Introducing E-Learning in a Norwegian Service Company with Participatory Design and Evolutionary Prototyping Techniques

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Abstract
Over a 2-year period, we have participated in the introduction of e-learning in a Norwegian service company, a gas station division of an oil company. This company has an advanced computer network infrastructure for communication and information sharing, but the primary task of the employees is serving customers. We identify some challenges to introducing e-learning in this kind of environment. A primary emphasis has been on using participatory design techniques during the planning stages and evolutionary prototyping during the implementation stages. We describe a conceptual framework for analysis that takes into account technological, pedagogical and organizational factors. The data we present include interview excerpts and video recorded images and it documents the planning, implementation, and preliminary use of a moderately successful e-learning pilot system. The paper provides new insight into the successful co-existence of old and new technologies and multiple information seeking strategies.

Introduction

During the past decade, E-learning has attracted a great deal of interest in the Norwegian service industry, and many companies are now pursuing various forms of e-learning for all or part of their staffs. Previous studies have shown that when successfully implemented e-learning can reduce travel costs and the time spent on learning job-specific tasks and procedures (Rosenberg, 2001). Furthermore e-learning can strengthen the integration of working and learning when part of the work is computerized (Fischer, 1991). On a broader scale one can identify technological, pedagogical, and organizational factors that impact the introduction of e-learning in an organization. New inventions in high-speed network technology, multimedia delivery, knowledge management (KM) and learning management systems (LMS) represent technological factors (Alavi, 1999; Elementk, 2003). Pedagogy in an e-learning context is about company-specific teaching programs, theories of workplace learning, and conceptual frameworks for evaluating individual and organizational learning (Burton, Brown & Fischer, 1984; Ludvigsen, Havnes & Lahn, 2003). Organization is about company-wide initiatives of sharing knowledge, designing new ways of working and learning, as well as encouraging participation from multiple levels in an organization when decisions about e-learning are made (Bjerknes & Bratteteig, 1995; Bjerrum & Bødker, 2003; Grudin & Palen, 1995). The complexity of introducing e-learning is to a large extent a result of the complexity of the interdependencies among these three dimensions (Fjuk, Sorensen & Wasson, 1999).

Unfortunately, e-learning is often introduced based solely on its technical potentials, supported by frequently-issued claims that e-learning systems can deliver learning material to employees' desktops and PDAs at the right time and right place and vice versa, allowing employees to search for job-specific information in order to complete required tasks with performance support systems. These claims can be realized in specific situations and successful implementations have been reported (Rosenberg, 2001), but more often they remain slogans for management. The reported studies are not easy to duplicate in other settings.

One the one hand, expectations of what computers can do when it comes to supporting learning and training are high. One the other these expectations are somewhat misleading because it contradicts previous research in computer-based learning and training. Although e-learning has been around for nearly a decade, it is still a new phenomenon. There is not yet any theoretical consensus on how e-learning should be implemented when taking into account the interdependency of pedagogically, technologically and organizational factors (Fjuk, Sorensen & Wasson, 1999; Qvortrup, 2004). Furthermore e-learning technology can be seen it at least two different ways: tool and media (Qvortrup, 2004). During the early stages of computer based training (CBT), the computer was seen as an instrument for transporting teaching content to students (distance education) or a tool for delivering instructional material from one head to another (teacher to student). However, new research on collaborative learning sees this differently, recommending that we should not mimic old ways of delivering information but instead identifying ways technology-enhanced learning can go beyond previous instructional techniques and how it can combine with them (Koschmann, 1995). The latter is often referred to as blended learning (Fjuk & Kristiansen, 2001). In the context of this paper blended learning is expanded to include how e-learning can be integrated with work support systems and new work practices (Suchman, 1994).

We define e-learning in its broadest sense, as a tool, medium and a strategy for delivering instruction that go beyond continuing the tradition of CBT and CD ROMs, the sources of e-learning technology (Rosenberg, 2001). E-learning can also be used in networked learning environments to present information and tools autonomously to users while they are working, even if learning is not an explicit goal of their activity (Fischer, 1991). In such a context it makes sense to distinguish two types of work: *primary* and *secondary*. Primary work is the tasks to be accomplished during a workday, which at a gas station could be anything from customer interaction to working with job-specific tools, products, and information browsers. A generic term we use for these systems is *performance support system*. Secondary work, on the other hand, is explicitly focused on training and learning. It is about the knowledge building that goes on in an organization and the knowledge needs of that organization's individual employees and work teams.

Context and goals

The paper presents and analyzes data from a Norwegian project, Learning and Knowledge Building at Work (http://www.nr.no/imedia/lap/). This project is organized as a consortium, consisting of three industry partners (two large companies and the Federation of Norwegian Commercial and Service Enterprises) and three research partners. A goal of the project is to introduce e-learning in the two companies. One of the companies is the gas station division of an oil company (hereafter called ServiceCompany). It is ServiceCompany's case that we report on in this paper.

From the ServiceCompany's point of view e-learning is way to organize work to help reduce the high turnover rate among its employees. The average worker at a gas station stays in the company for about 12 months. Although the work at the gas stations is for the

most part manual labor it is thought that the addition of online training could extend this time by giving employees more enjoyable conditions in which to work. It is estimated that this can be achieved in at least two different ways: 1) improving the cooperative problem solving that goes on between customers and attendants; and 2) providing access to computerized product information. The former is related to helping the attendants answer difficult questions from customers and the latter is a result of third-party vendors' efforts to make their products accessible online as a supplement to paper-based catalogues. Both of these goals are challenging. First, the work is not computerized. Computers are only used in the cash registry and the back office. Second, there are no theories of learning-on-demand that can guide our analytic efforts. We have instead adopted pedagogical theories and models from related areas (situated learning), which have helped us to conceptualize workplace learning as an extension of everyday work, alternating between primary and secondary work.

The rest of the paper is organized as follows. We start by identifying key issues in contemporary research on new ways of working and learning. Next we describe the basic characteristics of e-learning systems and go into some depth to identify the aspects of situated learning (apprenticeship) to provide us with a theoretical underpinning of learning-on-demand. Next we list a set of possibilities and barriers to look out for when introducing shared systems in large organizations, and we add an organizational dimension to learning on demand by incorporating elements from social learning systems. In the subsequent section we describe techniques for involving users in design (participatory design) and an approach to evolutionary prototyping we have employed in order to incrementally deliver an e-learning pilot system. In the final section we use the conceptual framework to analyze interview data and video protocols with employees based on their reactions to the pilot.

New ways of working and learning

In the "office of the future," e-learning has been envisioned to take on a prominent role as persuasive technology, which can be tapped into at any time to provide information that is relevant to an employee's task at hand. Bjerrum and Bødker (2003) have studied modern workplaces that are organized to increase learning and cooperation with new technology. In these environments the physical and computational infrastructure is open and flexible (open offices, transparent walls, wireless LAN) so that the employees and managers can tap into the company's knowledge assets and information repositories at any time. The potential for legitimate peripheral participation (Lave & Wenger, 1991) is high in this kind of environment, supported by an improved awareness (over-hearing and over-seeing) of the activities of others (Bjerrum & Bødker, 2003). However, the envisioned potential for increased learning was not realized in the companies studied by these authors, and they found patterns of conformity and anonymity rather than cooperation and creativity. The technology, artifacts and new physical spaces by themselves did not promote learning.

Koschmann (1996) has suggested computer supported collaborative learning should be seen as a new paradigm for learning in the networked computer era. Learning is best

organized according to a strategy he calls 'learning *with* computers', as opposed to 'learning from computers' or learning through computers' (Koschmann, 1995). By this he means that computer supported learning should be treated as equal to and as an alternative to other learning resources such as textbooks and classroom-based instruction. This strategy has the advantage that e-learning allows discretionary use, but has the disadvantage that it must to be readily available and enjoyable to use (a challenge for developers) and previous technologies need to be maintained in parallel (books need to be printed, seminars held, etc.). This is not always an attractive feature for a company, but costs could decrease if the previous technologies are provided in low volume and on a needs-basis, serving as back up when the e-learning technology does not work or is inefficient for specific learning needs. Thus in many companies e-learning will be introduced to profile the company's technological image, spearheading and enriching, rather than supplanting corporate training programs.

Technological factors

E-learning has been described as a merger of two previous technologies for computer-based learning: computer-based training (CBT) and multi-media programs delivered on CD-ROMs (Rosenberg, 2001). The merger of these technologies was realized about 10 years ago, when multimedia-based training material could be delivered over the Internet and presented in web browsers (WWW). E-learning systems today typically consist of a subset of the following six components:

- A high-speed computer network that allows training material and information to be instantly updated, distributed and shared with a potentially large group of users;
- Delivery platforms that make use of standard Internet technology (web servers, URL access), allowing training materials and information to be presented on desktop interfaces as well as on the screen of smaller devices, such as PDAs;
- Instructional applications and learning objects that make use of multiple data types (text, pictures, video, sound, animation) and widely accepted standards such as LOM (Learning Object Meta-protocol), so that training materials can be presented in their most suitable form depending on the topic to be taught, the delivery platform and the learner's individual preferences;
- Tools for managing learning objects, enrolled participants and online courses. This is supported by learning management systems (LMS) and often accomplished at the auspices of the organization's competence or human resource (HR) department (Elementk, 2003);
- Tools for accessing learning objects and related information. This is associated with representing information in shared repositories, such as knowledge management systems (Ackerman, Pipek & Wulf, 2003; Alavi, 1999) and supported by various techniques for organizing learning material and retrieving it with search engines;
- Tools for autonomously bringing learning objects to the learners' attention by activating KM systems and providing alternatives to learner-initiated queries. A technological approach to activation is pedagogical agents (Mørch, Jondahl &

Dolonen, 2004); while a human approach is “super users”: technologically skilled users who provide help to regular users (Åsand, Mørch & Ludvigsen, 2004).

E-learning is not appropriate for all organizations. For example, work that is predominantly manual, a characteristic of many companies in the service industry, poses many challenges to computer-based learning systems. In these organizations the employees rely on mechanical tools and customer interaction to perform their jobs. Nevertheless, computerization has increased the relevance of e-learning in this sector as well, the combined result of employers’ familiarity with new technology from other spheres of life (e.g. mobile devices for communication) and company-wide initiatives to introduce communication and information sharing systems for all employees.

Pedagogical factors

The need for learning at work in the service industry is evident. Previous studies have shown that customer interaction provides a rich setting for learning the ropes of the trade (Ludvigsen, Havnes & Lahn, 2003). However, the combination of high demands on quality of customer interaction and the rise in number of products and services an employee needs to know about to successfully interact with customers have given rise to new demands on workplace learning. Indeed, the gas stations we studied are also effectively small supermarkets, fast food snack bars, and outlets for automobile products. The employees in these multi-purpose service centers are faced with a large inventory that contains many different products. There are few people who know everything because knowledge has become increasingly specialized (in terms of the amount of products and routines to know) and fragmented (in terms of the amounts of services offered). For example, the expertise to answer customer questions may not be at arm's length of the employee, but located at a different gas station.

Workplace learning in ServiceCompany has until now been organized as a combination of informal, on-the-job apprenticeships and top-down corporate training. Apprenticeship can be illustrated by the following hypothetical situation. A customer is asking an attendant for help measuring the car’s antifreeze level on the liquid cooling system, but the attendant cannot answer the customer’s questions. He or she then asks a more experienced colleague at the station to demonstrate the procedure for the attendant. However, ServiceCompany is open 24 hours a day, with work periods organized into 8-hour shifts, which means that there will be times when no experienced colleagues are on site to help an inexperienced attendant resolve this type of situation.

One characteristic of the above situation is that the need for learning is grounded in a real concern, but this need may not always coincide with an opportunity to sit down and study the problem to resolve it optimally (conventional learning). A theory/model that addresses this type of learning is apprenticeship learning (Collins, Brown & Newman, 1989; Nielsen & Kvale, 1997). Apprenticeship is about bridging the gap between conceptual knowledge and practical problem solving in day-to-day work, and this gap is evident in ServiceCompany. On the one hand there is a corporate training program, which defines generally useful information every employee should know. On the other hand, practical concerns and local problem solving occur in the gas stations on a daily basis, and cannot always be planned for in advance. Learning in this context can be seen

as a by-product or side effect of practical action, not as an end in and of itself. The training programs provided by the HR department of the company can identify these learning needs and provide programs to support it, at a general level.

We are interested in various ways the apprenticeship model can be enhanced with computer-support to bridge the gaps between primary and secondary work, and practical problem solving and conceptual knowledge building. An approach to this is learning-on-demand (Burton, Brown & Fischer, 1984; Fischer, 1991). Learning on demand is how a computer can be utilized to find information to resolve a difficult situation associated with the task at hand. This could be by connecting the attendant in the above situation with a more experienced colleague, or automatically by the system itself, supporting the retrieval or autonomous delivery of relevant information from the company's knowledge management system. Previous work on learning on demand includes computer-based coaching (Burton, Brown & Fischer, 1984), critiquing systems (Fischer et al., 1991) and pedagogical software agents (Mørch, Jondahl & Dolonen, 2004), as well as knowledge management systems that assist answer seekers in finding expert answerers (Ackerman, Pipek & Wulf, 2003).

Organizational influence on technology and learning

The e-learning system developed in this project is an example of a shared information system (groupware). Previous studies of groupware adoption have identified critical factors that need to be taken into account when introducing such systems in large organizations (Grudin & Palen, 1995; Hummel, Schoder & Strauss, 1996, Markus & Connolly, 1990). These factors include:

- *Mandated use* during the initial phases of adoption to assure sustained use of the system. This is particularly critical in large organizations, because there are many different users, not all of whom may benefit or like the system (Grudin & Palen, 1995);
- *Critical mass* is the stage a newly introduced system reaches when it has enough mandated users to sustain use without further mandate. At this stage *peer pressure* takes over, which means non-adopters feel a pressure from the *early adopters* to also start using the system (Markus & Connolly, 1990);
- *Pleasure and fun* are powerful factors associated with a system when it needs no mandate to inseminate use because using it is a reward in itself (Grudin & Palen 1995; Blythe et al., 2003). Such systems are often not directly related to work (e.g. computer games, chat rooms and Internet surfing), but there is no intrinsic reason why they cannot support work related tasks as well (Blythe et al., 2003);
- *Appropriateness of functionality.* A frequent cause of groupware failure is providing new functionality as an alternative to previous functionality and requiring one to learn something new without providing perceived benefits for the users. Unless such systems are mandated or fun to use, they will not succeed (Hummel, Schoder & Strauss, 1996);

Workplace learning is not only about situated learning among individuals in small teams, it also about how an organization as a whole learns and evolves. When putting these two

concerns together the combined approach can be described as the interplay of social competence and personal experience. Organizations supporting this combined approach have been referred to as *social learning systems* (Wenger, 2000). The employees are the central actors in evolving the social learning system. Participation is measured according to the degree of closeness to daily tasks and vice versa, according to distance from the shared values of the organization. *Engagement*, *imagination* and *alignment* (Wenger, 2000) are three terms used to differentiate among the types of participation in a social learning system. Engagement is learning that is close to the task at hand, whereas alignment is learning that is associated with the shared goals of the company. Imagination is representations on the local situation for the purpose of reflection and self-regulation. These three modes of learning activity are associated with different kind of work at different levels in the company, but they will always coexist, often in uneven combinations. For example, using imagination one can gain a good picture of a problematic situation, which in turn can help to fine tune alignment so that one can better understand the reasons behind the procedure for a specific work task, which in turn can help to resolve the situation (Wenger, 2000).

In summary, in this section we have identified a set of factors that can impact the success or failure of introducing e-learning in a large organization. These factors combine technological, pedagogical and organizational concerns and include: 1) identifying the components of e-learning technology that users expect, 2) identifying models of learning that caters to both individual and company needs, and 3) addressing the concerns associated with organizational interfaces to shared systems. These issues will come up again when we analyze findings from a case study later in this paper.

Participatory design

In this paper learning is treated neither as "product only" nor "process only", but as an opportunity for acquiring and generalizing new information in collaboration with others that arise during breakdown (problematic situations) and improvisation of everyday work (Mørch, Engen & Åsand, 2004). From this perspective we have experimented with various ways to involve workers in the design of *learning scenarios* to identify situations for which technology-enhanced learning could improve existing work practice. To accomplish this we have made extensive use of Participatory Design (PD) techniques in the planning stage, combined with exploration of design alternatives at multiple levels of detail (from mock-up to installed prototypes). This has led to some degree of decentralized decision-making as well as extended time for reflection upon the implementation process.

In the spirit of the Scandinavian PD tradition, we opted for a high degree of user participation and cooperation at multiple levels of decision-making power (Bjerknes & Bratteteig, 1995). A reason for this is to give ownership of ideas to workers and to include the knowledge of their work in the design of new work and learning environments. Based on a survey of research in PD (Muller, 2002) we identified three techniques that seemed appropriate for our setting. These include workshop organization (Kensing & Madsen, 1991), design alternatives, which are intermediate-level mock-ups with "family resemblance" to tools and materials of the work setting (Ehn & Kyng, 1991)

as well as computer interfaces (Brynhildsen, 2004; Tødenes, 2004), and role playing (Brandt & Grunnet, 2000; Svanæs & Seland, 2004). We describe these techniques below.

Workshop organization

We started the participatory design by conducting a one-day design workshop at the company site, with participants ranging from gas station attendants to regional managers. The goal of the workshop was to design a future workplace that would make use of new technology and allow for improved learning opportunities. The design process can be summarized as follows, carried out in the following order:

1. All participants (employers and researchers) were given practical lessons in theatre techniques from an experienced drama teacher;
2. The participants were split into two groups (four members in each group; random mix of attendants and managers) with the goal of brainstorming around a specific work situation that could be improved;
3. Each group created a scenario to illustrate a typical work situation. The scenarios were acted out and presented to the other workshop participants;
4. The groups made mock-ups representing new artifacts to be used in the work situations;
5. The scenarios from step 3 were modified to include the new artifacts. The resulting examples of new work practices were acted out and presented to the workshop;
6. The scenario from step 5 was acted out once more, but this time with interruptions (freeze spots) at forks (decision points) in the task execution to explore creative workarounds for tasks that might go wrong;
7. All participants took part in a discussion about the relevance of the workshop and the quality of its outcome.

Kensing and Madsen (1991) suggested that design workshops be organized by dividing them into three phases: *critique*, *fantasy* and *implementation*. The critique phase is brainstorming in order to identify problem situations in the current work practice, whereas in the fantasy phase, the participants search for solutions to the problem situations. Finally, in the implementation phase, the ideas are discussed and unworkable solutions are filtered out. The workshop we organized made use of all of Kensing and Madsen's (1991) phases, plus a few more (see below). However, our step 2 (brainstorming) was slightly different from their critique phase in that problem identification was not explicitly on our agenda; rather, it was to find a typical work situation that could be improved. The groups brainstormed around current practices at their respective gas stations, identifying typical situations such as serving customers, answering difficult questions and finding product information. They were free to do this in their own way and their suggestions were written on post-it notes on the wall. The discussion and printed notes were documented on camera (still pictures and video).

Design alternatives

The use of low-fidelity mock-ups for rapid prototyping has been an integral part of the PD tradition since it was pioneered in the UTOPIA project (Ehn & Kyng, 1991). It is widely recognized that communication with end users must be done through concrete instantiations of product ideas, and that such models nurture the creativity of both end users and researchers in cooperative design settings (Svanæs & Seland, 2004).

For this workshop we had prepared foam boards of different sizes to mimic some of the computer devices available on the market, from "digital watches" and "PDAs" to "tablet PCs" (Figure 1). During the design phase (step 4 above), the participants were allowed to pick sizes that fit their needs, and to use these as props in the acted-out scenarios (Brandt & Grunnet, 2000). Screen content and interactive behavior was modeled with the use of post-it notes that were glued to the boards (Svanæs & Seland, 2004).

The mock-ups the employees created were not merely representations of the collective understanding of their workplace. The materials employed are inexpensive and readily available, which meant the participants could create different versions. When the employees had modeled their ideas, the mock-ups needed some polishing before they could be presented to the developers in the IT department. The two employee groups had produced two final models and to get more variety we decided to improve upon them. We (the researchers) made new mock-ups by varying the size and refining the interactive behavior of the user models. This is what we call *design alternatives* (Brynhildsen, 2004). Design alternatives are intermediate abstractions that have family resemblance to both workplace materials and computer interfaces.

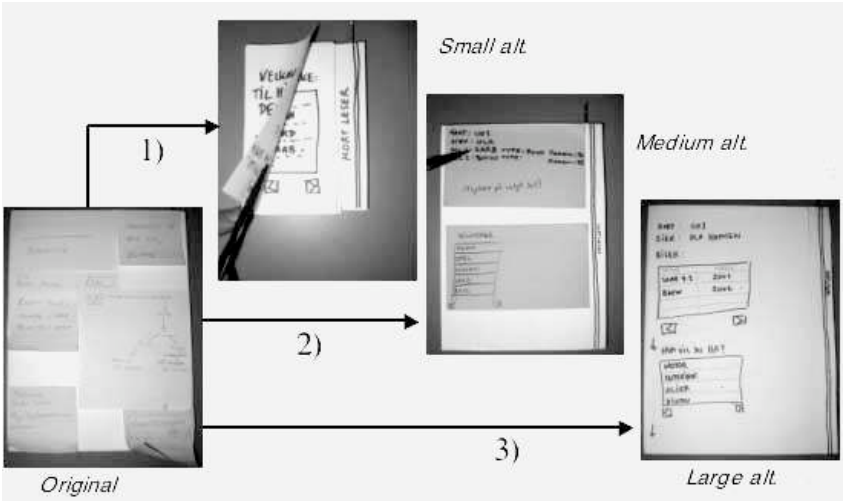

Figure 1: Design alternatives of information displays with post it notes and hand drawings. The "original" was created by one of the workshop groups. The numbered alternatives represent intermediate abstractions created by the researchers afterwards.

When design alternatives have been created, they can be compared to realistic work situations in order to pick the best one. In our case this meant selecting the version that would best satisfy the constraints of a normal workday. The mock-up that was finally

chosen by the ServiceCompany was a large-sized information display. The envisioned location in the store of this mock-up and its size turned out to be the decisive factors, because the smaller sizes would more easily be misplaced by attendants or stolen by customers. Nevertheless, the employees definitely contributed in the decision-making process by their constructive participation in the workshop. They came up with the ideas, they made clear what they wanted, and they understood the consequences of what we meant by learning on demand, i.e. providing relevant information to a task at hand without disrupting work activity.

Role playing

We hired a professional theatre instructor to give the participants an introduction to dramaturgy for the purpose of role playing. This started with a 'warm up' exercise supplemented with guidelines for how to create work-oriented scripts. The scripts were later played in two sessions (Figure 2 shows a scene in session 2). The first session was to simulate the current work situation, and the audience was told to identify potential breakdowns that could occur (e.g. someone pumping gas and leaving without paying), and write them down as comments on 4x6 index cards. The theatre instructor incorporated a selected set of these as prompts in the second round of role playing.

Figure 2: Playing a work-oriented script with the aid of a mock-up to resolve a breakdown (customer waiting in line is helping himself by consulting an information display).

The second session was dramatized in two acts: the first showed a future situation at the gas station, and the second was a re-run interrupted by "freeze spots." A freeze spot breaks up an act into two parts: before-act and after-act, in order to join them by a "repair action". This allows breakdowns to be resolved in multiple ways, since the repair actions are staged on the spot by the players. The instructor called the freeze and decided on the nature of the breakdown by selecting one of the cue cards. When the players were told to resume from the interruption, they would join the before-act with the after-act mediated

by a workaround to resolve the breakdown, resorting to the mock-ups they had previously created. Examples of freeze spots could be someone leaving a long line, or an information display that does not work (see Figure 2 for an example).

We have adopted the theatre techniques from Brandt & Grunnet (2000) and Svanæs & Seland (2004). Frozen images and freeze spots are techniques in which the actors are directed by the audience to interrupt their act and continue with on-the-spot (unscripted) recovery. When we dramatized the future situation with the aid of props (mock-ups, breakdowns, workarounds) the employees were able to realistically see to what extent they were able to improve upon their current work situation.

In summary, both employees and researchers considered the workshop entertaining and useful. It was not difficult to get the employees to participate constructively. The gas station attendants gave examples of real learning situations, and the regional managers were able to see what kind of performance support the attendants needed. The output and experiences were documented and reported to the developers in the IT department who got a much better understanding of the needs of the attendants than they would otherwise gain access to with conventional requirements engineering techniques. By the PD method together with video recording and analysis tacit knowledge was allowed to surface. At the same time the users got an understanding of what kind of technology would be useful to them. Most importantly, the users were not only participants but co-inventers of design artifacts and key ideas. In fact, they became "owners of the problems" (Fischer, 1994), some of which were later transformed into running prototypes (see below). When the users can see that their efforts can be transformed into tangible and useful results they will be more motivated and committed to using the system over time (Fischer, 1994).

Evolutionary prototyping

Transforming users' ideas into a software system is no panacea for an organization with many users in the design process. Participatory design takes us a step along the road, but it does not recommend techniques for system implementation and evolutionary prototyping. We have adopted techniques from evolving artifacts (Basalla, 1988) and software engineering (Budde et al., 1992) for this purpose.

Artifacts are said to evolve out of *convenience* rather than *necessity* (Basalla, 1988). By this is meant that artifacts may evolve along numerous paths, which may cross application domains and kinds (Mørch, 2003). At each decision point along the road of an evolving artifact there are many, near-similar choices that represent design variations and alternative configurations of the artifact at that point in time. Depending on the richness of variation and the choice being made, an increased degree of specialization or generalization will be the outcome, providing various degrees of conveniences to the users. Natural evolution, on the other hand, is blind to past mistakes (memory of evolutionary history is not accessible) and characterized by few choices, survival being the main decision criterion. Users can make a difference to artifact evolution if they are given access to the set of alternatives available, which may range from design alternatives (before the system has been implemented), to alternative system configurations (after the

system has been implemented). Each of these alternatives needs to lead to a satisfying solution at that level of development because end users are not expert designers or decision makers. Thus safe modifications and informal design techniques should be valued higher than tools for producing novelty, since new features may inadvertently cause a running system to malfunction. In spite of this we believe users can participate constructively in evolutionary prototyping and impact systems development in fruitful ways.

The ServiceCompany's IT department created the first computer-based prototype based on one of the refined mock-ups. This prototype was a touch screen-mounted terminal facing the attendant and placed in a pilot station for a period of two months (Figure 3). The system contained product information about car batteries and windshield wipers. During the trial period, all employees at the gas station explored the prototype's features at least once. They were eager to tell us what they thought about it and how it could be improved. The feedback we received gave us the impression that the employees really needed detailed information about automobile products in their daily work. They were enthusiastic about having a computer tool that could supply this information.

Figure 3: First prototype (touch screen) created by the IT-department based on the mock-ups created in the design workshop. It is located next to the cash register, facing the attendant.

Although initially intriguing, the system was only sporadically used by the attendants. Its design was criticized in various ways. For example, the information was organized from a system's builder's perspective and not from the users' problem situation (i.e. several menus had to be traversed to retrieve time critical information). Furthermore, the attendants misunderstood the use of color coding to differentiate the various models and types of car batteries and in some instances they found it difficult to understand the written explanation on the screen (to help the attendants select battery type). Based on these findings we decided to improve the user interface by providing a simpler navigation

structure, more intuitive icons and a uniform organization of information that was applied to a few test cases (Tødenes, 2004). The new prototype was created with a Flash-like development environment and a screenshot is shown in Figure 4.

Figure 4: Second prototype (laptop interface) created by the researchers based on the feedback from the first prototype. The emphasis of this prototype was to improve the user interface of product information and ease navigation. The bottom view shows a close-up of the navigation icons.

In the second prototype we made a deliberate design based on colors combined with direct-access navigation icons that had "family resemblance" with the products and services the ServiceCompany already offered to its clients. The rationale for this was to stimulate use by reducing skepticism for those who were familiar with the company's existing web site and advertising campaigns. We gave a demo of the system to the ServiceCompany and they decided to incorporate some if its elements in a third prototype, which was installed at three gas stations. This time their focus was less on usability and more on the kind of information it should contain and the extent to which it could support communication between gas stations, since cross-station communication was a common practice at the many of the stations.

The decision-makers of the company (the IT department in collaboration with HR department managers) opted for an intranet portal delivered on a laptop computer (see Figure 5). In addition to automobile product information, news and product campaigns from the central administration and a bulletin board for station managers to provide local

information were added. The aim of the bulletin board was to support communication among employees at the three pilot stations with the option that the other stations later would be able to use this feature as well. However, there was no mandated use of the system.

The third prototype has been in continual but sporadic use since 12/2003. The user interface and product database have been improved and the system was installed at 22 new gas stations during the summer of 2004.

Figure 5: Third prototype (laptop interface) created by the IT-department in response to demands for integration with the company's intranet portal.

Analysis of results

In retrospect the project followed an evolutionary prototyping approach, which has the objective of delivering a working system to end users (Budde et al., 1992). The system has been through multiple stages of the evolutionary process. The users (employees) have participated both by acting as designers (in the workshop) and informants (during real use). The system should thus be seen as a "living prototype" (Bjørkeng & Rolfsen, 2003). It is continually "growing" by updates and modifications and never really finished. We consider this an adequate approach for developing performance support systems, such as e-help, e-learning and knowledge management systems. Such systems are strictly not needed for a company's day-to-day operation because there are multiple ways of achieving similar goals, both technical (alternative technologies) and social (workarounds). However, the new technology is *convenient* for the company in at least two ways: 1) It provides the company with an image of a leading edge technology adopter, which may give it a competitive advantage in certain areas of business, and more

importantly from our point of view, 2) it helps to simplify a set of complex tasks (finding computerized product information) by introducing a new way of performing them.

From an evolutionary prototyping point of view, we see a shift from e-learning as performance support for small teams toward e-learning as communication and information sharing for the entire company. This is primarily a result of the company-wide initiative (intervention) launched by ServiceCompany to provide a shared portal for the organization. The end result could be seen in at least two different ways: 1) as a (partially completed) networked learning environment supporting secondary work according to the learning-on-demand philosophy (Fischer, 1991), and 2) as a centralized information-sharing system emerging as a new form of work (Bjerrum & Bødker, 2003). At this point we can only speculate as to what extent these two views are accurate and whether or not they are converging or diverging. Our current best estimate is they are converging.

From a user participation point of view, we see a shift from local engagement to an alignment with the company's overall profile and shared values (Wenger, 2000). The hands-on, work-oriented material of the mock-ups and dramaturgy sessions (Svanæs & Seland, 2004) created a close connection with the operations of the first prototype, thus resulting in a higher level of engagement than we have seen with the third prototype. On the other hand, the third prototype has more durability due to corporate backing. If it is allowed to evolve over time it may eventually lead to a system that will meet with enthusiasm and engagement by the employees.

We were unable to maintain the close loop between evolutionary prototyping and user participation after the third prototype was introduced. The users were not as personally motivated as they were with the first prototype. Therefore, company guidelines and strategies also influenced the further design process. On a more technical level, it seems that ServiceCompany was keen on keeping the project within the same framework as the other application packages it supported. This has sacrificed the system's usability and weakened local ownership. On the other hand, the "global ownership" we have witnessed increases the chances of resolving potential difficulties with respect to creating shared data formats among product vendors due to the decision making power it entails.

Preliminary findings based on the employees' reactions to the third prototype can be grouped into the following categories:

- Appropriateness of technology;
- Co-existence of old and new technologies;
- Information-seeking strategies.

We asked one of the employees if he could use the system to find out about the different models and sizes of windshield wipers, but the system simply does not support the task (Hummel, Schoder & Strauss, 1996), or in his own words:

"I don't find it flexible enough. It is very time consuming to use. It is much easier for me to - and customers become impatient - it's easier to just go out and measure it."

On the other hand, the system does provide the answer in one of its databases. It is an open question as to whether or not the employee's use of the system would increase if ServiceCompany provided a better user interface for it and made it more enjoyable to use (Blythe et al., 2003), possibly followed up by mandated use (Grudin & Palen, 1995).

It is not likely that ServiceCompany will encourage mandated use. Their strategy seems more in line with seeing new technology as a way of working that will provide an alternative to current ways of working over time, replacing them in certain situations when the older ways become too cumbersome. The employees we spoke with acknowledged this by providing us with examples to illustrate specific use situations. For example, in many situations they preferred paper-based catalogues to the computerized information display in order to find product information. As one employee said:

"I am not very good with computers. Most of the time it is much faster to use the paper catalogues."

Even though some of the employees are not skilled with using computers to find information, they are familiar with using paper-based catalogues. Suchman (1994) calls a similar phenomenon "artful integration," which she defines as a hybrid of technology and work practice where technology is comprised of multiple layers of heterogeneous devices, each associated with a specific generation of work support. In our case, this would mean the coexistence of multiple technologies and practices associated with helping employees to serve customers and find information: cooperative problem solving with customers, contacting colleagues, checking customers' automobile parts, paper-based catalogues, computerized information displays, etc.

We asked the employees how they would get access to the relevant information if none of the self-help strategies applied:

"We just pick up the telephone and call a nearby company gas station."

The new information system was implemented more or less in competition with already well-functioning technologies for communication with others. The employees had already established information-seeking strategies that supported a kind of "learning on demand". These strategies currently outperform computer-based information retrieval. Whether or not this will also be the situation in the future we can only speculate. Certainly information browsers will evolve and improve over time, making them more efficient for job-specific tasks; but equally important, older technologies may be harder to replace or update, and may be serviced less frequently. Critical mass, early adopters, peer pressure and mandated use (Grudin & Palen, 1995; Markus & Connolly, 1990) will be important social factors for successful adoption of the new technology at selected gas stations. On the other hand, if older technologies (such as the telephone or paper-based catalogues) continue to be sought after so that the market for periodic updates and service remain, these technologies will persist as well. This is analogues to how computer

supported learning technologies are not considered to be a replacement of traditional forms of learning with text books or teachers, but an alternative to them in certain situations they prove to be convenient (Koschmann, 1995; Fjuk & Kristiansen, 2001).

An example of a constructive transformation of one generation of technology to the next was identified in one of the gas stations. This station had established a routine for using a book leaflet to exchange useful information among the attendants between the various shifts on consecutive days. This routine was transferred over into the new medium and was ultimately made a mandated practice at that station. Interestingly, its use was not limited to internal communication, but it became a communication channel with the two other stations as well.

Conclusions and directions for further work

We have over a 2-year period participated in the introduction of a web-based learning environment for a group of employees at a large Norwegian service company, the gas station division of an oil company. During the early phases of the project we made extensive use of participatory design techniques to involve future users (employees) in the process of designing their future workplace. They created mock-ups and learning scenarios that suggested new ways of working, simplifying some of the current work, and providing new opportunities for learning. Learning in this context is seen as access to new information that could help improve work performance. To distinguish these two forms of working we introduced the terms primary work and secondary work. To extract the "e-learning potential" from this, we asked the participants to reflect on the process from which we produced a first prototype. After the introduction of the first prototype the focus changed from user participation to company-wide initiatives at selected pilot stations. The systems were improved with more features, but use of the systems did not improve. The system building model we adopted was a modified version of evolutionary prototyping.

Preliminary findings indicate difficulties with respect to the appropriateness of the new technology. The new information system and accompanying learning resources have not yet been integrated into daily work practices in the ServiceCompany; employees therefore rely on other information-seeking strategies they are already familiar with. In this regard we provide new insight into the successful co-existence of old and new technologies (as a form of artful integration) and the use of multiple information-seeking strategies during work tasks.

An open question we leave for the readers and others interested in continuing the line of work we have presented here is whether the results we report could have been obtained by other means. For example, could the results have been foreseen in the early stages of the project when we conducted the PD workshop, and could conventional software engineering methods more effectively bring out the fact that e-learning would be replaced with a company-wide information sharing system?

We have no definite answers to these questions. Our approach is unconventional compared to the standard way of introducing e-learning in large corporations, which is to deliver pre-designed systems, or high-level authoring tools for super users. The PD techniques we employed gave us room for experimentation and direct user involvement, which was partly rejected and partly accepted by the management. The parts that were accepted were incorporated into the two first prototypes. The parts that were rejected served as arguments for excluding non-working alternatives. We also know that the ServiceCompany previously attempted to introduce e-learning the conventional way, and that attempt failed.

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