research, claiming that it fails to explain the complexity of relationships in the design process. They view the boundary between users and developers as being fuzzy, with users and developers having equal influence on each other. They argue that design is not a one-way process and that the boundary between designers and users is fluid, negotiated, constructed, managed and configured. Millerand and Baker (2010) extend this view by defining design processes as a web of users and designers in which the roles tend to evolve and the users do tasks traditionally assigned to developers. The authors describe this web as a dynamic ensemble of interrelations between users and developers, and emphasize the fluidity of such webs: "Users and developers are not stable entities; they tend to adopt multiple roles that are constantly evolving throughout information system development processes" (p.23). Consequently, the relations or roles among the developers and users develop over time, become a result of the design process and depend on the context in which they are performed: "entities achieve their forms as a consequence of the relations in which they are located …, they are performed in, by and through those relations" (Law, 2003, p. 2).

Building on these theoretical premises, this study seeks to explore generative socio-technical characteristics of an integrated IS, and thereby expand upon the conceptual views of design processes and the role of users in these processes.

METHODS

The case that is described and discussed in this paper involves the design of a system for electronic orders of laboratory analyses and referrals. Fieldwork was mainly carried out in the ICT-vendor DIPS, the University Hospital of North Norway, the University Hospital of Akershus and the Sentrum general practice in Tromsø.

The study adheres to an interpretive research approach (Klein and Myers, 1999; Walsham, 1995) which aims to understand why the people involved, in this case users and developers, enact their realities and thereby act the way they do (Orlikowski and Baroudi, 2002). It also assumes that social reality cannot be discovered; only interpreted. The approach does not attempt to predefine variables, but emphasizes context and seeks to find meaning in actions (Schwandt, 2003).

Empirical data were primarily collected through participant observation and interviews from December 2007 to December 2009. The first author is employed by the vendor DIPS in an effort to integrate research and industry. During the study, her desk was within the work area of the development team, which allowed her to follow the work of the developers closely on a daily basis during these two years. She also participated in the development team by performing miscellaneous work on a part time basis. This afforded her the opportunity to participate in informal discussions, as well as internal and external meetings which facilitated awareness of emerging situations and issues. These meetings included information sessions with general practitioners (GPs) and secretaries, project group meetings, training sessions, meetings and workshops between the user groups and developers, meetings with other vendors and internal meetings in the development team. The meetings involved a broad range of professions: ICT consultants, administrative personnel, physicians, GPs, laboratory technologists, marketing personnel and developers. The first author was also granted access to internal meetings, guided tours and observation of work processes in the laboratories. Notes were taken during these observations and subsequently refined and organized. Questions and analytical points were added ex post.

In addition to the meetings, we were particularly interested in the history of the project from the time before the authors became involved, and the reflections and ideas of some of the key people involved in the process. We therefore conducted eleven in-depth, semi-structured interviews with members of the development team, as well as users in the hospitals and in general practice. The interviews lasted from 30 to 70 minutes. Six were with laboratory technologists, one with a manager of a collaborating vendor, three with designers in DIPS (twice with the same person) and one with the person responsible for the electronic laboratory order product in DIPS.

The data analysis was based on a hermeneutic approach in which a complex whole is understood ''from preconceptions about the meanings of its parts and their interrelationships'' (Klein and Myers, 1999, p.71). The approach is based on the hermeneutic circle, which underscores the interdependability between the issue to be interpreted, preconceptions and context. The interpretation process is an iterative process switching between a whole and its parts, between the issues to be interpreted and the context, and between the issues to be interpreted and our own preconceptions. This implies that the different sources of field data are all taken into consideration in the interpretation process. The method includes relatively detailed case write-ups for the sites involved (see for instance Eisenhardt, 1989), followed by an examination of the data for potential analytical themes. The analysis has been a process back and forth between fieldwork, case description and use of related literature to gain new theoretical insight. This has provided new understanding and has in turn spurred further data collection. This iterative process continued until we had a rich description of events, meaning and action involved in the development process. The findings have been discussed with the other authors, who have thorough knowledge of the field from studies of innovation and IS in healthcare.

For a period after the formal data collection, the first author deputized for the product owner of the electronic laboratory order product; this experience gave her a thorough knowledge of the product, as well as the opportunity to get to know the users portrayed in this case from another position. Although this was after the formal data collection period, it might have influenced the interpretation of the case presented in this paper.

INITIATION AND STATUS OF A SYSTEM FOR ELECTRONIC

LABORATORY ORDERS

This section will briefly describe the background for the design process, outline the resulting product and provide an update on implementation.

Initiation

The University Hospital of North Norway (UNN) is the largest hospital in Northern Norway, with approximately 5,000 employees and 600 beds. The hospital has seven laboratories conducting approximately three million analyses a year, from general practitioners (GPs) and from internal orders. In 2006, the UNN and the ICT vendor DIPS established a project aimed at designing a system for electronic laboratory orders between general practices and the laboratories. DIPS is the largest Norwegian vendor of hospital electronic patient record systems (EPR) and systems for communication and interaction in healthcare, with approximately 150 employees.

For years, UNN had experienced high error rates and a lack of information in the paper orders sent from general practice to the hospital laboratories. Further, paper orders required the manual entry of information from the orders into the laboratory IS. Figure 1 shows the paper based ordering process. UNN viewed an electronic system as a way to ensure quality in the reception of orders and samples. DIPS envisioned a generic system for ordering processes with the potential to gain a large share of the market. The system resulting from the project was called Interactor, and it was taken further by DIPS as a commercial product after the project phase ended. Interactor was designed within a close cooperation between users in general practice, users in the hospital and DIPS. The design progressed incrementally, starting with a small user group consisting of one laboratory system and one EPR to integrate and then expanded in an evolutionary way. University Hospital of Akershus (AHUS), one of the largest hospitals in the Southeastern part of Norway, had a tender competition for electronic orders. DIPS won the contract and gained the first real customer for the product. At this time, the Interactor system had not been completed yet, and thus AHUS became part of the design process along with the existing users.
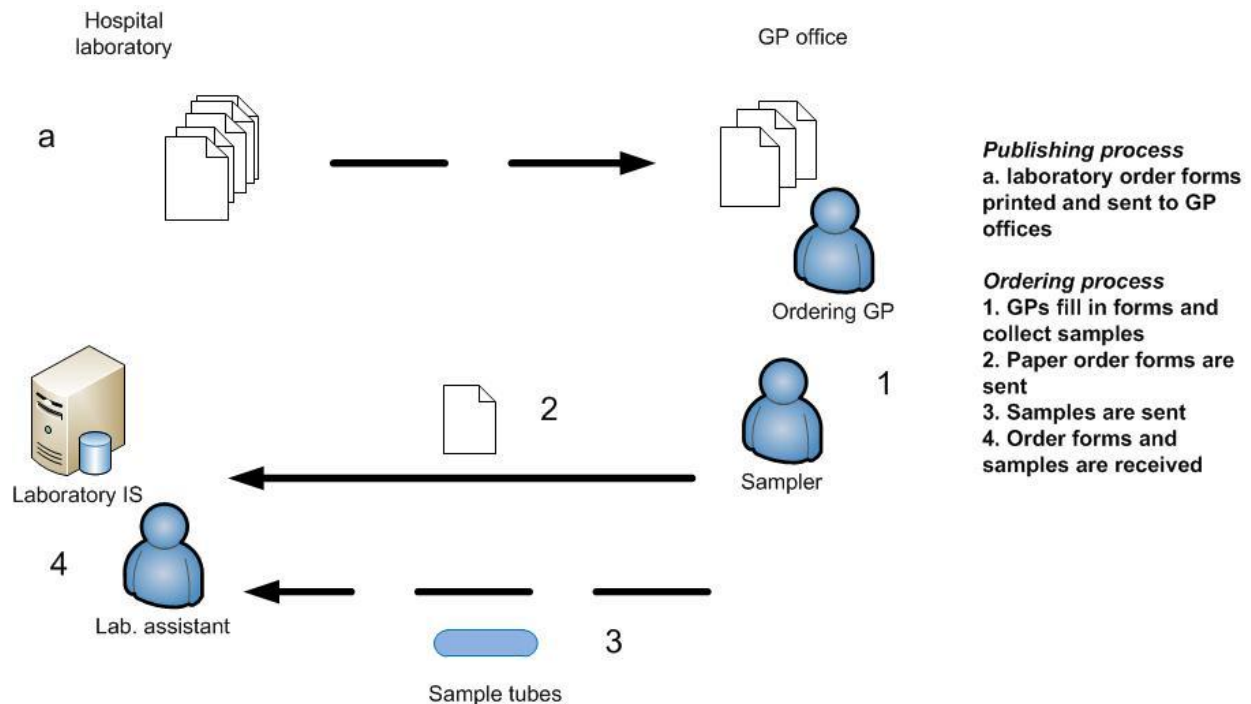

Figure 1: Paper Based Laboratory Ordering Process

Description of the Interactor System

The main architectural decisions were made by the developers early in the process, while the details evolved as a result of the cooperation between users, other vendors and DIPS. Interactor is modularized and made up of three components: Publisher and SiteServer installed in the hospital, and SmartClient installed in general practices. A fundamental idea for its architecture was to utilize the maximum amount of existing infrastructure while integrating Interactor into these systems as tightly as possible. The system therefore uses the national healthcare network for sending orders and adheres to the national standards specifying the content of order messages. Presentations of the repertoire of analyses the GP can order are made in the Publisher component. Every time changes are made to the presentations they are uploaded to the national healthcare network, and the SmartClients at the GPs are set up to automatically download the updated analysis repertoires. New versions of the Interactor software are downloaded in the same way, updating all users with the newest versions automatically. The SmartClient is fully integrated with the GPs' EPR, and the GPs can choose and order laboratory services or make referrals directly from this system.

Interactor creates labels with bar codes to be stuck onto the sample tubes, which are sent using regular mail or a delivery service to the hospital laboratory. Here, the bar code is scanned and information from the order is transferred directly into the laboratory IS. Figure 2 shows the information and material flow of the Interactor system. The interactive referral service uses the same technology and allows the hospital to present further information about a diagnosis or medical problem to the GP before the referral is made. It also allows the hospital to specify questions they want the GP to answer as part of the referral.
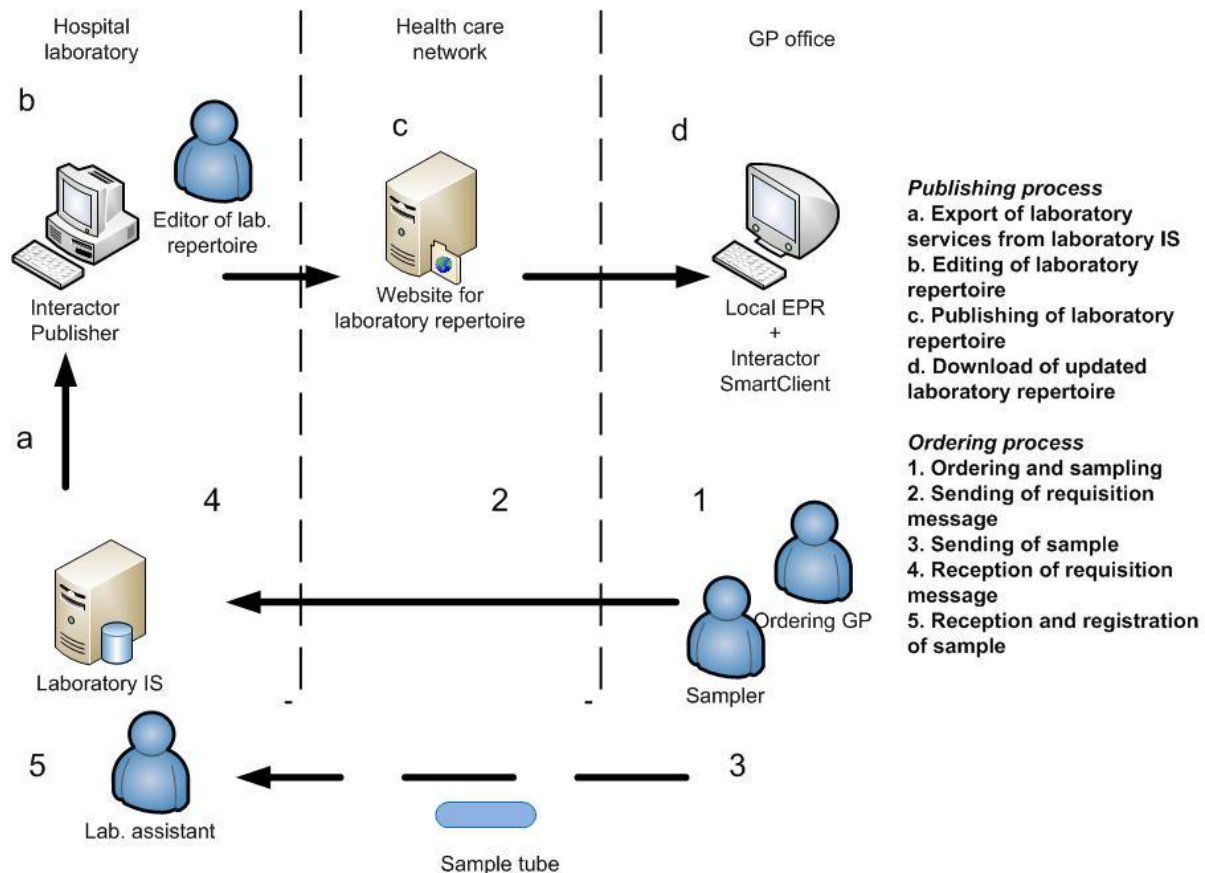

Figure 2: The Interactor System for Laboratory Ordering

Status of Implementation

The electronic order project was completed within two years and the system became a commercial product. The users have mostly been satisfied; some GPs found that it made their work practice more effective, while others did not. AHUS reported that the process of receiving orders in the laboratory was more effective. While UNN has had significantly fewer errors, they have not seen the same increased efficiency as AHUS. Finally, the editing tool used to create presentations of laboratory services reportedly simplified the work of the editors. The system maintains a good reputation, and more hospitals are ordering it; presently nine hospitals and approximately 60 GP offices are using Interactor. The referral part of the system is used by six GPs offices in AHUS' catchment area, and is also soon to be implemented into general practices in UNN's catchment area. Further sales and implementations have been stopped because of prolonged procurement processes initiated by the regional healthcare authorities.

DESIGN PROCESS

The next sub-sections elaborate on the design process and the contribution of users and developers to this process. The conditions for doing design work varied for different parts of the system. To show this variation, the description is divided into two parts; the overall system, which is the total electronic order and referral system, and the design of the analysis repertoire and tool for making the presentation of the repertoire. The design work described includes both changes in users' work practices as well as changes in the technology. These are presented in separate sub-sections, but in fact these processes were intertwined and proceeded iteratively. But first, this section presents a description of the groups of people involved in the design process and the design methodology.

The User Groups Involved

When the design process began, a project group consisting of administrative personnel and managers from UNN and the vendor, and an advisory reference group composed of members from general practice and UNN were established. At UNN, there was also an internal group in the laboratories organizing implementation and doing testing. This group continued after the project phase ended.

The end-users of the electronic ordering system were laboratory technologists and physicians in the hospitals and GPs, local laboratory personnel and secretaries in general practice. In this paper, we use the term user for those representatives of the end-users who were actually taking part in the design process. At UNN, the users in the internal group within the laboratories, consisting of laboratory technologists and computer support personnel, were the first users to be part of the design process. In addition to working with the electronic orders, this group also worked with other related changes such as the implementation of a laboratory IS in the microbiology laboratory and a new unit for receiving and further distributing incoming sample tubes. This group carried out planning, testing and implementation, organized training, made presentations of the analysis repertoire, and stayed in contact with and provided feedback to the vendor. This group was highly motivated because they had been wishing for electronic orders for years. The users participating in the design of the interactive referral part of Interactor were surgeons from AHUS and UNN.

Among general practices, the Sentrum general practice was the first to be included in the initial test implementation, and the only GP office to test implement the microbiology part of the system later in the process. The Sentrum general practice had six GPs and five secretaries. One physician and one secretary were particularly interested in information technology and had the necessary commitment; hence, they were the driving forces at the office in this process. Because the hospitals were Interactor's paying customers, participation from general practice was voluntary and based on the expectation of an improved service. AHUS ran their own test implementation with a few general practices involving a small group of laboratory technologists with a special responsibility for ICT, and a person in the laboratory department responsible for all contact with ordering GPs. The contact person knew the general practices in her area very well, and she was responsible for training staff, and spent a day at every GP's office on their first day of system use. End-users in the general practices called her with questions to report bugs, or to give suggestions, and she would forward this feedback to the vendor.

The persons named as developers in this paper were employed by the vendor and belonged to the development team of Interactor. This group consisted of five programmers and the vendor's chief designer.

Development Methodology and Implementation Strategy

DIPS had previously chosen to employ agile development methods (Beck, 2000) throughout the company as a reaction to their bad experience with the traditional waterfall model. In contrast to waterfall methods, they view agile methods as being less bureaucratic and slow without the pre-planned process of requirements for capturing, analyzing and designing. When DIPS started to build a system for electronic ordering from scratch they had some ideas for the technological concept, but the developers did not know the work practice of the users well enough to be able to design the system on their own. The vendor viewed the close relations between developers and customers that pervade agile methodology as a way to make up for the lack of knowledge about the users' work practices. Through the early and continuous delivery of valuable software, they wanted to get timely feedback from real life use and therefore presented and implemented a simple but working system to the users four months into the project:

> *"We kept the initial discussions as short as we dared. We took a chance delivering functionality early, and let the pilot general practices [the users] shape the solution together with the laboratories. ..When the users start using it they will see how this fits their daily work, and they will correct us and give feedback on how it should be." - Developer*

One of the laboratory technologists argued along similar lines: "...we have to see it in use to see what the problem really is, or what has to be improved... If you have to finish the development before we start using it, we will never get started." The developers at DIPS worked in short but complete development cycles lasting two to four weeks, each including the formulation of user stories, estimation of workload, and programming, testing and release of new versions.

User stories, which are two to three line notes describing new functionality, changes to be made or failures to be fixed, were the basis for all development. The development team maintained a long list of user stories, which was continually updated with descriptions, estimations of workload, and prioritization of the user stories. New development always started with the user stories of the highest priority. The user stories were written by the developers themselves, or the product owner, who is the person in the company responsible for the particular product in question. Even so, a new user story would typically be initiated to provide feedback or communicate direct requests from the users, and the prioritization was decided based on how urgent the user story was for the users.

Four general practices in UNN's catchment area implemented the system from the beginning, sending approximately 1,000 electronic orders per month. The vendor wanted to start integrating one system at a time; therefore the clinical biochemistry laboratory and three smaller laboratories with the same IS were included in the first implementation. After approximately one year, more general practices started to use the system and it was gradually perceived as being in regular use. AHUS, and the general practices in AHUS' catchment area, began to use the system after the first implementations at UNN were acknowledged as being successful. AHUS was using a different laboratory IS than UNN, so this implementation required the integration of a new laboratory IS. After clinical biochemistry had implemented the system successfully, Interactor was expanded to microbiology analyses. Hence, there was a need for a new test implementation phase which included the microbiology laboratory at UNN and this time only the Sentrum general practice.

The implementation of referrals at AHUS started out small, including six general practices with guidelines for eleven medical problems, while UNN had chosen to install the system at all 24 general practices in Troms County and urged all GPs to use the system from the beginning.

Designing the Interactor system

This section provides a detailed description of the process of designing the total Interactor system, with the exception of the analysis repertoire and the tool for presenting the repertoire, which will be described in the next section. In addition, the related work processes, both new work practices due to the implementation of the new technology and routines temporarily established for testing or back-up will be described.

Designing New Routines and Work Practices in The Laboratories

Parallel to the existing work routines, the laboratories had to set up completely new work practices related to handling electronic orders when receiving sample tubes and in the process of conducting analyses. Although the electronic orders accounted for a small percentage of orders, all personnel could potentially be in touch with the electronic orders, and therefore had to be trained in handling them. One example of designing new work practices occurred in the microbiology laboratory, which initially had no electronic laboratory IS and instead, logistics had been based on physical paper artifacts. Before the introduction of Interactor, every sample had come with a piece of paper; thus the laboratory personnel would make lines of sample tubes that corresponded to piles of paper orders. They would then sort samples and paper, for example, according to time of follow up or different treatments. Before the implementation of the system for electronic orders, a laboratory IS had to be implemented and completely new routines had to be established for all work practices connected to logistics in this laboratory. With the new electronic work process, the visual workflow disappeared. The computer gave users the opportunity to make many kinds of lists and allowed for many kinds of searches, but it lacked the visibility that the paper pile and notes had provided. Thus, to make up for this, the users needed to devise new routines for controlling work lists in the laboratory IS, and for checking up on samples.

The process of handling received sample tubes is another example of a new work practice that subsequently required changes in other routines as well. All samples had previously been sent from general practice directly to the different laboratories in the hospital, while electronic orders were all received in a shared receiving unit. Barcodes were now scanned to register the samples, and handling instructions were automatically sent to the appropriate laboratories. Although this new work process appears simple enough, it created challenges. One problem occurred because GPs could order analyses from more than one laboratory in a single order, but the receiving unit was supposed to distribute samples to the appropriate laboratories. Therefore, a quick look at a sample tube often resulted in sending the sample to only one of the necessary laboratories. This was problematic because the other laboratories indicated in the order received an electronic order but not the physical sample. Previously, all logistics had been organized around the physical sample and paper order, and receiving one without the other was very noticeable. In the new system, being able to discover that a sample was missing called for yet another new routine in the laboratory: "We do have lists [in the laboratory information system] and we can search for missing samples, but then again people in the lab are not very good at checking those lists. They are supposed to be checked every day, but…" - Laboratory technologist. So, the new opportunities that the ordering system and the new work practices provided also incurred the need for new control routines to check that nothing had gone wrong.

Designing New Routines and Work Practices in General Practice

Work processes in general practice also had to be altered because of the introduction of electronic orders. In the cases where the GP would collect the specimen from a patient in the examination room, the GP had to print the label and stick it to the sample tube in addition to sending the order electronically. However, most of the samples were collected in the general practice's laboratory, and here the changes were more comprehensive, requiring new routines for both logistics and patient safety. One example was the routine of calling in patients for the collection of specimens. The former practice of physically handing over orders from the GP to the secretary was replaced by a work list in the EPR. These changes were quite straightforward and the work practices were easily established. A

more complicated and risky process was ensuring that the correct label was stuck to the corresponding sample tube. This potential mistake was viewed as one of the largest risk factors in the entire system for electronic orders, particularly in large general practices where many patients could be in the laboratory at the same time. The general practices' laboratory staff therefore had to develop routines for the printing sequence of barcode labels and for checking to make sure that there was a match. Yet, because the flexibility in the laboratories in general practice was high, due to a small staff and autonomous organization, the necessary changes were accomplished quite easily.

Designing Test Routines and Back-Up Systems

Even though the Interactor system was tested automatically and manually by the developers, the users also established routines for testing in search of system failures and for back-up. They established routines for sending test orders through the entire system, including integrated systems, to test all changes or new features before implementing them in the laboratories. Some of these test routines eventually became part of the regular work practice. For example, UNN required all general practices to send a printed copy along with each sample tube, in addition to the electronic order, as a back-up in case the line of communication between the hospital and general practice failed. The practice of sending a back-up paper copy is still in use, and has become part of the normal work routine. AHUS did not demand the same of the GPs ordering from them, but some GPs lacked sufficient trust in the system and implemented their own local routines involving an extra set of labels adhered to a piece of paper and sent along with the samples. In addition, test routines were established in general practice, for instance, manually checking to be sure that the analysis reports received from the laboratory matched the sent orders. This routine was established at Sentrum and lasted for about a year until they felt that they could trust the system.

Collecting Feedback from Use

The users' experiences with the new work practices and routines were reported to and discussed with the developers, and changes and new functionalities of the system were continuously released. One of the pilot users explained how new requests from the end users came up: "The challenges have been queuing. Every time the system has been installed in a new general practice there has been a new list of requests for changes in the system" - GP's contact person at AHUS. Other requests came after more organized feedback sessions. The staff at Sentrum used weekly internal meetings to collect feedback and to solve problems. On some occasions, the developers visited the users and tried to perform the users' jobs to gain a sense of how the system worked in its real setting and to become better equipped to discuss changes. A workshop with users from different hospitals and general practices and developers was arranged. The result of this meeting was a list of changes that the users agreed upon, ranging from small details like the moving of a button and the design of the bar code labels, to larger changes like new fields of use. Although everything on the list was not changed immediately, it served as a roadmap for changes in the system for a long time.

Making Changes to Interactor

One example of a request from the users was changing the method of recording the time of sample collection. In the first versions, the system was set to automatically record the time when the label was printed, because it was assumed that it would be printed when the sample was collected in the general practice's laboratory. Yet, after using the system for a while, users realized that for various reasons they occasionally needed to print a label at a different time than collecting the sample. This caused a change in the system that made it possible to manually change the recorded time whenever it differed from the collection time.

Another emerging need was the ability to specify in each order what parties other than the GP should receive the analysis report. This functionality was added in the Interactor window, allowing users to manually type the name and address of the person to receive a report copy. This was only partially satisfactory for the users; they wanted the option of searching and linking to a national register of physicians' e-mail addresses. However, such a register did not yet exist.

A third example of a change in Interactor was that the users experienced a need for the laboratory staff and secretaries in general practices to be able to make or alter orders on behalf of a GP. This required only small changes in the Interactor system, but large changes in the GPs' EPR. This was immediately accomplished by the integrated EPR, because the vendor of this system viewed this as an important feature that would benefit a great number of their end users.

These three examples illustrate how requirements from users resulted in changes made in Interactor. Figure 3 shows the resulting user interface for the GPs.
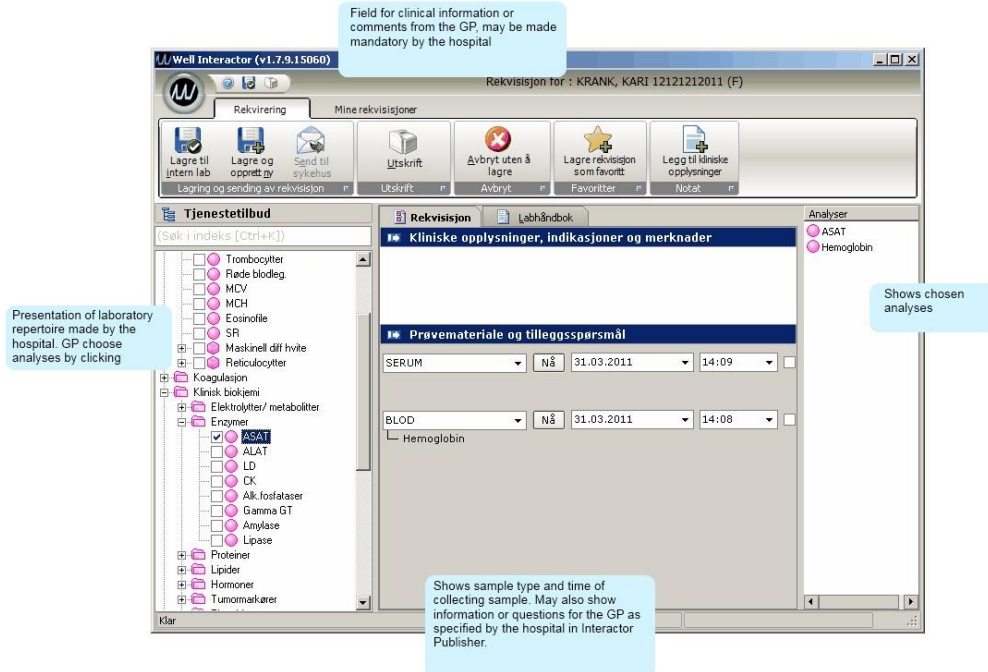
Figure 3: The GPs User Interface

Expansion to Referrals

When UNN and AHUS envisioned that Interactor could be used for referrals, the vendor decided to expand accordingly. This was the largest single add-on to the laboratory ordering system. The idea was the same; make a list of diagnoses or medical problems that the GPs could choose from, and for each diagnose; add information or questions for the GPs. For Interactor, this implied using a different national standard and a different integration with the EPR because there was already a referral function in the EPR to which Interactor could add. The solution became to establish an even tighter integration with the EPR than with the electronic laboratory orders, and the Interactor window became part of the EPR window for referrals. Figure 4 shows this integration, with the Interactor part of the window marked with a red frame. The extension to referrals required small changes in the system for electronic orders, while the changes in the integrated EPR were considerable.
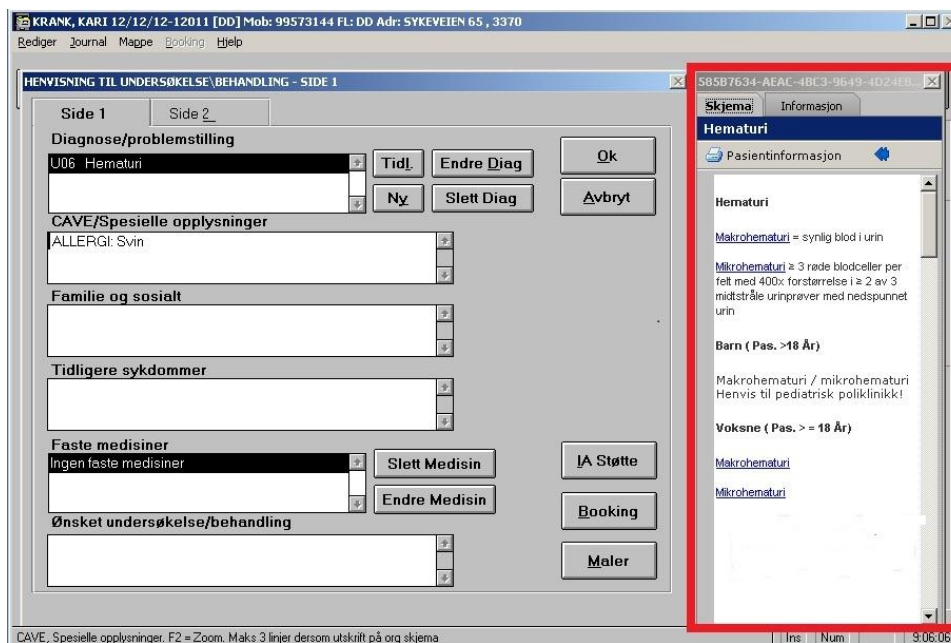
Figure 4: The Integration of the EPR's Referral Window and Interactor

Difficulties in Making Changes in the Integrated IS

Although expanded referrals and the inclusion of secretaries in the ordering process invoked large changes in the integrated EPR and in Interactor itself, these processes went quite smoothly. However, other user requirements were not easily accomplished in the integrated systems. The basic idea for the design of Interactor had been to use the EPR as much as possible, so that when users needed to start a laboratory order process they would create an order file containing all necessary information about the patient in the EPR. In Interactor, the order file was made ready for the GP to choose laboratory orders and add information when needed. The order file was then saved, traced and finally sent by the EPR using the e-mail based communication lines. This tight integration was challenging. For example, the identification number of the ordering GP, which was registered in the EPR, could not be exported to Interactor. This number was needed by the laboratory IS, and its absence caused extra manual work for the receiving unit in the hospital. It was possible to manually insert the number into the order, but this was a cumbersome process subject to error and was seldom completed by new GPs. Thus, electronic orders were often sent to the laboratory without this number. The EPR's vendor has yet to prioritize this automatic transfer into Interactor.

The development of microbiology orders can also illustrate challenges related to integrated systems. The laboratory IS' logistics functionalities had problems handling the electronic orders and, despite promises from the vendor, the necessary changes were not immediately implemented: "Our laboratory information system has not been able to handle these things, and it has taken a very long time to get those changes. We have waited and waited…" - Laboratory technologist. Microbiology orders required changes in the GPs' EPR as well, but were not immediately prioritized by these vendors either: "We have reported the errors of the incoming laboratory reports…and they tried to fix it, but now we have not heard any more [about it]" - Secretary. The users regarded these deficiencies in the integrated systems related to microbiology as being so severe that the deployment of the microbiology orders to general practices other than Sentrum was postponed.

These examples show that the changes required in the integrated systems were all quite large and difficult to achieve.

Design of the Hospitals' Analysis Repertoire

The repertoire of analyses offered by the hospitals and how it was presented to the GPs has been one of the key issues in the design process of Interactor. While seemingly simple at first glance, it proved to be rather complicated. Hospitals offer several hundred analyses from which GPs have to choose, and since there is no standardized terminology in Norway, the same analysis may be labeled differently by different laboratories. This led to an almost impossible situation for GPs, who repeatedly had to browse through all of the analyses to decipher which were appropriate. One solution to this was to make it possible for GPs to make their own 'favorites,' which could be single analyses or combinations of several analyses. However, this solution was not enough, and finding a good way to organize and present this repertoire of analyses was therefore crucial in the design process.

Negotiations between the Users in Hospitals and in General Practices

The presentation of the analysis repertoire was developed by the users in the hospital laboratories. Differences in analysis techniques called for different ways of handling the various specimens, and information about the handling requirements had to be included in the presentation of the analysis repertoire. Adding to this complexity, the information needs differed depending on the type of analysis ordered. While some analyses did not require much information from the GP placing the order, others, like the microbiology analyses, required comprehensive information. There were infinite possible ways to organize this presentation, and there was also the danger of overloading it with information and questions. Because of the great influence the presentations had on the GPs' work practice, the users in the laboratories struggled to make them as intuitive as possible for the GPs; it became apparent that they would need to collaborate with the GPs in the design process. The users in the laboratories discovered, however, that GPs were not a homogeneous group in articulating their preferences; some wanted an alphabetical list while others wanted the information organized according to clinical problems. The different presentations were tested out in general practice through many iterative steps. The first attempts by UNN were not successful from the perspective of the GPs, and a secretary in one of the general practices felt that she had to take action: "In the testing of microbiology, we had to call for a meeting because we were so displeased with the presentation they had made. [...] Everybody came from the microbiology laboratory and all our physicians. And everyone got to state their opinion and we kind of cleared the air" - Secretary. During these processes, close relationships developed between the users in general practices and the laboratories. This was partly due to the formal meetings, and partly because the users in the laboratories conducted the actual installation and training at new general practices. This made it easier for the users in the laboratories to obtain feedback from a larger number of general practices: "Now we are out in the general practices, and we can talk to them. That way we can find out what they want. I think that is the best way of doing it... It will be exciting to get more feedback from them [the new general practices]" - Laboratory technologist.

Although there were good relationships between the two user groups, there were constant struggles between them as well. For instance, the new system allowed laboratories the option of requesting particular clinical information before the GP could complete and send the order. This was certainly tempting for the laboratories, and it gave them power that they lacked with the former paper based order. On the other hand, the users in the laboratories knew that if they put too many restrictions or extra work on the GPs, they would simply reject the solution and discontinue its use. Together they had to negotiate a balance. These examples have shown how the integration of laboratory and GP work practices required changes in both, and that this integration required substantial amounts of work and negotiations from both groups.

Designing a Publishing Tool

At the start, the presentation of the analysis repertoire was made by the users in the hospitals as a simple Excel spreadsheet file, converted by the developers into the required format, and finally downloaded to general practice. Every time a new analysis was added or other changes were made, the users sent these changes to the developers, who made the update to the presentation. When the microbiology laboratory and new hospitals implemented the system, the need to simplify this editing arose. Thus, an End-User Development tool, the Publisher, was developed to allow the users in the hospital to formulate and edit the analysis repertoire and create the final presentation for the GPs.

The Publisher component was designed from scratch and the users were heavily involved in the design process. They had clear ideas about how it should function: "It had to be visually simple. We make a lot of changes, for instance, add new analyses, and that has to be very easy to do. And we have to adjust where we place the analyses. The way it looks " - Laboratory technologist. The Publisher was put into immediate use, and many different suggestions for making it more user friendly arose; for example, the addition of special buttons for grouping analyses and using the right mouse button for frequently used functions. Another example was the need to design a specific function to keep track of changes and allow users to overrule changes made in the laboratory IS. The reason for this was that the analysis repertoire was exported from the laboratory IS, and frequent changes in these systems necessitated new exports and presentation updates. The vendor employed a developer who worked exclusively on this component, thereby making it easy and quick to implement changes based on feedback from the users: "I felt that everything went very fast when we had things that we wanted improved. At least most of the time. It depended on how easily it could be changed" - Laboratory technologist. A screenshot of the resulting product is shown in Figure 5.

Making the presentation of analyses required substantial changes in the laboratory work practices. However, this part of the work process was easily accomplished due to very loose integration with the rest of the work processes in the laboratory and the laboratory IS.
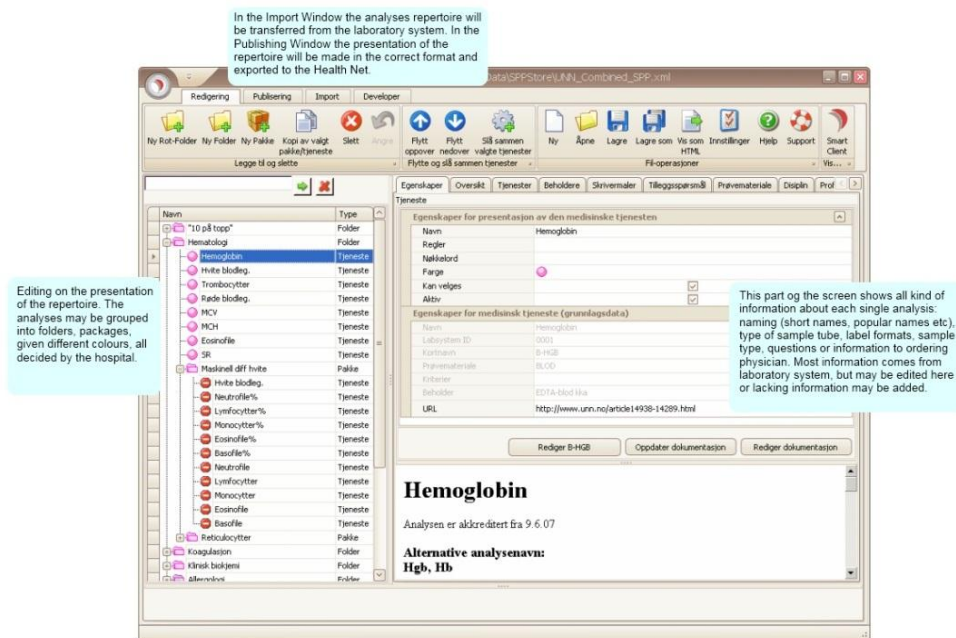

Figure 5: The Resulting Editing Tool for the Laboratory

DISCUSSION

The current study seeks to offer a framework to assess generative characteristics of large socio-technical integrated systems, and examine how these characteristics play a role in users' involvement in changing the system. Using our case as a basis, we will discuss the generativity (Zittrain, 2006) of both a large-scale IS as and the integrated systems. We will then discuss how users acted as designers of parts of this large-scale integrated IS and how various distinctions and relationships between users and developers evolved.

The Generativity of an Information Infrastructure - A Condition for Making Changes

In this section, we draw attention to the generative aspects of the system itself, and the way it was integrated with the existing infrastructural portfolio (the installed base) to allow infrastructuring to take place. We have described the design process of Interactor, and how it evolved from a small and simple solution to a more complex system. Yet the case also demonstrates that the design of the Publisher component, which was loosely integrated with the installed base, was quite straightforward, while the design of the more tightly integrated parts of Interactor was often more difficult and time consuming.

From an information infrastructural perspective, the role of the installed base, consisting of existing technical components, organizations and work practices, is crucial. The installed base may both hamper and facilitate design. In this regard, Hanseth and Lyytinen (2004) have suggested always building on the installed base when growing an information infrastructure. We certainly agree that this is the only way to develop an information infrastructure. On the other hand, it should be remembered that when the new component is built upon the installed base, it inherits the installed base's flexibility or lack thereof. Although the installed base might be perceived as being irreversible, this does not mean that it cannot be changed; rather, that it has to be changed gradually through cultivation of the installed base (Hanseth and Monteiro, 1998). The more tightly the technical system is integrated with work practices, routines and other systems (i.e., the installed base), the more the generativity of the installed base will determine the ability of the users and developers to design something new (Andersen and Aanestad, 2008). In such systems, generativity in only one part is not enough; one should think of the entire system as an ecosystem of generativity (Grimmelmann and Ohm, 2010). This implies that the opportunities users have to design their own components of an IS using, for instance, tools for End-User Development, like the Publisher, will only influence the parts of their work practice that have limited dependence on integrated systems and work practices of others.

Based on Zittrain's (2006) definition of generativity, Table 1 offers a comparison of the generativity of Interactor's Publisher component and the complete Interactor system in relation to the existing infrastructure (the installed based).

The single component Publisher that is loosely coupled with the installed base can be characterized as highly generative. It has been shown to leverage the work of the users in the hospital, and it is easy to learn and use. It has a high level of adaptability to both changes in work practices and to other systems, and such changes can easily be shared and made immediately available to the users. The Interactor system can be characterized as partially generative. In particular, the extension to referrals demonstrated that the system was both adaptable and adoptable for new users. In addition, the Interactor system inherited the generative characteristics from the Publisher component. However, other, more integrated parts of the system proved difficult to change for the users (as well as for the developers). In principal, the Interactor system can easily be adapted to other areas, for instance, pathology orders or other ordering processes, and it can also easily be adapted to other IS, like EPR or laboratory IS. In contrast, the installed base (integrated laboratory and GPs' systems, national standards and existing work practices) was less generative. Not surprisingly, the more wide-ranging and complex, the less generative. National standards also have low change flexibility. The more independent the work practice was from other work practices (for instance in the hospital) or other IS, the easier it appeared to integrate the new system with and change existing work practices. This was evident, for example, in the work practices of the editor of the analysis repertoire, and to a certain degree in instances of general practice involving a rather small, autonomous staff.

Although Interactor was adaptable to other systems, the integration and adaptation of these systems also required changes to be made by vendors of other systems and national standardization bodies. Hanseth and Lyytinen (2004) argued that flexibility could be secured in the installed base by avoiding technological lock-ins. We argue, however, that flexibility in the installed base is not a purely technological issue. Flexibility is just as much a social issue; it is about willingness to change and balancing needs and priorities. In our case, we saw that it was not impossible to change the installed base, but that change was difficult within a reasonable time frame. For instance, the national standards require long processes before alterations can be made, and other vendors need to compare and prioritize the needs of their users. An information infrastructure is inherently made up of heterogeneous groups of users as well as heterogeneous groups of vendors. The different components of infrastructures will have different meanings for

various users (Grisot, 2008). Hence, the users as well as the vendors will have different priorities for making changes in these components. This was obviously the case with the GPs' ID numbers that would benefit the laboratory, but had to be changed in the GPs' EPR.

Table 1: The Generativity of Interactor and the Installed Base

	Publisher	**Interactor System as a Whole**	**The Installed Base (GPs' EPR, laboratory IS, established work practices and routines, national healthcare network, standards, etc.)**
Leveraging	Makes the job of the editors of the presentation of laboratory services much easier.	Leverages the editors' job (because of Publisher). For the GPs: some say it makes their work practice more effective, others do not. It makes the receiving of orders in the laboratory more effective at AHUS, but not at UNN.	The EPR and laboratory IS effects on work (if it makes it easier or not) are disputed (Greenhalgh et al., 2009). National healthcare network and standards are the backbone of the infrastructure, but are not used directly by the end users.
Adaptability	Takes whatever it gets from the laboratory IS and converts it to XML format. Is a standalone system not dependent on integration. Can easily make changes to adapt to new work practices both in the laboratory and in general practice.	Can easily be adapted to other areas, e.g. referrals or other ordering processes. Can easily be adapted to other IS, like EPR or laboratory IS. Adaption must be made by developers. GPs can adapt to their own work practices to a certain degree, e.g. 'favorites.'	EPR and laboratory IS are complex systems with many users, and are not easily adapted. Need for change must be balanced against many other requirements. Work practices in hospitals are complex and the more integrated the less adaptable. General practice more adaptable. National healthcare network and standards require long processes to be changed.
Mastering use and adoption	Easy to learn and use.	Easy to learn and use.	EPR and laboratory IS are complex, but quite easy to learn and use. National healthcare network and standards not used by end users.
Accessibility of use and ability to build on	All hospitals can purchase it. Within certain limitations the users can build on/with the system using the editing tool.	Hospitals purchase it. Only accessible to GPs ordering/referring to hospitals that have the system. Only Publisher accessible to build on. The rest of the system is inaccessible for users to build on.	EPR and laboratory IS available to be purchased. Cannot be built upon, but to a large degree local configuration. National health net available for all health related institutions to use. Standards are accessible to all vendors for free. Impossible to build on.
Transferring of changes	New presentations automatically downloaded to users. Easy to share presentations with other laboratories.	Share presentations (Publisher). GPs may share their 'favorites' with other GPs. New versions of software automatically downloaded to users.	Users cannot share changes. Distribution of new versions differs: on-line manual or automatic download, CD's etc.

Towards A Co-Constructive Perspective on Design and the Potential of Agile Methods

The users in our case made a great effort in designing new work practices that involved the new technology, and contributed to further design by using the technology during the iterative design process. This infrastructuring (Star and Bowker, 2002) was possible, but also limited, due to the degrees of generativity of the component and the installed base.

In the Technology Appropriation Cycle, Carroll (2004) advocates continuing the design of the technology after the appropriation phase (i.e., after it is tested in real-life use). This view coincides with our case. However, we extend this perspective by pointing out that the users did not merely test how the technology fits existing work practices, they actually contributed to the development and adaptation of the very same practices. Our users were decisive in changing existing work practices and establishing new ones, as well as establishing routines for testing and backing-up the new system. It was also interesting to observe how the conflicting work processes in general practice and the laboratories related to the presentation of analysis repertoire served as a trigger for the development of an editing tool. It was evident that the technology and work practices existed symbiotically, and their designs were mutually dependent. The use of the technology resulted in changed work practices, and experience with the changed work practices fed into the continuous design of the system.

While the Technology Appropriation Cycle calls for an iterative process, the traditional phases of development are still evident. We argue for the blurring of boundaries between the phases by suggesting that the design and use phases exist in parallel: "The (in)visibility of a work infrastructure makes it hard for users to be fully aware of their own work procedures, making it difficult for designers to elicit requirements, and making it more likely that a technological solution needs several iterations of evaluation and design improvement until it is considered useful" (Pipek and Wolf, 2009, p.311). Agile methods, for instance, promote this parallelism by reducing the duration of the design cycle to one to three weeks, followed by releases of new versions and the welcoming of new requirements (Beck, 2000). Although agile methods do not address how to involve users in the development process, we think that these methods provide unique opportunities for involving users in ways that challenge traditional distinctions between users and developers. The short period of time from feedback to improvement is also a great motivational factor for users (Johannessen and Gammon, 2010). By introducing the unfinished technology into real-life use early in the design process, the design of work practices can begin immediately, complementing the design of the technology as well as constituting a complete design process.

An Evolving Web of Users and Designers

The notion of generativity (Zittrain, 2006) indicates roles for users as well as developers in the change process. Our case revealed some relations between users and developers and how these emerged. It also showed the users' active role in the design process and how this role changed throughout the process, such as users taking on greater responsibilities. Finally it showed how power relations were a result of negotiations between the different groups.

The conceptualization of a design process as a web of users and designers with evolving roles (Mackay et al., 2000; Millerand and Baker, 2010) fits nicely with our findings. However, we also draw attention to the time dimension and how the user roles changed over the course of the project. Initially, the roles were quite traditional and clear cut; developers developed the system based on discussions with the users, and the users subsequently tested the system. Yet as the project evolved, closer relationships between the users and developers were established, and the roles started to change. Gradually, the users took on responsibility for the process and the developers became involved in planning laboratory work. These relationships and altered roles were partially facilitated by social events, where the aim was to get to know each other, and partially by the large amounts of time spent together working on the system. On one hand, as Millerand and Baker (2010) point out, user and developer roles are not stable; therefore a rigid organization between users and developers is not appropriate. On the other hand, such fluidity does not necessarily happen by itself. The relationship between the actors needs to be nourished, such as through various meeting venues, for the users and the developers to take on new roles and responsibilities.

In light of our findings, we question the position that the users' empowerment is a prerequisite for participation (see for instance Beck, 2002). We instead argue that the actual power of influence is not necessarily given to either developers or users at the outset of a design process. Similar to roles, degrees of influence are performed, and are somewhat circumstantial. In Mackay et al.'s (2000) case, the user representatives were in-house customers with formal authority in their organization, and occasionally made the developers feel disempowered and configured by users. In our case the vendor was in a formal position to make decisions, but as the process played out it was evident that users also had a degree of power, mainly because the developers depended on the cooperation of the users to make a product with maximum market potential. This was also the case in the relationship between the two user groups. At first glance it appeared as though the laboratory had the authority to configure the GPs' work practices; however, in reality the GPs wielded influence by threatening to boycott the system (and laboratory) if their voices were not heard.

Implications and Limitations

This study was conducted in a healthcare context, and thus may be characterized by considerable complexity and intricate integration of technology and practices (Norris 2002). This in itself indicates relatively low flexibility and generativity, which was particularly evident in the installed base in this case. The assessment of generativity in another less conservative and complex setting might have shown more generativity, similar to Zittrain's (2006) findings regarding the Internet. However, a major drawback associated with generativity might be hostile access to

the IS resulting in security risks (Zittrain, 2006). In a healthcare context, privacy of patients and system reliability are serious issues, and therefore one could ask how much generativity is appropriate in healthcare IS. The challenge for those designing healthcare IS is to balance the restriction and promotion of generativity (Grimmelman and Ohm, 2010). In a public healthcare setting, healthcare authorities play a large role in the purchase and design of systems and do not always facilitate an evolutionary design processes or include users (Larsen and Ellingsen, 2010). This limits the close cooperation between users and designers. Future work could include more systematic insights into how to best facilitate beneficial working relations between users and developers in public healthcare development projects.

This study shares the limitations that are inherent in studies of complex social settings. The wealth and complexity of data in our case are considerable, and nuanced relationships exist between applied concepts. Simplifications are required that do not always do justice to the data, or may invite alternative interpretations. We have sought to strengthen the transparency of our analysis and findings by offering rich descriptions of the processes and contexts studied. Particularly in an integrated setting, there is a need to conduct investigations in many different but related contexts.

CONCLUSION

The case of designing and implementing the Interactor system has demonstrated how socio-technical characteristics of the information infrastructure to be designed influence the roles that users play and the nature of the design processes. More specifically; if the system is to be changed by the users, it must be flexible enough to allow the change. Information infrastructures are complex integrated systems, and when one part of the system is changed then changes are required in other parts of the system. We found Zittrain's (2006) concept of generativity to be a useful framework for assessing the flexibility of information infrastructures. As the assessment of the generativity of the Publisher component in the Interactor case showed, a high degree of generativity in the system itself is a necessary condition for the users to make changes. However, the Interactor case also showed that in an integrated and complex setting like an information infrastructure, generativity in the system is not enough. As all changes and new components of the infrastructure have to be built upon the installed base, the flexibility of the installed base will heavily influence the opportunity to build on the information infrastructure. The more tightly integrated the technical system and work practices are with the installed base, the more the generativity of the installed base will determine the actors' ability to design, for instance using End User Development tools. We would therefore go so far as to claim that when generativity is lacking in the installed base, users (and developers) will only be able to do design work on the parts of their work practice that have limited dependence on integrated systems and work practices of others.

Given a high degree of generativity in the information infrastructure, and in particular in the installed base, users have the opportunity to play major roles in the design of the system. This gives rise to new ways of viewing design as well as user roles. Conceptualizations of both design and user roles have evolved considerably in IS literature. Concepts and roles traditionally described as being stable and one-dimensional are now given broader characterizations. Also, distinctions between users and developers have been recognized as somewhat blurry and changing. The case analyzed in this paper supports the view that both user and developer roles change over time. These groups' roles and mutual influences were performed and changed due to different circumstances, relationships, phases of design and system characteristics. The fact that these changes were constructive rather than chaotic was in large part due to the establishment of measures that facilitated good working relationships between users and developers throughout the design process.

In the same way that users perform a broader role than just technology use, the design of IS is more than merely the design of technology. The concept of infrastructuring (Star and Bowker, 2002) denotes how information infrastructures are made and changed due to the users' integration of technology and work practices. Our case supports this understanding of design of IS, but further suggests a co-constructed view of design which also encompasses the design of new work practices that accompany the technology. We observed that the technology had to be used during the design process in ways that also encompassed the design of work practices in a continuously iterative process. The design of work practices is arguably the users' most valuable contribution to the design process, and agile methods can be well suited to elicit user contributions.

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