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A WALK INTO THE DIGITAL WORLD
– A LONG AND WINDING ROAD

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‘’To our daughter Anna,
Have a really good life… and still I know You made
research long before me…’’

ABSTRACT

Radiology departments are changing rapidly due to the implementation of digital image management and PACS (Picture Archiving and Communication Systems).When new information and communication technologies are implemented, there are organizational effects. PACS have been implemented not only within radiology but also within the orthopedic and other healthcare contexts, affecting healthcare services more broadly. To improve the usefulness of PACS in health care, we need to understand how it affects different aspects of health care, and the underlying reasons for these changes.

The aim of this research was to inform health care management of change processes relating to digital image management and PACS use through an understanding of its effect on professional roles, work practice and technology in use, as well as highlighting accelerators and decelerators in change processes associated with the use of PACS in health care.

This is a longitudinal study with a qualitative approach. Data were collected by means of semi-structured and open-ended interviews. The interviews were transcribed, analyzed, and coded using grounded theory as an organizing principle. The trends of change in the professional role over time indicate that radiologists shifted from a role which emphasized their individual professional expertise to becoming more of an actor in a network. Their diagnostic practice changed. Reading x-ray films was seen as an art form in 1999, requiring years of training; but once other clinicians had easy access to view digital images, including those generated using 3-dimensional technology, it became easier for clinicians in other disciplines to see and interpret the images, and the skills of interpretation became more widespread. The change in technology associated with the use of digital imagery has led to an increased level of specialization in the work of the radiologist.

The changing trends within the radiographer’s professional role indicated that radiographers, as image producers, have shifted their focus from simply producing an optimal image for diagnosis to becoming expert in a much wider range of activities.. The implementation of PACS gave rise to marked changes in the processes associated with image production. Radiographers became early adopters of the new technology; new practices and routines were soon implemented, enabling radiographers to find new ways of collaborating with colleagues. When using PACS technology, medical staff had little control over the organization of image production and its workflow, so that radiographers experienced PACS as a more technical, deterministic system, allowing little human control in the organization of work

The scope of orthopedics has shifted from a single specialty to one with a diverse range of subspecialty expertise, and from a relatively static practice in the interpretation of images to a more flexible practice, where every orthopedic surgeon could view and access images from anywhere at any time, including 3-dimensional images. It became easier for surgeons to see and interpret the images, and their diagnostic skills became accessible to their colleagues. The use of PACS also improved the quality of

communication with patients, according to the respondents interviewed in this study. Clinicians refer to the digital images when discussing diagnosis and treatment options with the patient. PACS therefore acts as an information and communications technology, and users acquired new knowledge and skills in this area.

The findings of this study indicate that at least four aspects of improvisation are key factors in the implementation and use of information and communication technologies (ICT). These factors are vision, time, negotiations and information technology use. It was demonstrated that the work practice in the healthcare process needs to have a vision (direction). In the health facilities in this study, the vision developed into a commitment to enable access to images at “anytime – any place”. In a process without a direction, individuals cannot differentiate between responsive strategic action and action that is purely ad hoc. This study also illustrates that the implementation and constructive use of new ICT takes a long time, about six years. The reason is that the use of new ICT is a healthcare development process, in the course of which new professional roles and new work practices must be developed. In practice, many meetings need to take place, and problems at hand need to be considered from a wide variety of perspectives. There has to be scope for negotiations to achieve a stable and robust work practice. Negotiated changes lead to a step-by-step innovation and development process. The development process occurs hand in hand with the use of the new ICT. This means that there should be a focus on the technology, with regard to its use and its capacity to support actors through the provision of relevant information and other kinds of support, in a variety of contexts.

It may be postulated that the success of PACS is mainly due to the professionals’ improvised adaptation of the PACS technology. Digital imaging and communications systems are not predetermined products that can simply be implemented according to a rigid plan; rather, the adoption of PACS entails the introduction of a set of new processes, with unpredictable effects, in which the trajectory of events cannot be foreseen. The results affect people, their professional roles, work practice, communication, spaces and information technology — i.e. the entire organization. PACS thus represent a tool for healthcare development rather than simply an ICT tool. When organizations adopt this view of ICT innovation, we have reached the point when the real potential of the ICT can be realized.

LIST OF PUBLICATIONS

I. The Impact of PACS on Radiologists´ Work Practice
Fridell K, Edgren L, Lindsköld L, Aspelin P, Lundberg N
J Digital Imaging, Vol 1, No 1, 2006:1-10

II. PACS Influence the Radiographers´ Work
Fridell K, Aspelin P, Edgren L, Lindsköld L, Lundberg N
Radiography Vol 15, Issue 2, May 2009, pages 121-133

III. The effect of PACS on Orthopedic surgeons' Diagnostic Practice From Analog to Digital to Social
Kent Fridell, Peter Aspelin, Li Felländer-Tsai and Nina Lundberg
In press J of Telemedicine and Telecare

IV. PACS and Organizational Improvisation
An Empirical study of human factors in ICT implementations
Fridell K, Lundberg N
Submitted for publication International J of Medical Informatics

CONTENTS

1 INTRODUCTION

''Images Anytime, Anywhere: They'll Love You for It...or Not'' (Mazurowski, 2005)

During the Renaissance, the sculptor and painter Michelangelo wrote: *"The greatest artist has no conception which a single block of marble does not potentially contain within its mass, but only a hand obedient to the mind can penetrate to this image."*

According to Michelangelo, it was up to the sculptor to free what was inside the material. This is a powerful metaphor for today's radiology, a profession which today offers methods for extracting very useful medical information which can be found in enormous blocks of binary data. For a full understanding of the potential of these methods, new strategies and new work processes will be required. It is not simply a matter of images in digital form (Thrall, 2005, part II).

Commitment to IT and its share of the cost burden have increased both in the corporate sector and in preventive health care and health care (Gäre, 1999; Lundberg, 2000). For 2007, a budget of SEK 200 billion was allocated to preventive health care in Sweden; six billion of these were for IT (Sveriges Landsting- och kommunförbund [The Swedish Association of Local Authorities and Regions]), (Statistiska Centralbyrån [Statistics Sweden]), (Socialstyrelsen [The National Board of Health and Welfare]), (Dagens Medicin 2006).

The production of digital images has been well-known within radiology for many years. Modalities such as computed tomography, magnetic resonance tomography and medical ultrasound have, since their introduction, been based on the production of digital images. In many cases, these images have been converted into analogue form for further handling, e.g. for display during rounds or for archiving. During the 1980s, a new concept called picture archiving and communication systems (PACS) was introduced, which allows continued handling of X-ray pictures in their original digital form (Lamminen a, Lamminen b, 2003). Lawrence (2005) writes that technology is increasing and spreading in an explosive way to areas other than radiology, e.g. cardiology, pathology and ophthalmology. Lemke (2003) and Foord (2001) report on studies of the expansion of PACS as an IT tool within radiology. Both articles show the same trend: greater distribution and extended use of the production system. Several studies have identified problems related to the implementation of complex technologies such as PACS and electronic health care records (Collin 1995, Heath & Luff 1996, Strickland 1997, Nagy et al 1997, Berg 1998, Wild, Peissl & Tellioglu 1998, Bryan, Weatherburn, Watkins & Buxton 1999, Lundberg 2000). Everywhere, the problems appeared similar, irrespective of the national health care system (Lundberg, 2000). There were a few dominant vendors. Each vendor had its own system, which did not vary by country - one bought the same computer system in USA, China and Sweden. The full potential of these technologies has not been achieved, and their use is thus limited (ibid.). Therefore, there is a need to study more closely how the use of information and communication technology (ICT) in healthcare can be improved. To improve the use of ICT in health care, we need to understand the underlying reasons for

the problems and what accelerators and decelerators are central in the use and change process that is related to the use of new ICT. We gain some insight into this question by focusing on the medical profession's interpretation of how the professional role, work practice and technology change over time through the use of ICT, but also by identifying accelerators and decelerators in change processes in health care related to the implementation and use of new ICT.

Lundberg (2000) shows that the use of PACS influences how the work is performed and in which order the different activities are carried out. However, there is a lack of studies on the sociological aspects of the introduction of PACS with a focus on how humans accept it and their opinion of the new technology. Such studies can help us to understand the influence of PACS on the context into which it is introduced.

The study was longitudinal, extending over a period of seven years. The aim of this research was to inform health care management of change processes relating to digital image management and PACS use through an understanding of its effect on professional roles, work practice and technology in use, as well as highlighting accelerators and decelerators in change processes associated with the use of PACS in health care. Due to staff changes and other factors, certain respondents were the same and certain were new. However, the purpose was not to measure the change in the same individual's opinions over time, but to describe the opinions about the change process at different stages of the process.

The definition of PACS used in this thesis refers to work with digital information and work flows within radiology and its referral units. This includes the PACS installation in question, other PACS, digital modalities, the radiology information system (RIS), other electronic health care records, etc. PACS is thus used as an umbrella term for the digitized health care work flow.

Improvisation is defined according to Ciborra pp 369 (Ciborra, C (1999) Notes on improvisation and time in organizations, Accounting, Management and Information Technologies 9:77-94.)

> *Improvisation is situated performance where thinking and action seem to occur simultaneously and on the spur of the moment. It is purposeful human behavior which seems to be ruled at the same time by chance, intuition, competence and outright design. In improvising, features of a situation are "suddenly" framed and combined by the actor, so that they become resources at hand for intervention. "During" the suddenness of the problematic situation, the problem solving strategy and the deployment of resources for implementation precipitate into a burst of action.*

2 AIM OF THE STUDY

The main research question in this study was “How do radiologists, radiographers and orthopedics perceive that their profession, work practice and use of the technology have been influenced at their departments in the region of Skåne and at Karolinska University Hospital following the introduction of digital image management and PACS?” The aim of this research was to inform health care management of change processes related to digital image management and PACS use by understanding the accelerators and decelerators in health care change processes in detail.

This thesis emphasizes three different aspects—professional role, work practice and use of the technology—both because these aspects are fundamental to health care work and because each aspect is related to the others. Over time, the role of each aspect is defined in terms of how that aspect is related to the other aspects.

The main research question and aim have been addressed by considering the following issues:

1. How does PACS affect the radiologist’s professional role, work practice, and technology in use?
2. How does PACS affect the radiographer’s professional role, work practice, and technology in use?
3. How does PACS affect the orthopedist’s professional role, work practice, and technology in use, from the perspective of how corresponding developments have affected radiologists?
4. What is the connection between improvisation in work and the use of digital image management and PACS in health care organizations in Sweden?

3 BACKGROUND

This section provides a brief description of the radiological services and work as well as the information and communication technologies (ICT) used in the radiology and orthopedic departments. It is important to have insight into the radiology and orthopedic services in order to understand the effect of new ICT on these departments regarding professional roles and work practices.

3.1 RADIOLOGICAL SERVICES

A radiology department is mainly a service department for health care units within the same hospital and for primary care centers; however, depending on the nature of the radiology department, it may also provide services to other hospitals. The department may vary in size from a few employees to over 100 employees. The larger radiology departments do not only perform diagnostic tasks; in combination with diagnostics, they can perform various treatment interventions. Examples include opening clogged arteries in blood clots and different treatments for cancer diseases as well as support in interventions for kidney diseases. At the larger or medium-sized departments, these interventions are usually divided between sections. These sections perform examinations within orthopedics, urology, gastroenterology, thoracic conditions and mammography; there may also be a special section for children.

Today, a typical radiology department in Sweden / in the Swedish region of Stockholm or Skåne performs a large number of examinations, which may range from 20,000 to 200,000. These may include conventional examination methods, magnetic resonance imaging, computed tomography, and ultrasound; there is also likely to be a section for artery examinations and treatments, where interventions are performed.

The study included six radiology departments. Of these, three departments performed a comprehensive range of examinations. Three departments only performed conventional examinations. The introduction of PACS in these departments was included in a commitment to paired hospitals, which meant that hospitals in the region collaborated in pairs as a method of increasing availability and effectiveness.

Berggren (1982) studied the introduction of computed tomography (CT) and the changes in professional roles that occurred in conjunction with it, concluding that it was generally not possible to predict developments prior to the introduction of the new technology. The same conclusion would seem to apply to the context of this study focusing on digital imaging and PACS.

Radiological work is complex, with large numbers of contacts both within and outside of the radiology department. The main radiological task is to provide a diagnosis; however, as mentioned, treatment can be performed as well. To facilitate the workflow, there is support available for different systems, including PACS.

In this study, radiological practice is defined as a radiological occupation, i.e. a community of practice with defined tasks and a set of relations between them. New radiologists and radiographers learn by conducting the defined tasks as well as through the interactions and relationships within the community. The professional role is defined as the staff's interpretation of core abilities needed to perform work and properties of work.

The starting point for the work of the radiology department is a question which is sent via a referral to the department. This launches a number of activities which interact with each other. One activity must be completed before the next can be started.

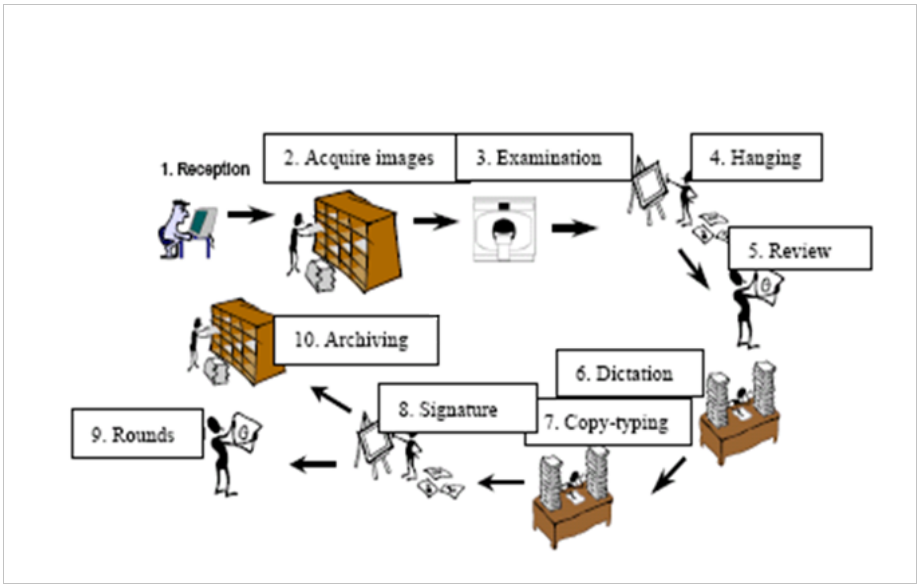

Figure 1. Illustration of the workflow in an analog radiology department.

3.2 COMPUTED MODALITIES, PACS AND RIS

The change from an analogue to a digital environment has been described as dramatic, and one of the greatest changes in the history of radiology (Osteaux, Van den Broeck, Verhelle & de May 1997). The interactions between work practice, digital technology and changes within professions have not been analyzed sufficiently (Crump & Pfeil 1995; Schrader, Kotter, Pelikan, Zaiss, Timmerman & Klar 1997).

X-ray radiation was discovered in 1895, and it was realized at an early stage that one of the properties of this radiation was the ability to darken photographic film. As a result, photographic film was used to record data from X-ray examinations when the method was introduced into health care. Today, this method is referred to as the analogue work method. This entails the direct imaging of the patient on a photographic film. Examinations were performed in this way until the 1990s. At this time, photographic plates were introduced instead. These could collect the X-ray radiation which passed through the patient and transfer it to a computer. However, the image, which was now in digital form, was still transferred onto the usual photographic film. The reason for this was that there were not sufficient technological possibilities within radiology to

transport or store the film in digital format. It was this problem that the introduction of PACS addressed.

Until the 1970s, radiology relied on two methods: one was the conventional method of examination with X-ray tubes and photographic film, and the other used angiographs. The latter method entails injection of a contrast medium into the patient's blood vessel to enable diagnosis. This method of examination was also documented using photographic film.

During the 1960s, experiments were performed where instead of the conventional method of taking a photographic image of the patient; a cross-section of parts of the patient was created. For this method to develop, very powerful computers were required for the mathematical calculations involved in creating the examination images. These powerful computers were introduced during the 1970s. This was also the start of the development of computed tomography and magnetic resonance tomography.

Computed tomography involves an X-ray tube which rotates around the patient. The radiation transmitted through the patient is gathered and the measured values are sent to a computer. The computer then reconstructs a cross-sectional image of the organ being examined on a matrix. This meant that the images produced were digital, but in order to transport and store them they were transferred, as mentioned earlier, to photographic film.

Magnetic resonance tomography, which also produced cross-sectional images of the patient, was introduced into health care during the 1980s. With this method, the patient lies within a powerful magnetic field. Radio waves sent through this magnetic field are absorbed by protons in the tissues of the patient. When the radio signal is switched off, radio waves are returned to the transmitter where they create measured values of the signals. In a method similar to computer tomography, we could now, with the help of powerful computers and a matrix, create cross-sectional images of the patient's organs. The images in this case were also digital, but for further transport and storage, they were transformed into photographic film.

The new methods of examination produced large amounts of photographic images and together with the conventional methods this caused extensive problems with management and archiving. Large storage areas and personnel for administration were required.

When PACS was introduced during the 1990s, it was as an easier way to manage examination material produced by the radiology departments. PACS was based on managing images in digital format and as described, the basis for these digital images was already available, since photographic plates and computed tomography as well as magnetic cameras produced images in digital format during examinations.

PACS is a world-encompassing computer-based system for the archiving, distribution, communication, display and processing of digital images. PACS has existed for about 25 years and was developed in Europe. The first system was not installed in Europe, however, but in the USA in the beginning of 1980 at the University of Pennsylvania,

UCLA, and Kansas City University. A few more or less successful installations also took place in the Netherlands, Belgium, Austria, the United Kingdom, France, Italy, Scandinavia and Germany. Most of these were installed with a focus on a system to be linked to a radiology department. The first systems to integrate other users as well were implemented at the beginning of 1990 at the Hammersmith Hospital, London, and in Vienna (SMZO). There are a number of references describing the development of PACS (Huang; Lemke 2003).

Figure 2. Schematic illustration of a department using PACS

The main function of PACS is to archive and distribute images. However, PACS is also designed to facilitate other tasks within radiological work. Examples include: 1) the manipulation of images by changing the gray scale or enlarging sections of the image or by taking measurements of the image, 2) creating work lists for the organization of the work, 3) retrieval of previous radiological examinations, 4) reconstructing three-dimensional images of, for example, CT or MR examinations (Lundberg, 2000).

PACS is closely related to RIS (Radiology Information System), which is an administrative system used to manage administrative routines related to the performance of X-ray examinations. The patient is booked for examination using the RIS, which then links the patient's ID to the examination images to be stored in PACS.

The computed modalities, PACS, and RIS have together created the distributed radiology department. The distributed radiology department can be defined as involving the sharing and transfer of data within and across health organizations (Orlikowski, 2002). In this study, the term "PACS" refers to the communications and archiving system as well as digital images.

3.3 ORTHOPEDIC SERVICE

Orthopedics is a branch of medicine which treats the musculoskeletal system. An orthopedic facility serves outpatient centres, emergency departments, surgical departments and health care departments. Orthopedic surgeons specialize in

orthopedics after graduating from medical school. They meet their patients at the places described above. Regardless of how orthopedic surgeons meet their patient, their first task is to diagnose the problem that led to the consultation. In most cases, this results in the orthopedic surgeon referring the patient to the radiology department for further examination. A decision is made on further examination or treatment based on the radiologist's opinion and the orthopedic surgeons own opinion of the X-ray results, together with other clinical data. Orthopedic surgeons work in a very large field and require various support systems for their work.

3.4 ORTHOPEDIC COMPUTERIZED SUPPORT SYSTEM

Orthopedic surgeons use a number of different computer systems to help them in their administrative and practical work. These include *electronic health records* (EHR), *PACS, quality systems and e-mail.* Communications are made through e-mail systems which can distinguish between the different clinics.

The EHR and PACS systems used are described below, because these are the most central systems in the production process.

ELECTRONIC HEALTH RECORD

The central EHR is a standardized database system for managing patient records. There is one central database that makes it possible for many hospitals to use the same files. The technical solution builds on three different parts: a platform, various modules, and integration functions.

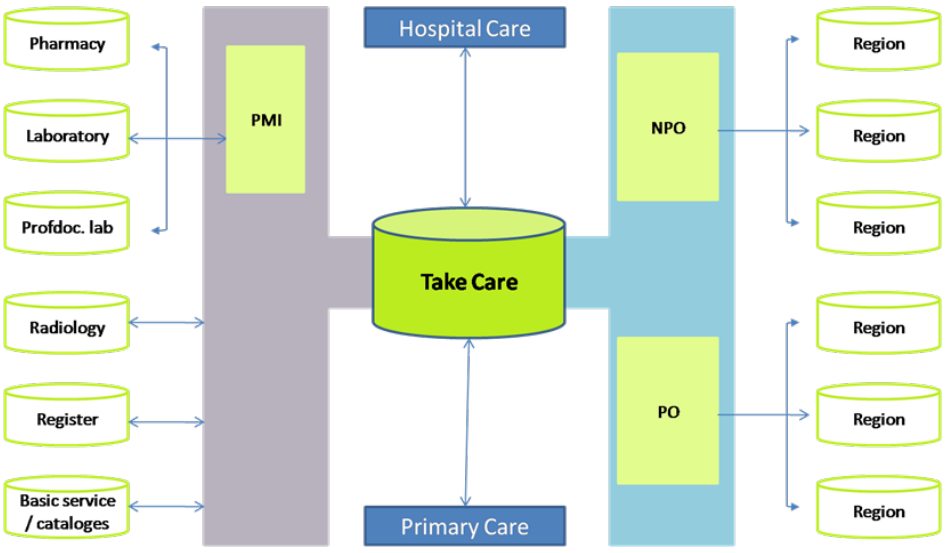

Figure 3. Illustration of Electronic Health Record in Stockholm County

The modules include *documentation* with functionality for managing patient records, writing letters to patients, templates for other administrative communications, general information about the patient, and numerical data about the patient's physical status. There is a module for recording medication that the patient is using and has used previously. One module is designed to manage requests for various examinations for

the patient, such as radiology or laboratory requests. Another module supports planning of the patient's progress through the health care system. This module is linked to a

The activity module shows the status of examinations and tests that have been ordered. The multimedia module makes it possible to save images, sound files and video files related to a patient. There is a module for management of patients' admission and discharge details. This module may include an interface with the hospital's general system for financial management.

LOGISTICS PLANNING / EHR SYSTEM

The logistics planning / EHR system (Orbit) is a program designed for supporting the information flow and planning of the operating departments at hospitals. In the operating departments there are many actors and the logistics between these actors are important. The system is also designed for evaluation of the activities carried out in the department as well as for presentation of statistics and reports.

Orbit is designed for both planned and emergency activities. The system provides automatic suggestions for operation schedules and coordinates the planning of different activities between different activities.

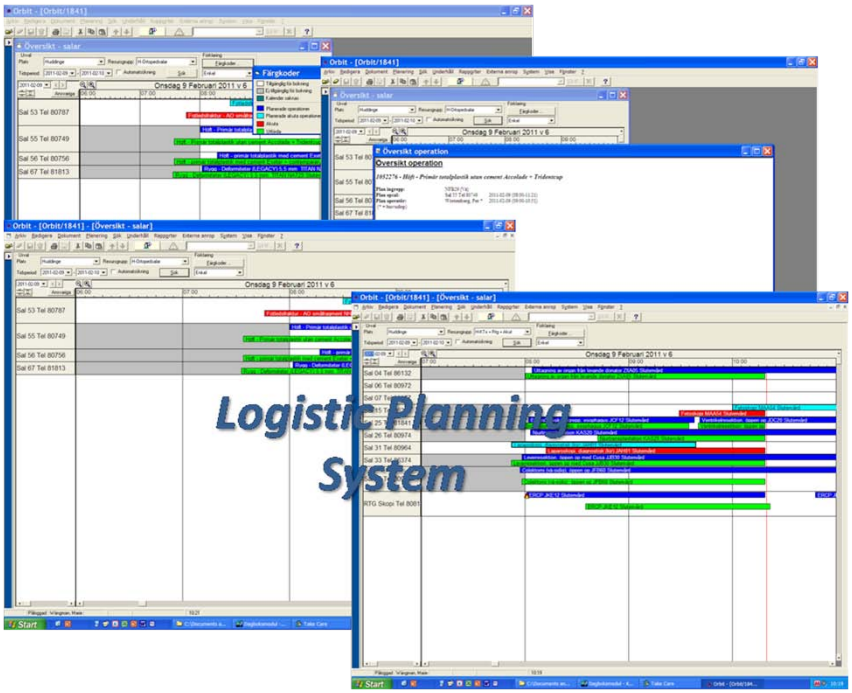

Figure 4.Overview of a Logistic Planning System

The system includes four different types of activities: 1. Preoperative functionality for managing lists of surgery requests based on priorities defined in advance. This also takes care of other information related to the patient's surgery, such as the case history. 2. The planning module takes care of the bookings from given resources and rules specified to the system in advance. 3. For surgery, the system registers the time and duration of every operation, the staff involved, any complications during the operation,

materials used, and other data from the operation of relevance to the patient. 4. The postoperative module supports documentation of the postoperative process for the patient and the patient's physical condition after the operation.

Today, the system is installed at about 35 hospitals in the Nordic countries. Further development of the system is taking place, with new functions such as new statistical methods and links to medical equipment used.

3.5 RELATED RESEARCH

Related research on PACS in health care has focused on technical, economical, workflow, sociological and management issues. The change from an analogue to a digital environment has been described as dramatic, and one of the greatest changes in the history of radiology (Osteaux et al, 1997). The interactions between work practice, digital technology, and changes within professions have not been analyzed sufficiently (Crump & Pfeil, 1995; Schrader et al, 1997).

Research has slowly started to focus on PACS implementation not only as a technological project but also a project of change (Knepper, 2007). Cohen, Rumreich, Garriot & Jennings (2005) write that in order for PACS to be a successful project, "cultural" changes at the level of the individual are also required. If the introduction is considered on the basis of the change in perspective, the processes which evolve from changes also come to light, e.g. the resistance to these changes (Gäre, 1999 and Cohen et al, 2005).

3.5.1 Technical and economic focus of PACS-related research

The initial research on PACS was, naturally, focused on the technological and economic issues (Strickland, 1996, Bryan, Weatherburn, Watkins & Buxton, 1999, Brelstaff, Moehrs, Anedda, Tuveri & Zanetti, 2001). Recent studies of the costs involved show wide variation, from findings that large savings are possible to reports of never being able to realize a return from the investments (Eggers, 2007; Friedman, Halpern & Fackler, 2007). The costs cannot only be compared to expected savings; they must also be compared with other and changed possibilities (Arenson, 2000; Saaranummi, Inamura, Okabe & Laerum, 2001). According to Saaranummi et al (2001) the challenge is to realize that reorganization can result in extensive possibilities for savings. Siegel and Reiner (2002) agree. PACS is described as the system which resulted in a review of the workflow, which in turn resulted in large profits.

> In 1998, Reed Gardner, an informatics pioneer, stated: *"In my opinion, the success of a project is perhaps 80 percent dependent on the development of the social and political interaction skills of the developer and 20 percent or less on the implementation of the hardware and software technology!"* (Lorenzi & Riley, 2000)

Recent studies of radiology systems implementation emphasize teleradiological descriptions (Thrall, 2007), but still there is an interest in implementation descriptions of PACS (Haugen, 2007), workflow (Mariani, Tronchi, Oncini, Pirani & Murri, 2006), PACS integration with other health systems (Kolovou, 2005), hardware and infrastructure aspects (Brelstaff et al, 2001), leadership and changes in the radiology department (Bedel & Zdanowicz, 2004, Lawrence, 2005), as well as effects of PACS on work practice (Yu, 2005).

3.5.2 Workflow focus of PACS related research

Work tasks which can be performed by the computer can free time for radiologists so that they can focus on more complex tasks. Lundberg (2000) showed that implementation not only influences the technology which is to be integrated, but also the people, work routines and organizational aspects. Saaranummi et al (2001) emphasized that PACS open up a possibility to implement new diagnostic routines. However, the real challenge is reorganizing the workflow within the radiology department (ibid.). The same ideas are expressed by Siegel and Reiner (2002), who describe the changes in routine work and workflow that took place during eight years' experience of PACS. They found that PACS brought about a review of the workflow in the department, resulting in greater flexibility. The focus related to the PACS implementation process has shifted from the technological aspects towards workflow issues. According to Sacco, Mazzei, Pozzebon and Stefani (2002) cost savings result from reductions in staff rather than from the elimination of film and chemicals. Such staff reductions are highly dependent on optimizing the workflow in the department. To realize the potential of PACS, the implementation process must be considered as a whole, including users, strategic decisions, and insight into the risks involved in the process. Van Essen and Hough (2001) emphasize the importance of adapting the PACS to the radiological profession and not the other way around.

3.5.3 Sociological focus of PACS related research

The introduction of new technology tends to erase professional boundaries for those professions in the environment where the new technology is introduced (Foster, 1986). Cabrera (2002) pointed out that it was only following the implementation of PACS that the need for a reformation of professional roles was realized. Carrino (2003) states that the relationship between humans should be examined: technology can change. In a study applying Blackler's knowledge theories and ethnographical qualitative methods, Larsson et al (2006) and Larsson, Lundberg & Hillergård (2009) analyze and describe how the transfer from analogue to digital technology influenced the work of radiographers and the requirements for knowledge. They found that the introduction of PACS did not simply entail the transfer of data and information from the analogue to the digital world, but also led to the introduction of new ways of communicating, and new activities and responsibilities for radiography staff. Radiographers are required to work increasingly independently, and individuals need higher levels of professional expertise. In all, these articles describe how new technological solutions lead to substantial changes in work.

Historically, the implementation of PACS occurred as a practical solution for radiology and was seen as an isolated "radiology departmental solution" (Hagland, 2007). This opinion was revised in a study by Aas and Geitung (2003) who interviewed 26 radiologists at 11 wards in Norway. They found that the most common reason for establishing teleradiology was to increase the accessibility of radiology images from the clinical wards.

Lundberg (2000) conducted an ethnographic study on the change of work practice in the PACS-based department. One conclusion from this study was that the larger the sociological network, the greater the difficulties in coordinating all actors involved in the process. These results are in line with theories on complex systems (Senge, 1990; 1999; Levin & Normann, 2000; Normann, 2001). This socio-technological field developed to address the problems that arise when humans and technology are to work together. It has been found that technological systems introduced without taking the related social systems into account may disturb or even break the established social systems (e.g. Trist & Bamfort, 1951).

3.5.4 Management research in relation to PACS implementation

The management perspective is very scarce in the literature of the implementing and use of PACS. The importance of good management when implementing PACS is emphasized by Hasley (2002) and Carrino (2003). They write that the management should have a vision, strong support from people in the immediate surroundings, and a strong conviction that the project will succeed.

In recent years, there have been studies published with a more theoretical perspective than before on the evaluation of implementation. The theoretical perspective comes from users' acceptance and focus on technology usage or technology acceptance Other models have developed from the perspective of diffusion of innovation, focusing on factors which are thought to be critical to the adoption of PACS and IT (Duyck et al, 2008).
Van der Wetering, Batenburg and Lederman (2010) conclude that strategies for implementation, strategic and situational planning methods for the evolution of PACS maturity are scarce in the scientific literature. Consequently, they propose a strategic planning method for PACS deployment. This method builds upon a PACS maturity model (PMM), based on the elaboration of the strategic alignment concept and the maturity growth path concept previously developed in the PACS domain.

Niss (2010) followed a university hospital that implemented integrated RIS/PACS. In the process, it became clear that some aspects of the changes had been ignored and that the impact on the organization would be substantial. One activity was aimed at formulating a vision/activity plan by using café seminars to involve all employees. The plan for implementation included 35 activities to support the realization of the vision. Bottom-up organizational development does work—provided that responsibility for the process is delegated.

From the above, it is clear that there are a number of studies which focus on different aspects of the introduction of PACS. Few have however tried to view the

implementation and use of PACS in its organizational and social context. We have found no such longitudinal study within this context.

3.5.5 Related research of the improvisation concept

Organization and management studies have recently shown increasing interest in improvisation process and in unplanned behaviors (Leone, 2010). Ciborra (1996) introduced the concept in an article, where he argued that improvisation is a much more grounded individual and organizational process then planned decision making. Traditional MIS theory focuses on planned decision making, but he argued that improvisation is a ubiquitous process in economic institutions.

Crossan et al (2005) provided a useful framework outlining the conditions in which improvisation is important in organizations. They based their model on the idea that improvisation contains elements of both creativity and spontaneity, but that these elements can exist independently. They described improvisation as "an orientation and technique to enhance the strategic renewal of an organization".

One of the reasons to study organizations from the perspective of improvisation is the very promising explanatory potential of this concept. Previous researchers regarded organizational improvisation as a medium to obtain positive outcomes (Leone, 2010).

The literature (Ciborra in Avgerou, 2009), (Leone, 2010) still offers multiple definitions of improvisation, even if it is quite possible to identify several common aspects that scholars usually relate to this concept. In particular improvisation is a *creative* process, characterized by *spontaneity* and *extemporaneity*, peculiar features that have been often overemphasized by literature (Leone, 2010, p. 3). According to Ciborra (1996) some of the key components of improvisation are immediacy; situatedness; idiosyncrasy; local knowledge; access to and deployment of resources at hand.

Crossan (2005) relate planning and improvisation on the basis of two dimensions, time pressure and uncertainty, which have been frequently suggested as stimuli of improvisational processes.

Outcomes of improvisation rely on experience and consolidated routines (Leone 2010). This process involves a specific learning loop to reach a reconfiguration of new routines and knowledge. Some organizations, promoting experimental culture and emergent learning, captured improvisation principles in their cultures, strategies or structures of *"designed chaos"* as a state of mind (Leone, 2010, p. 2).

The ability to adopt and change is essential for organizations (Ciborra, 1996). Improvisation has a purpose and occurs during action (Ciborra, 1996); it has a learning potential, often dealing with the unforeseen (Avgeruo, 2009). Individuals who improvise need to be adaptive and flexible, and have an open mind toward change (Crossan, 2002, Orlikowski, 1996).

The improvisation concept highlights the need for longitudinal studies to make it possible to see the real changes (Ciborra, 1996).

Researchers use a large number of metaphors to describe improvisation (Lewin, 1998). This is one of the main criticisms of the use of the improvisation concept in research (Leone, 2010). As a consequence, scholars attempted to define a formal theoretical framework related to improvisation (ibid). This was done initially through the construction of grounded theories and later through the identification and empirical testing of some of the antecedents and consequences of improvisation (ibid).

4 METHOD OF DATA COLLECTIONS

"T*he best way to get information on how people think about things is to ask them."* Kvale (1996). Therefore in the present thesis the primary method of data collection chosen was the use of interviews (Jaber, 2002).

The reason for this choice of method arises from the purpose of the study, to describe how radiologists, radiographers and orthopedic surgeons interpret and conceptualize the changes which have occurred as a consequence of the introduction of PACS. The opinions offered reflect the respondents' subjective experience over time. Interviews were identified as the method which would most effectively elicit these subjective opinions. Other methods, such as the use of a questionnaire, were also considered. The advantage of an interview is that it provides an opportunity for a respondent to include information which otherwise might not have been obtained, for example if a questionnaire is used.

The qualitative interview resembles one of a normal conversation. The researcher sets the thematic context but, at the same time, should not control the conversation. In a qualitative interview, standardized questionnaires are not used since the conversation might be too closely controlled. However, it is possible to prepare a set of general questions, to ensure that specific themes or issues are addressed in the interviews. For this study, a manual with a few key themes was used. The themes covered in all the interviews were: *adaptation, changes in the professional role, changes in the work organization and acceptance of the new technology.* There was also an opportunity to expand the content of the interview with information classified under the heading other.

During the interview, the manual does not need to be followed rigidly; the questions should just be asked in a natural order emerging from the discussion. While it is important that the interview covers those themes decided on, it also allows space for other topics to be raised. The purpose of the qualitative interview is to increase the value of information and to create a base of deeper and fuller understanding of that which is to be studied (Holme & Solvang, 1991).

For this study, the interviews were carried out in the following way:

- The respondent was invited into a separate room at the clinic in question.
- The time scheduled for the interview was communicated to the respondent in good time. The time allowed for each interview was one hour.
- Before starting the interview, the respondent was given the manual that was to be followed during the interview

- During the interview, notes were made about the answers given by the respondents relating to each of the previously identified themes
- The interview was concluded with a verbal summary by the interviewer of the informant's responses, thus providing an opportunity for the respondent to correct or add to the interview material.

5 METHOD

In this section, the use of grounded theory is presented. This method became the starting point for gathering knowledge about qualitative changes in relation to the use of information technology in healthcare. The section begins by presenting the theoretical background, followed by a short history of the application of grounded theory, and finishes with a discussion about the criticisms of grounded theory.

Grounded theory is a method of research developed within medical sociology which is now also applied in many other areas of medicine, e.g. oncology (Madsen, Holm & Riis, 2007), gastroenterology (Hall, Rubin, Huning & Dougall, 2007), odontology (Newton, 2007) and in medical information methods (Hendy, Fulop, Reeves, Hutchings & Collin, 2007 and Obstfelder, Engeseth & Wynn, 2007). The method has also spread within many other areas of research, such as economics (Gustavsson, 1998) and pedagogy (Håkansson, 2007).

Grounded theory (GT) is a form of empirical research which has realistic observation as its only source of knowledge. Theories are based on empirical research which increases over time.

Knowledge generated within scientific disciplines is generally structured in terms of theories.

Traditionally, a distinction is made between two scientific theoretical traditions, the positivistic and the hermeneutic traditions, and their respective methodologies, the quantitative and the qualitative method theories. These method theories are also known respectively as deductive and inductive. These two scientific traditions describe different kinds of theories. Within the positivistic tradition, the theories constitute clauses which describe connections between different measurable data, while the hermeneutic tradition creates theories on occurrences which are not directly measurable; people's conceptions of reality are studied instead. The theories within the hermeneutic tradition have as their goal to describe how people see reality.

Grounded theory (GT) falls within the hermeneutic theoretical tradition. The purpose of GT is to describe theories directly derived from empirical data. Unlike many other qualitative methods, the way in which the method is to be used in data collection, in analysis and in describing theories has been carefully identified (Glaser & Strauss, 1967). As a result, GT is both a scientific tradition and a method. In this study GT is used as both method and theory.

As indicated above, the idea of GT is to generate theories. Theories can be described at three levels of abstraction (Hartman, 2001). At one extreme there are theories with a high degree of abstraction; these are intended to provide general explanations. At the other end are smaller working hypotheses, which are intended to describe the connection between a few characteristics. Between these, there are theories which do not provide general explanations for society at large but which do describe relationships between a few characteristics. In this instance, the use of GT is intended to describe and understand the phenomenon which is common to a group of people. The theories in this case are based on categories, and the characteristics of each category. The opinions to be described are those collective opinions at a specific point in time.

The purpose of this study is to describe and understand how different groups of people, e.g. radiologists, radiographers and orthopedic surgeons interpret and conceptualize how their **professional role, work practice and technology use** has been changed through the introduction of a computed image management system at a number of radiology and orthopedic departments in Sweden.

The reason for this choice of study method is that grounded theory is suitable for studies where earlier research is scarce (Charmaz, 1990), as the study addresses changes which occur in connection with the introduction of a digital image management system within radiology services over a recent seven-year period. However, studies dealing with computerization of other businesses do exist; see e.g. Gäre (1999, 2003). It may also be logical to choose this method as it has the potential to add to the understanding of social processes and shed light on general events, not just on the actions of individual people (Guvå & Hylander, 2003). Glaser (1978) writes that grounded theory concerns phenomena which are undergoing a process of change.

5.1 GROUNDED THEORY – A SHORT HISTORY

The concept of ‘grounded theory’ was developed in the early 1960s by two American sociologists, Barney Glaser and Anselm Strauss. They studied people approaching death, who were being cared for in hospitals. The study was published in 1965 under the title *Awareness of Dying*. Later they wrote the book *The Discovery of Grounded Theory* (Glaser & Strauss, 1967), where the inductive method used in their study is more described in more detail.

Glaser and Strauss had different academic backgrounds, but shared a discontent with the traditional qualitative and quantitative methods. These different academic backgrounds later became the cornerstones of grounded theory (Hartman, 2001).

According to Glaser and Strauss, the limitation of the established deductive method was a one-sided emphasis on the importance of hypotheses, without explaining how

these arose. In the established methods of qualitative research, the problem was that data collection was controlled to a marked extent by earlier theory building, and so could not be performed in an unbiased way. There was a risk of missing important data, as one simply did not know in advance which data would turn out to be important.

Glaser and Strauss went their separate ways, and later interpreted their joint method in somewhat different ways. These were described in the books on grounded theory which they later wrote individually (Hartman, 2001). Strauss published *Basics of Qualitative Research: Grounded Theory procedures and techniques* in 1990 with Juliet Corbin, and this is probably the most popular book on grounded theory.

Both Glaser and Strauss describe three phases of the research process; however, they assign different procedures to each phase.

Strauss calls the different phases *open, axial* and *focused coding* while Glaser uses the terms *open, selective and theoretical coding*. In the first phase, the categories appearing in the data are generated. The difference between the researchers in this phase is that Glaser chooses one category which is identified as being more important than the others. In the next phase, Strauss identifies the relationships between the different categories, while Glaser designates his core category instead. In the final phase, Strauss finds his core category while Glaser describes the relationship between the categories.

In short, three differences can be described between Glaser and Strauss. The first and greatest is the stage at which the core category is identified. This is the category that can describe large parts of the content of the research. Glaser believes that this should be done in the first phase, while Strauss believes this should be done in the final phase of the research. The other important difference between them is the point at which the data collection is completed.

In Strauss' methodology, this is done after the first phase; Glaser recommends that an initial period of data collection is followed by the analysis of the data in terms of the three phases, after which the study continues with further data collection. The third difference between these two is the point in the study when relationships between categories are identified. According to Glaser, this should conclude the research, while Strauss recommends an early description of the relationship between the categories.

This study is based on a working principle close to the approach that Strauss recommends: first data collection, then analysis and identification of categories and core categories. One pragmatic reason for this way of working was that the data collection had to take place on specific dates.

In this study, the material was analyzed and coded using grounded theory as an *organizational principle* to describe the evolving theory. The principle was to analyze and describe emerging categories and core categories noted on each measuring occasion (1999, 2000, 2002 and 2005/06). A comparison between the different measuring occasions was then performed, and the overall core categories were then formulated, using the procedures described by Strauss and Corbin (1990). These categories described those opinions of the changes which could be identified.

The use of GT has influenced this study in several different ways. One of these was that the results should be presented in the form of a developed theory, and that this should be empirically based. Also, GT has been very useful in creating the categories. These were identified from the material examined right at the beginning of the analysis. There is some risk in applying GT of the categories being too general, and not always being directly based on the material analysed. The way the data was analyzed also gave rise to a large number of sub-categories, which were useful when the content of the core categories were to be described.

5.2 CRITICISM OF GROUNDED THEORY

In recent years, there has been some criticism of grounded theory. This is primarily directed towards some of the cornerstones of the original methodology: the decision not to use existing theoretical descriptions within the research area, and assuming that the researcher is unbiased. Researchers at the University of Linköping have criticized and developed GT. They have developed a new way of working with GT which they describe as a multi-grounded theory (MGT) (Goldkuhl & Cronholm, 2003). In this method, it is self-evident that any relevant theories already existing within the research area should be used. Naturally, with the realization that many theoretical approaches recommend the use of previous knowledge in the form of those theories existing within the area, this was a factor limiting the use of the original method of grounded theory for this study.

Other academics have criticized the expectation that researchers enter the investigation without bias (Seldén, 2005). The researcher, in order to be a researcher, has considerable previous knowledge. This inevitably means that they have some pre-understanding of what might influence the investigation. Seldén points out four further weaknesses in grounded theory which must be kept in mind when the method is used.

In a somewhat simplified version, these are:

1. Pedantic coding – the technical tail is beginning to wag the theoretical dog.
2. Losing the connection during coding - only notes, no melody

3. Lack of insight with regards to understanding which causes inability to become a strength
4. Production of general knowledge at a level of contribution which opposes theories – trivial knowledge

For the purposes of this study, the weaknesses of the method can be discussed in terms of these four points.

1) The first criticism is directed towards the detailed description in grounded theory about how the analysis should be performed in order to create categories and core categories. This can be seen as limiting the scope for freedom and creativity in building these categories. However, this feature was helpful in this study, as the research material included a large number of interviews, obtained over a long period of time. The use of similar methods in each interview over the years led to the compilation of comparable material for analyses.

2) The second criticism is directed towards the large number of categories which can be created, and the possibility that these may lose their context. It is indeed true that a large number of categories can be created. This was not seen as a problem in this study, since the analysis was performed by two researchers, first individually and then together. In addition, the ambition from the beginning was to increase the level of abstraction for the categories created. In the end, the result was based on the application of numerous different levels of analyses.

3) Qualitative studies which involve insight and understanding mean that the researcher is participating and present. Naturally the researcher's understanding will then be of importance in the analysis and in the findings of the study. In this study, one of the researchers had a background as a radiographer, and was well-informed about the context in which the study took place. Radiology-related activities are complex, and a number of different participants are involved in them. Without this previous understanding of the context, it would have been more difficult to derive a deeper meaning from this part of the study. For example, during the third round of interviews (2002) the radiographers discussed extensively the area and equipment for the development of radiographic film, which disappeared when PACS was introduced. It was not hard to understand that this location and equipment was important, as it provided and symbolized a meeting place for the radiographers during their daily work.

4) The last criticism mentioned should also be understood against the background of the qualitative methodology. It is the researcher who decides when the analysis is complete, and this may mean that the results of the study are based on the application of categories which are unacceptably basic or superficial. This was counteracted in this study by specifying that the analysis was complete only after a number of levels of analysis had been carried out.

6 MATERIAL

The material used for the study was based on interviews with radiologists and radiographers at six radiology departments in the Region of Skåne. The study also included interviews with orthopedic surgeons at Karolinska University hospital. All interviews were then analyzed with the help of grounded theory as an organizing principle.

In the following section, the radiology departments and the orthopedic clinics included in the study are presented first, followed by the number of radiologists, radiographers and orthopedic surgeons included in the study. The selected departments can be seen in the tables, as well as how many interviews were performed at each department and which year the interviews were carried out.

In 1997, a group was appointed by the management of the Region of Skåne to investigate the possibilities for the introduction of digital image management using PACS. This coincided with the desire to test a system of "pair hospitals", which meant that hospitals within the region collaborated in pairs, as a method to increase availability and effectiveness. This was important in determining which hospitals in the Region of Skåne were to be included in the study. For example, Ystad would be a hospital pair with Simrishamn Hospital and Landskrona Hospital with Lund University Hospital along with the larger healthcare centers in Eslöv and Hörby.
The radiology departments in the Region of Skåne included in the study were: the radiology department at the Lund University Hospital, the hospital in Landskrona, the hospital in Ystad, the hospital in Simrishamn, the radiology department at the healthcare centre in Eslöv and the radiology department at the healthcare centre in Hörby. However, the Hörby radiology department was closed down during the final interview session.

For the orthopedic surgeons at Karolinska University Hospital PACS was introduced at different times, at the Huddinge site it was introduced at 2004 and at the Solna site it was introduced at 2007. The implementation of PACS at the different radiology departments was carried out at different points in time and on the basis of the hospital pair structure.

Table 1. Table illustrate introduction of PACS

Hospital	Year
Lund	1999
Landskrona	1999
Eslöv	1999
Hörby	1999
Simrishamn	1998
Ystad	1998

A more detailed presentation of the different departments appears below:

Lund

The university hospital encompasses most medical specialties; it has 1,176 beds and a total of 7,850 full-time employees.

The radiology department consists of different units: Emergency Radiology, Radiology 1, Radiology 2, Neuroradiology and MR (Magnetic Resonance Tomography). At emergency radiology unit, patients coming to the emergency ward are examined. The activities in Radiology 1 include consultations, patient-related diagnostics and catheterized treatment procedures on inpatients as well as polyclinic patients. Radiology 1's areas of activities involve abdominal organs including oncology, mammography including screening, and conditions of the heart, thorax and arteries. The department also includes a thoracic section which is responsible for both conventional radiology, such as CT (Computerized Tomography) and MR, and radiological interventions within the rib cage, except for corona angiography and percutan coronar intervention (PCI). The section is also responsible for the venous diagnostics, artery access activities within X-rays as well as CT and MR of the peripheral arteries.

Radiology 2 consists of consultations, patient-related diagnostics and catheterized treatment procedures on inpatients as well as polyclinic patients. The areas of activities include children and adolescents, skeleton and soft tissue.

The MR unit performs magnetic resonance examinations of the brain, back, the ear, nose and throat region, heart, abdomen, skeleton and soft tissue.

The neuroradiology-odontological section consists of diagnostic examinations, treatment procedures and consultations in the form of rounds and conferences dealing with the cranium, ear, nose and throat and back as well as teeth, jaws, facial skeleton and salivary glands.

When the study started, year 1999-2000, a total of 61 radiologists (of which 49 are specialists and 12 are non-specialists) and 107 radiographers work in the radiology

department, 168,000 examinations were performed year 2000 and 170,000 examinations were performed year 2006.

Eslöv

The activities consist of consultations and patient-related diagnostics with the help of conventional radiology on polyclinic patients. The most common examinations are radiology of the skeleton and thorax. Mammography screening is also performed here. Three radiographers worked at the beginning of the study at the department, but when the radiology department at Hörby was closed down, the number was increased to five radiographers. The department performed 15,000 examinations per year.

Landskrona

The hospital in Landskrona consists of two medical divisions and two surgery divisions. In addition there is an emergency unit and wards for orthopedics, surgery, urology and ear, nose, and throat conditions.

There are 57 beds available and a total of 340 employees work at the hospital. The radiology department in Landskrona performs patient-related diagnostics on inpatients as well as polyclinic patients. Conventional X-ray examinations, computed tomography, magnetic resonance tomography and ultrasound as well as mammography screenings are performed for the purpose of diagnosing or treating diseases as well as following the progression of diseases and evaluating results of treatments. The number of radiologists employed is three and the number of radiographers is seven. The division performs 24,000 examinations yearly.

Hörby

The radiology department at Hörby had the same structure as Eslöv. However, the department was closed down during the study in 2005.

Two radiographers worked at the department, and these two radiographers were transferred to Eslöv after the closure.

Ystad

Ystad hospital includes an emergency unit, surgery and medical divisions, a psychiatry division, a geriatric division and an intensive care division. There is also an eye and ear ward. There are a total of 168 beds and the number of employees is 1,300.

The radiology department performs examinations on all organs with the help of conventional radiology, ultrasound, continuous X-ray screening, CT and MR.

The radiology department at the hospitals in Trelleborg, Ystad and Simrishamn have since the turn of the year 06/07 been connected during on-call hours and have a

common telecommunications link. The new organizational form resulted in an increase from 4 doctors to 15 who share the on-call burden. The radiology department are among the most widely dispersed in Sweden, with examination premises at three hospitals and radiologists living and working in ten cities, with Stockholm and Härnösand (approximately 1050 km) being the furthest apart. The department performs 38044 in 2006.

Simrishamn

At the hospital in Simrishamn there are two divisions: medical and rehabilitation. These have 30 beds. There are also a number of special wards with a total of 160 people working at the hospital.

The radiology department performs 11,000 examinations per year, including computed tomography. One radiologist and four radiographers work in the department.

Karolinska University Hospital – Huddinge and Solna

The Karolinska University Hospital encompasses most medical specialties and has two sites Huddinge in the southwest of Stockholm and Solna situated in the centre of Stockholm. Most of the medical specialities are found at both sites. Karolinska University Hospital was created in 2004 when the two hospitals Huddinge hospital and Karolinska Hospital, Solna were put into the same organization. The hospital have 1600 beds and produces 104 000 ‘’medical occasions’’. There are 15 000 employees. At the University hospital there is an orthopedic surgeon’s clinic in both Solna and in Huddinge. Both orthopedic clinics have wards, operation theatre and receptions for outpatients. There is also at both places an orthopaedic reception at the emergency ward. At the Huddinge site there are 35 orthopedic surgeons and at Solna 32 orthopedic suregeons. The orthopedic clinics use PACS in the same way at both sites. A difference is the timing of when PACS was introduced at each orthopedic clinic. At the Huddinge site PACS was introduced 2004 and at Solna in 2007.

6.1 SELECTION PROCESS

It was decided 1998, by an appointed group, to implement PACS in Skåne Region. The chair of this group decided that an evaluation of the effects from the use of PACS should be carried out. To do this a researcher was contacted to perform the evaluation. After the acceptance of the project, the researcher and a colleague initiated the project.

A radiographer, super user of PACS, located at the Lund University Hospital was engaged as coordinator for the upcoming interviews with both radiologists and radiographers at all the different units in Skåne Region. He joined the PACS implementation project at an early stage and was assigned a comprehensive responsibility for training prior to implementation at the different units. Through this

role, he became well-acquainted with the radiology departments and their personnel. It was this person who invited the radiologists and radiographers at the Lund University Hospital to participate in the study. It was also this person who contacted the department managers/clinical managers at the other participating departments.

Carrying out interviews started with the booking of an upcoming interview round. This was agreed between the coordinator and researchers. The coordinator hereafter checked the schedule for available interviews with radiologists/radiographers for that upcoming booked day. All available radiologists and radiographers available that day was asked for participation in interviews. The ones whom had signed up were booked in an interviewee schedule by the coordinator. The interviewee schedule was sent a couple of days on beforehand to the researchers. No further information was given to the researchers regarding any addition information of the booked radiologists and radiographers.

The participating respondents in the study were selected on the basis of the special method called theoretical sampling used in grounded theory (Strauss & Corbin, 1990; Folkesson, 2005). This method of selection is also mentioned by Robson (1993), who used the term *purposeful sampling.* In this selection procedure, the purpose of the investigation determines the selection of the respondents. It is important that these information sources give an overall view of the area of research and complement each other. Included in this study were different professional groups, different positions, different ages and different units. As a result, the selection of respondents may mirror the total composition of the personnel.

Table 2. Number of participating radiologists at the respective hospitals in Skåne Region

	1999	2000	2002	2005
Lund	7	5 (3)[1]	7 (3)	5 (3)
Ystad	2	4 (2)	2 (2)	2 (2)
Landskrona	2	2 (2)	2 (2)	2 (2)
Simrishamn	1	1 (1)	1 (1)	1 (1)

[1]The number of radiologists, which remained unchanged throughout the study, was 3 for Lund, 2 for Ystad, 2 for Landskrona and finally the same radiologist on all occasions during the study at Simrishamn (these are the numbers in parenthesis in the table 1).

The y-axis of the table shows those hospitals participating in the study and the x-axis the occasions on which the interviews were carried out. The table also shows the number of radiologists interviewed at each hospital at a predetermined time. The number of radiologists interviewed throughout the entire study is shown in parenthesis.

The total number of radiologists employed at the participating radiology departments was 69 for the Skåne Region as a theoretical or purposive sample (Strauss et al, 1990; Robson, 1993).Of these 12 were chosen for the study in 1999, 2000 and 2002 and 10 radiologists in 2005. A total of 24 interviews were conducted at the radiology department at Lund University Hospital, 10 interviews at the radiology department at the Ystad hospital, 8 interviews at the Landskrona hospital and 4 interviews at the Simrishamn hospital. All participating radiologists were specialists within radiology; some also had administrative responsibilities.

Table 3. Number of participating radiographers at the respective hospitals in Skåne Region

	1999	2000	2002	2006
Lund	8	14	11	5
Landskrona	2	2	2	2
Hörby	2	2	2	0
Eslöv	2	2	2	2
Ystad	2	3	2	2
Simrishamn	1	1	1	1

The y-axis of the table shows those hospitals participating in the study and the x-axis shows on which occasions the interviews were conducted. The table shows the number of radiographers interviewed at each hospital at a predetermined time

The choice of participating radiographers was made from a total of 133 possible respondents as a theoretical or purposive sample (Strauss et al, 1990; Robson, 1993). For the study performed in 1999, 17 radiographers participated, for the study in 2000,

24 radiographers participated, the study in 2002 had 20 respondents and finally for the study in 2006, 12 radiographers participated.

A total of 38 interviews were carried out at the Lund University Hospital, 8 at the hospital in Landskrona, 6 at the radiology department in Hörby, 8 at the radiology department in Eslöv, 9 at the radiology department at Ystad's hospital and finally 4 interviews at the department in Simrishamn.

No interviews were conducted at Hörby in 2006 due to the closure of the unit the previous year.

Table 4. Number of participating orthopedic surgeons at Karolinska University Hospital

	2008	Position as orthopedic surgeons
Huddinge, KS	10	1 manager 4 professors 5 specialists
Solna, KS	5	1 manager 4 specialists

Managers at both hospitals were contacted and a request was forwarded to provide information about the study to both departments. After consent had been given, further details of the project were emailed to the managers. The project was then presented by the researchers at a clinical meeting at both hospitals. At the end of the meeting, orthopedists interested in participating in the project signed up. The prerequisites to sign up were that individuals needed to:

- have working experience from both the analog and the digital environment
- be an orthopedic specialist

In all, there were potentially 67 participants as a theoretical or purposive sample (Strauss et al, 1990; Robson, 1993). At Karolinska University Hospital, Solna, there were 32 potential participants and at Karolinska Hospital, Huddinge, there were 35 potential participants.

The study including radiologists and radiographers is longitudinal, extending over a period of seven years, which means that certain respondents were the same and certain were new. However, the purpose was not to measure the individual opinions, but to describe the different opinions which existed within the change process on a particular occasion.

7 RESULT

How individuals in the organization perceive their work is important for the result of the work, both at the individual and at the organizational level. Figures 1 and 2 below present changes in how radiologists and radiographers perceived their work between 1999 and 2005/06. Changes take place when a new technology is introduced into an organization. How individuals handle these changes represents important information for the understanding of the outcome of the introduction. We have analyzed and compared both these studies in this results section in order to see whether there were any significant events or factors that have affected the process.

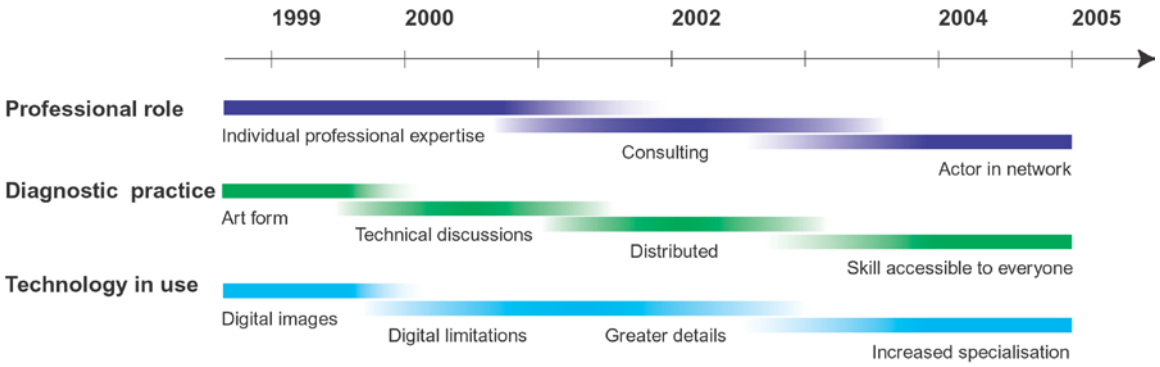

Figure 5. The changes in radiologists' perception of work from 1999 to 2005

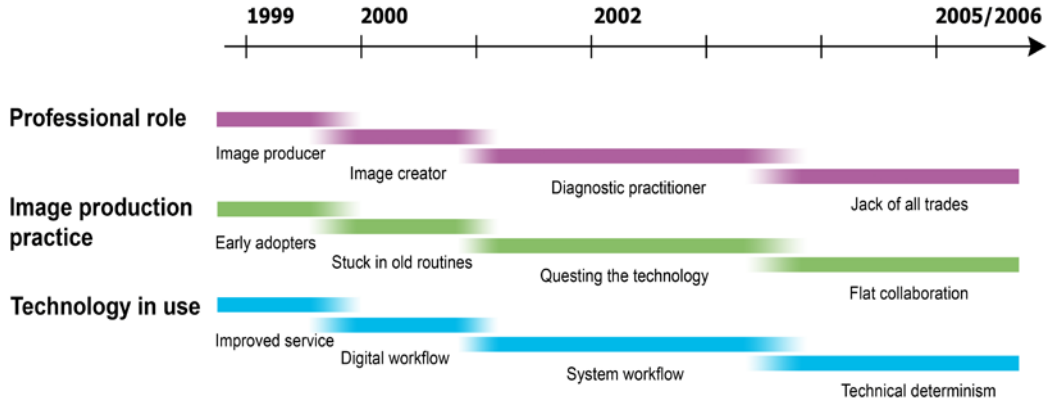

Figure 6. The changes in radiographers' perception of work from 1999 to 2005/2006

The study on which the result is based is longitudinal, lasting from 1999 to 2006. Therefore, an important aspect of the results is that it mirrors the changes that have happened over this period. Through the study's design, we can see that the changes do not happen overnight. This is important information to have when planning the implementation of a new technology (Gell, 2006).

This results section is based on two articles (Supplement 1 and Supplement 2). Each article focuses on a workgroup, with Supplement 1 focusing on radiologists whilst Supplement 2 focuses on radiographers. I will give a separate account of each article, with the aim of seeing how the results look per workgroup and year, after which I will list the common themes that are of most interest and discuss them further. The focus for this discussion is what the change has meant to the organization. One can see from the results that both workgroups are relatively similar in their definition of the parts that make up their "Work Practice". Both work categories describe their role and the technology they use. However, they seem to have differences regarding "what I do", with radiologists defining diagnostics, whilst radiographers describe image production.

7.1 RADIOLOGISTS 1999 - RADIOLOGY AS AN ARTFORM

From the beginning of 1999, radiologists described their core competencies as closely tied to the review process of radiological material diagnosis. This is so central and important that one would be tempted to describe the process as a form of art. One needs to successfully differentiate between the sick and the healthy. This process not only includes the actual diagnosis of images, but also deep knowledge of medical specialties.

"*...some colleagues are able to define 20 possible diagnoses from one patient, but the clinician is only interested in which is the most likely...*"

The material brought to light differences between older and younger radiologists as regards their outlook on this new technique. Older radiologists were somewhat cautious, whilst younger ones, perhaps due to their previous general computer use, tended to have a more positive outlook. This means that younger radiologists took on the role of teachers for this new technique.

In the analogue world, radiography images were tied to the radiography departments and could be "loaned out" if they were officially requested. The digital world opened up the possibility of allowing radiography images to be accessed by anyone with access to PACS as soon as the images had been exposed. This could cause concern among radiologists, with the risk that clinicians would themselves be able to begin diagnosing radiography image material and thus make radiologists redundant in the long term.

"*…it's possible we might no longer be needed …*"

It therefore became clear relatively quickly that radiologists belonged to a workgroup that was used to participating in decisions and so used to taking a strategic approach. Besides the possibility of the radiologists' services no longer being needed, the discussions tended to concentrate around how the profession would develop in a way that was attractive for clinics.

7.2 RADIOGRAPHERS 1999 - POSITIVE MENTAL FRAMEWORK

The first interviews, from 1999, have radiographers describing their core competencies very clearly. These involve the art of knowing which exposure parameters to use in order to result in a well exposed radiography image, without giving the patient an overly high dose of radiation. This was, however, an ability that was foreseen to have lesser importance in the future.

"…knowledge of exposure parameters will not be needed in the future …''

However, this was not seen in a positive light, as expected, in conjunction with the introduction of PACS. For the job description it was a positive challenge to work with a technique that was seen as new and modern for many radiographers. They foresaw that the new technology could possibly mean that work tasks would be shifted from radiology to radiographers. One conclusion from this reflection was that due to fewer radiography departments, there might not always be a radiologist in place, as one might instead be able to send the images to a larger unit. This would also mean that radiographers, by necessity, would need to diagnose images more carefully before sending them off. Positive changes were also foreseen for the organization. Images were now digital and could be found gathered in an image database (PACS). This should mean that they no longer disappeared, and one would often be able to avoid the lengthy search for the actual physical images. It was also foreseen that the process would be faster, as the images would be easy to access and no longer lost within the organization, which would enable a better patient service.

7.3 RADIOLOGISTS 2000 – FROM DIAGNOSTIC TO TECHNOLOGY FOCUS

In the second round of interviews, in 2000, radiologists did not discuss organizational changes to any significant degree. Instead, their conversations were mainly concerned with the fact that the conditions for diagnosing images had changed. The image diagnosis is of particular importance for radiologists and it is therefore very natural that, should the image diagnosis process change, their discussions would pay special attention to these changes. The main experience was that the focus for radiologists' work had changed from that of diagnosis to technology.

"*…today, we go to technical courses instead of to diagnosis ones …*"

This description shows the extent of the change that radiologists experienced. Much of the work that was previously done manually, for example, arranging images from a patient in a pre-determined manner, used to be undertaken by other work categories.

Now, together with the introduction of PACS, this work was expected to be done by actual radiologists. There was also much discussion regarding the quality of the digital images. In many radiologists' experience, digital images lacked the quality of analogue ones in, for example, dissolution, which is decisive for determining the minimum size of details that can be detected in the image.

7.4 RADIOGRAPHERS 2000 - TAKING ON DEPLOYMENT

In the study's second interview period, radiographers described their core competencies as consisting of two parts. The first was knowledge of exposure parameters needed to produce a well exposed radiography image, whilst the second consisted of knowing how to take a radiography image.

"*…you should know what the image will look like before you even take it …*"

Both are skills that are difficult to describe and where experience will determine one's level of knowledge. Only a few years after the introduction of PACS and digital images, and as feared by radiographers in 1999, the knowledge of exposure parameters has become less important. In interviews, radiographers instead chose to focus on the technique for taking radiography images as the most important aspect of their competence and toned down the importance of the knowledge of exposure.

"*…you should know what the image will look like before you even take it …*"

The context in which radiographers worked had undergone significant changes. Radiology images were developed faster using a machine. The procedure involved feeding the exposed radiography images manually into a machine to develop them and the developing process only took a few minutes to produce the developed images. These images were then manually shown to the radiologist. Both these activities were undertaken in the radiography departments. Once the context changed, radiographers were no longer necessarily granted natural communication access to their colleagues and radiologists.

" *…we didn't realize what the developing machine meant to us until it was gone …*"

At this second round of interviews, radiographers discussed the policy of consciously keeping up old routines. This could be good, in terms of management, but it quickly became clear that it also made it easy to "become tradition-bound". The smaller units, for example, Hörby and Eslöv, on the other hand, were quick to take up the possibilities created by PACS, principally because they no longer needed to send patients to other units. The radiography images were taken at a health centre, and then sent directly to

the specialist radiologist. This meant that the patient could, in many cases, then stay at the health centre for treatment.

7.5 RADIOLOGISTS 2002 - THE WIND OF CHANGE

Radiologists' attitudes since the first round of interviews had changed. They were clearly more positive in the interviews undertaken in 2002. There was a shift from worries about the future need for radiologists to thoughts about how to ensure one's development in a manner that would continue to be attractive to inpatient clinics. Radiologists saw the possibility of remaining attractive to these clinics. Their work would take on more of the nature of a consultant's professional role. Modalities such as MR and CT produced more and more image material. Clinicians sought people who could choose relevant images and present them in an understandable manner. This is when the so-called "stacking tools" became very successful. This technique made it possible to present a large amount of image material from CT and MR scans in a three-dimensional presentation.

In radiology, continuous learning is important for both individuals and the profession. With the new technology, radiologists identified great opportunities for the development of knowledge at the smaller units, as the new technique created opportunities for easy access to specialists in order to discuss an image.

This round of interviews saw the winds of change blow over radiologists.

A great change had taken place in the rounds, where radiologists meet clinicians to present their diagnostic results. This had previously taken place with analogue images shown on a backlit screen. The size and format of these images made it difficult for everyone to see them, but with digital images, it was possible to display them using a projector, thus ensuring that everyone was able to see them.

''…now we are finally understanding what clinicians are actually looking for… we are asked more questions and that means we have to know more …''

This meant that discussions between clinicians increased, as well as those with radiologists. The radiologist became the person to consult before choosing the inspection modality. Radiologists experienced this change as extremely positive, now that they were included in the patient treatment team.

7.6 RADIOGRAPHERS 2002 - EMPOWERING THE PROFESSION

Previously, radiographers had identified knowledge of exposure parameters as an important part of their competency. It was quickly realized that the need for this knowledge was about to disappear, as digital images were not dependent on the exposure process. Instead, at the 2002 round of interviews, radiographers chose to describe how they appreciated no longer having to retake images due to wrong exposures, which occasionally happened before. In compensation for the loss of this competence, the new technique, through the speed at which it worked, allowed radiographers to assimilate a whole new competence into the workgroup.

"…today we began learning preliminary diagnosis of radiography images and it was great…"

Radiographers were given more responsibility for the preliminary diagnosis of radiography images, enabling them to conclude the investigation of the patient. This decision had previously come from radiologists. This new opportunity for the expansion of competence came in a new context for radiographers. Previously, in the analogue departments, radiographers worked side by side with radiologists, as radiologist needed to approve every patient. This provided plenty of opportunity for discussion and competence development. In the new digital world, the radiologist was removed without the possibility of a speedy return.

"…nowadays it feels unusual to have the chance of discussing with a radiologist …"

There were differences between the larger and smaller units. The change continued to be regarded as very positive at the smaller units. One reason for this was that there had previously been talk of closing these units, but in conjunction with PACS, they instead came to be renewed and according to the respondents, become more productive than before. One also noted that patients appreciated that they could be diagnosed at their local health centre, instead of having to travel to a larger clinic.

The suggestions for change that others tried to implement often resulted in failure, as the system was too rigid. What happened instead was that the work processes were forced to adapt to the system.

''…we are experiencing that the PACS system is very rigid …''

One change that was extremely noticeable was that the workflow through the PACS system meant that the short pauses due to waiting times that were previously prevalent, disappeared.

''…we don't get any breaks, like we used to …''

This meant that radiographers experienced increasing levels of stress.

7.7 RADIOLOGISTS 2006 - COOPERATION AND SPECIALIZATION

When we returned for the last round of interviews they mainly showed very positive aspects, even if they still contained negative points. This did not happen immediately, but took a few years, although now radiologists had become accustomed to the new technology and there were now no differences between junior and senior radiologists. The difference we found in the first years had now leveled off or disappeared. The great difference that had taken place over time was that radiologists were now able to take part as members of the team taking care of the patient, in which the radiologist represented a diagnostic specialization that had grown in importance. Quotes from the interviews include:

''…today the clinician is no longer able to place the patient into observation and see what happens in unclear cases. Instead, they want a quick answer: is the patient ill or can he be sent home …''

Quotes like this one support the development from which radiologists will continue to benefit, in becoming more and more specialized.

Many also saw the positive side, although the possibility that many clinicians would begin to investigate the images themselves had constituted one of their apprehensions at the beginning of the study. This could, in the long term, lead to radiologists gaining greater scope to make a contribution in more difficult cases and allow them to deepen their knowledge and become specialists.

In the interviews, radiologists were able to describe the development as positive for the profession. There were three main reasons for the change: the ease of access to investigation of images, 3D tools, and the possibilities opened up by the Internet.

''…today we are conscious of the possibility of retrieving images over the Internet, although the importance this will have still remains to be seen …''

This comment was made by the head of a clinic who saw the possibilities of distributing images over the Internet and used this opportunity to carry out several radiological tasks.

7.8 RADIOGRAPHERS 2006 - EXTENDING THE PROFESSION

By the end of the 2006 round of interviews with radiographers, an exciting change in their competence was revealed. Since the introduction of PACS and digital radiography images, radiographers had anticipated that knowledge of the best way to expose a radiography image would not be necessary in the future. As it turned out, this knowledge became unimportant for a few years. At the 1999 round of interviews radiographers had explained that this knowledge was important to produce a well exposed radiography image. By the last round of interviews, radiographers once again saw a need for knowledge of these parameters, but not for the quality it brought to the radiography image. The importance of this knowledge had shifted to a focus on patients not receiving a stronger dose of radiation than necessary.

"…it is important to know about kV and mAs so that patients don't receive too much radiation …"

The workgroup had now incorporated new competencies as well as taken up their earlier ones. They were very satisfied with how work competencies had developed during the change that had taken place from 1999. They found that the new work assignments involving diagnostics also necessitated new knowledge. The work was experienced as more lonely due to the loss of contact with colleagues around the developing machine and the contact with radiologists, even though this created the need for new abilities to make the preliminary judgments of the images. However, this also meant that new ways of establishing natural contact with colleagues and developing diagnostic abilities were sought.

''…we speak more and more often with our colleagues today and work together more.''

The interviews brought to light different aspects of the new technique. One aspect is that the technique today is so invisible and that one does not really understand it. Radiographers are used to the technique and understand that the system can "hang". What has happened is that the new technique is largely built on digital techniques and computers, making it invisible to those who use it. Errors that crop up can be difficult to relate to.

''…before, errors also cropped up and things went wrong. But it was easier to understand why the errors occurred and we used to have tricks to correct them nowadays it just goes wrong …''

7.9 ORTOPEDIC SURGEONS 2008

Below is a summary of the influences *that PACS have on orthopedic surgeons' professional role, orthopedic practice and technology in use*. This is followed by a more detailed description of how the concept in figure 1 has been identified.

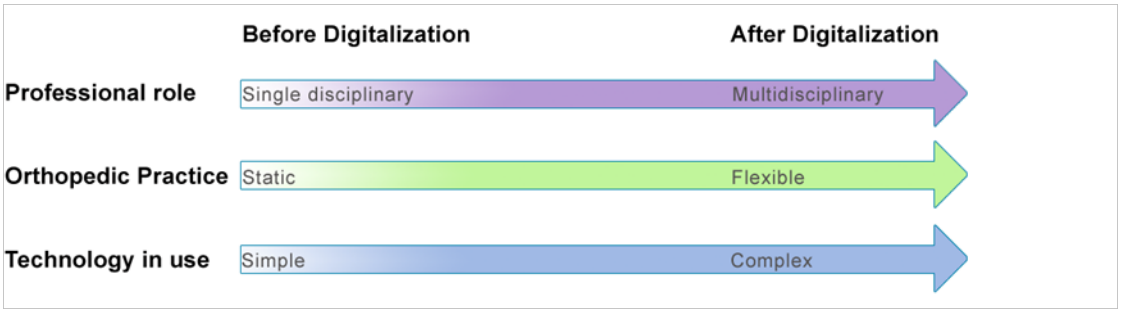

Figure 7. The consequences of PACS for orthopedic surgeons': professional role, practice and technology in use.

The result is structured as follows: first, an interpretation of the quote is presented and then the actual quote is presented.

From Single disciplinary roles

Before Digitization - Orthopedic Surgeons' Professional Role

The professional relationship between radiologists and orthopedic surgeons' has been quite clear. The radiologist's role is to read the images while the orthopedic surgeons' role is to apply that information in action, e.g. in surgical or non-surgical treatment. In practice this means that they have **single disciplinary roles**. At the clinical meetings the radiologists contribute with expert knowledge needed by the orthopedic surgeons' for the diagnostic workup.

"...The radiologists use the images to describe the phenomenon and the orthopedic surgeons' use them to plan the surgery...I want to go from image to action...what I mean is that I think that we use the image in different ways."

In the orthopedic surgeons' specialist education there is no theoretical training in image interpretation. Thus, the communication with the radiologist is a form of educational meeting for the orthopedic specialist.

"...orthopedic surgeons' view and interpret the images during a shorter period of time compared to radiologists and could therefore miss things, they do not use the same systematic way of interpreting the images as radiologists."

Orthopedic surgeons' interpret images in a slightly different way compared to radiologists. They need more information about the patient in order to make their clinical diagnostic workup.

"We may not be as interested in angles and degrees as the radiologist, but instead more interested in what kind of fracture and where the fracture is and all this in relation to the patient's age and other patient-related factors that have the possibility to influence choice of treatment and/or intervention."

The orthopedic surgeons' consider the X-ray film as an important tool in their work. When access to these films was limited, the orthopedic surgeons' possibilities to combine information related to films and clinical patient data were limited.

"…the X-ray films used to be the property of the radiology department. When viewing images there is always a need for clinical information that was not available through the PACS system…"

In the orthopedic surgeons' meeting with the patient, at the outpatient clinic, the surgeon had to rely on the diagnostic report and try to mediate this to the patient in a form that the patient could understand. This limitation was due to the lack of the access to the images.

''...when you meet the patient you always want to have the films. Depending on where you were, this was not always possible before. Often you just had the report and it was hard to describe to the patient what the problem was or what we had done...How can you in a pedagogical way describe the problem for the patient – why does it hurt – when there is no image to describe this with?"

To Multidisciplinary roles

After Digitalization - Orthopedic Surgeons' Professional Role

There are different professional roles of the orthopedic surgeon and the radiologist. Where does the radiologist's work stop? And where does the orthopedic work start? This boundary differs from individual surgeon, individual radiologist and their personal relations as well as from patient to patient. In practice, it more and more leads to the development of spontaneous groups of multidisciplinary teams that differs over time.

"...the radiologists describe but the orthopedic surgeon has to do."

The radiologists' PACS have created new possibilities for orthopedic surgeons' and radiologists to work more closely together in heterogeneous teams. The trend is a more **multidisciplinary** way of working where radiologists need to become more knowledgeable about clinical work and orthopedic surgeons' need greater knowledge about the systematic interpretation of images.

"In a way the professions are separated today, but the technology could be a trigger that makes us work more closely together in the future."

The orthopedic profession has gone through a process of specialization during the last decade. Knowledge within different areas has grown and made it impossible to be an expert on everything. This has forced orthopedic surgeons' to become more specialized, and may also force the radiologists to specialize.

"...for instance the radiologist may become an "orthopedic foot radiologist", and the radiologist will then be in the "foot team."

From Static Work Practice

Before Digitalization - Orthopedic Surgeons' Work Practice

Working in the analog environment, the orthopedic surgeon was supported in the planning and preparation work by other categories of staff working in the department. The radiologist identified and analyzed the images to be demonstrated at the upcoming clinical meeting. If an orthopedic surgeon wanted a specific patient case to be demonstrated at the clinical meeting, he/she needed to inform the radiologist in advance of the conference. If possible, the radiologist informed a secretary that additional films, relating to a specific patient request, were to be retrieved from the radiological archive and mounted on the light boards in the clinical meeting room. Performing the work required the handling and management of several actions.

''...the management of the films before we had PACS was time consuming…you always had to think in advance of what and when you want something done...it seems that there were a lot of small tasks to be done until everything was ready and orthopedic work could start..."

Conferences are an important communication forum in orthopedic practice.

"We have radiology conferences as a forum to demonstrate images to each other; this is the only formal forum where we can discuss cases between orthopedic surgeons'."

If the surgeon wanted to discuss a specific patient, the surgeon sent a request to the radiology department to have the relevant patient examinations demonstrated at an upcoming clinical meeting. The fixed properties of the film made practice more **static**.

‘’ In the old days we had to order demonstration of films in advance of the conference, in the best cases it worked, but often there were obstacles and they were not demonstrated for the orthopedic surgeon that requested them...when you requested a film to be seen at the clinical meeting you were never sure at what meeting this would be brought up. Sometimes your films were demonstrated at a later stage when you were not present because you were on leave or at a conference or...”

To a More Flexible Work Practice

After Digitalization – Orthopedic Surgeons Work Practice

In the digitized environment, images are accessible to orthopedic surgeons’ from everywhere where there is a connection to the hospital network, opening up for a more **flexible** practice.

“Now I can work undisturbed in my office. I can go through a number of requests from other places (for instance the hematology department). I can approach colleagues and ask for their opinion and retrieve the images at their work space.”

The new digitized images and communication systems open up new ways of communicating and team working between orthopedic surgeon colleagues.

“More people are able to have an opinion about a case. Earlier I firstly had to retrieve the images; secondly I had to walk over to someone to illustrate the X-ray. Ask for them to be mounted for demonstration at a conference. It is a fantastic revolution, image handling and processing.”

Digitized images and communication systems create the possibility to carry out clinical meetings from anywhere at any time where there is a PACS workstation and projector.

“During the last decades, all orthopedic surgeons’ at the hospital started their day by going to the clinical meeting at the radiology department. Today, with PACS, there are new possibilities in organize work…’’

From Simple Technology in Use

Before Digitalization - Technology in use

Before digitization, orthopedic surgeons’ used **simple** tools to support their work. These consisted of films, paper documents and templates, which have a fixed format. Template properties are tangible, exact in measures and “light in weight”. These properties have implications for the ease with which they can be physically placed and scaled in order to develop the most suitable prosthesis for patient. They have exact measures.

"…we used to have tools that were simple to use. For instance, when we were going to take measurements for a new prosthesis, we used the analog film, which could be placed anywhere. Templates were superimposed on the films to determine the exact prosthesis to use for the patient. The templates were substantial; we held them in our hand."

Working with simple films had its drawbacks.

''… before the images were digitized and in a computer, they often seemed to be somewhere else, but not where you wanted them…"

The process of purchasing and implementing PACS was carried out by radiologists and the radiology department. The involvement of orthopedic surgeons' was limited.

"We were not very integrated in the process as a group. It may be that an orthopedic surgeon may formally been placed in a working group, but it was more like a fifth wheel under the wagon, no-one here had a bird's eye view."

To more Complex Technology in Use

After Digitization - Technology in use

The PACS that was implemented was slow; retrieving images of a patient from the digital archive took 10-15 minutes on average. The expectation was that one would simply be able to press the "enter" button.

"…before, the films I needed were always preordered from the radiology department and mounted on the light board. When PACS was implemented I had to fetch these images myself from the digital archive…requiring waiting times in my work?"

The orthopedic surgeon had to log into and use many different systems at work.
"...there is not just one system... I need to log into Orbit, TakeCare, Novell, PACS..."

The systems are not integrated.

"We must document so much that I think is unnecessary. I double document in both Orbit and TakeCare; in parallel the nurses often document the same thing that I already have documented..."

After digitization, the digital environment has made work more complex, in the sense that there are more technologies, interconnections and activities included in the work.

‘’ ... with the new technology you are supposed to do things that used to be done by other occupations. We used to have secretaries to do the writing, to get information... today there is an idea that everything is so simple and not time consuming so it is easier that you do these things on your own, but the systems both take and give more time.”

7.10 PACS AND ORGANIZATIONAL IMPROVISATION

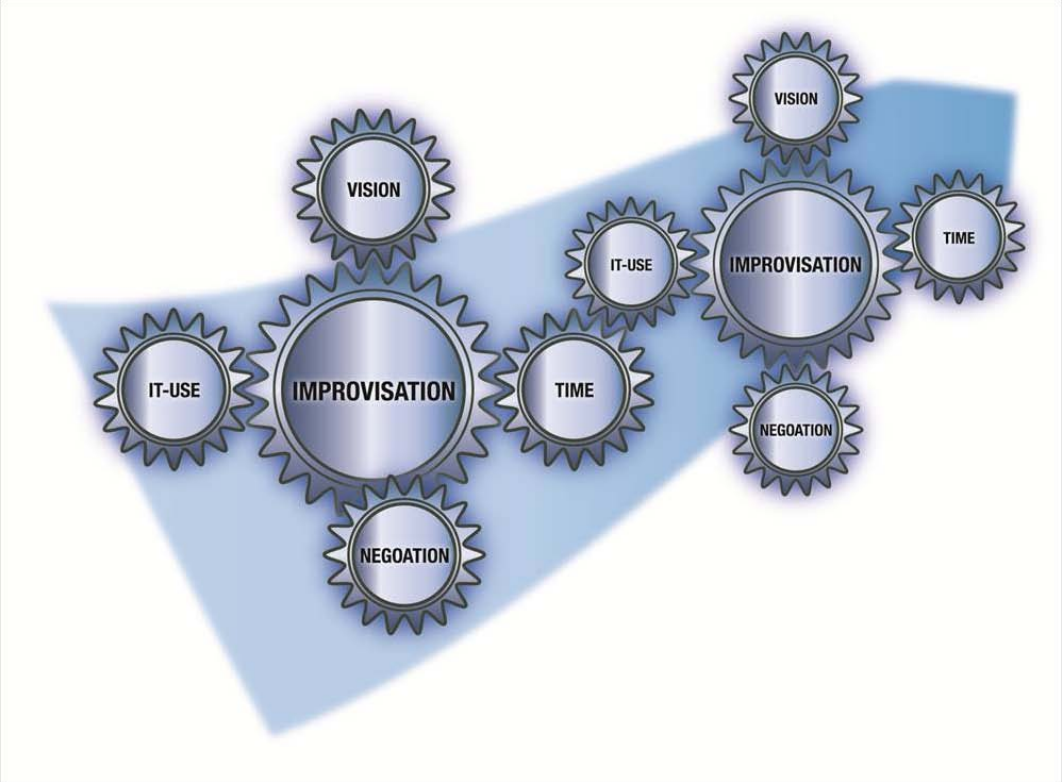

Figure 8. Illustration of the act of improvisation and its properties in a change process

The important properties of improvisation in a change process are illustrated as the following in this study: **vision, time, negotiations and ICT use**. To achieve a successful implementation and use of technology, there needs to be a vision in place. In this case, the vision **“**anytime—anyplace” was developed. It takes a long time to fully implement PACS in practice. To realize the vision, numerous open-minded and flexible negotiations related to professional roles, work practices and work processes needed to take place. Nothing comes from nothing—there needs to be (new) technology or ICT use in place. The new technology must enable professionals to communicate and perform work in new ways.

Vision

The vision of the future radiologists were cultivated and identified over time as radiologists tried out new ways of working and cooperating.

"When images are accessible for everyone, is there a need for the radiologist? I, as a radiologist, need to find ways to stay attractive…this was also a reason for the start of the process of trying out."

The PACS has created new possibilities for orthopedic surgeons and radiologists to work more closely together in heterogeneous teams. These possibilities have been realized and a more multidisciplinary way of working has been developed, following the "anytime – any place" vision. The tighter multidisciplinary way of working has made the radiologists more knowledgeable about clinical work and orthopedic surgeons more knowledgeable about radiology diagnostic work.

"In a way the professions are more separated today, at the same time the technology could be a trigger that makes us work more closely together in the future."

Questions as *''why are we doing this*?*''* were unanswered. Initially there is no vision in place for the expected outcome of PACS. Instead this vision was identified over time e.g. when users understood the aspects of technology.

''One was first missing a vision, the junior radiologists showed the way by testing…realizing any time – any where.''

Access to important information and results from colleagues at other radiology departments was suddenly accessible to everyone. Radiologists could search for rare traumas and illnesses and take part in consideration of rare cases in the whole region instead of being limited to a local search at one hospital. They could also at their own convenience send and receive questions regarding rare cases to individuals at other radiology sites.

"You understood after a while that it was possible to connect online discussions with an expert at the University Hospital regarding the more rare cases, for instance tuberculosis *(TBC)…it was also possible to gather all TBC examinations in the region and learn from them…these were new ideas and new visions of work that we had not planned for."*

In summary, the PACS change process initially represented a threat to the professional existence of radiologists and radiographers. To meet this threat, they forced themselves to take action and perform activities that over time led them to formalize a vision of the future. This vision included the idea of a changed future in which their role was still in demand among clinicians, including orthopedic surgeons.

Time

How to implement the PACS was not a planned activity at the radiology departments. At the outset, individuals had no vision of how things would turn out in practice. But the feeling was that "we will be modern, we will work in a modern way with computers, and we will find our way by trial and error

" When the PACS was introduced we had no idea what it was ... but all of a sudden we realized that the images were accessible from everywhere, as we had no handbooks we just tried it out by ourselves, when successful tipping one another off."

There were no predefined ways to process and manipulate images; instead, it was learning by doing in practice.

"Radiology images went from being physical to virtual and there were no operating manuals on how to process these images… you had to find your way to learn by yourself, and it takes time. In practice it was see one – do one – teach one".

The process of change was expected by radiographers, but was not realized in the way that they expected.

"We have never had a meeting about work organization. We solve problems as they arise. We should perhaps have thought about this but we don't have time.…We could have made more changes, absolutely. We think in terms of the familiar."

During the PACS training, both radiologists and radiographers found it difficult to picture how this technology would be implemented in practice. When they came to work one day and were supposed to start using it in action, it was only at that point that they obtained a better picture of its use.

"It was when we first started to work with PACS that we understood. Some individuals were more daring and pressed enter, or another button, more frequently…..oops, things started to happen …"

In summary, the quotations in this section illustrate that improvisation is executed randomly over time. That means that improvisations are not identified at the start, middle or end of a project; they happen "all of a sudden". However, these quotations also illustrate that they do happen if given time.

Negotiations

PACS creates new possibilities for specialization. The way that these opportunities will be realized in practice, however, is highly dependent on how negotiations between actors evolve. Knowledge within different areas has grown and made it impossible to be an overall expert within radiology. Negotiations have evolved between orthopedic surgeons and radiologists, seeking balance between the professions. This has forced orthopedic surgeons and radiologists to become more specialized continuously over time.

"...for instance, the radiologist may become sub specialized in foot radiology, and the radiologist will then be in the 'foot team'."

Orthopedic surgeons and radiologists have different professional roles, but where does the radiologist's work stop, and where does the orthopedic work start? This boundary differs depending on the individual surgeon, the individual radiologist, and the relationship between them; it also differs from patient to patient. In practice, there is a growing tendency toward the development of spontaneous groups of multidisciplinary teams that vary over time. How things develop in practice depends on how the negotiations will be carried out and evolves.

"...the radiologists describe, but the orthopedic surgeon has to do."

Negotiations and discussions between orthopedic surgeons and radiologists led to the development of a new meaning for clinical meetings, i.e. clinical meetings developed new significance for work and professional roles.

"It was at the clinical meetings we understood for real what it was possible to do with the images. New possibilities led to increased discussions during these meetings. One understood that here new ways of presenting images could be identified."

When PACS was implemented, it created opportunities for reorganizing who was to do what. Some activities were negotiated, while others were just changed in an improvised way without negotiations. The digital environment has made work more complex, in the sense that there are more technologies, actors, interconnections and activities included in the work.

"With the new technology you are supposed to do things that used to be done by other professions before. We used to have secretaries to do the writing, to get information... today there is an idea that everything is so simple and not time consuming so it is easier that you do these things on your own. All these small things take time – so the system both takes and gives more time."

The junior doctors were more eager to start using the new technology. The senior doctors were humble and open minded, appreciating and accepting when juniors taught them how to use new technology.

"One could say that it was the junior doctors that were first out to test …but that was good because it was then colleagues that showed us how to do things during our training sessions."

In summary, the quotations in this section illustrate that improvisation is closely related to encounters between people. When people meet, something happens. This means that the formal conferences and informal meetings are most important work settings if improvisation in work is wanted, e.g. if managers want to stimulate improvisation in work.

Information and communication technology use

The smaller hospital units were quicker to implement the new technology and to make use of its advantages in practice. In the digital work, smaller hospital units started to routinely produce images that were sent to the university hospitals for reading. This meant a brighter future for the small satellite sites, which in the analogue work environment were threatened with closure. Radiographers also became more of a "key personnel group", as they were not dependent on the presence of radiologists on site. Radiographers made it feasible to produce images, which enabled patients to visit units that were closer at hand.

"Today we can do and finish an examination without having a radiologist on the spot by sending the images to a department where radiologists can read and report on the examination."

In the digitized environment, images are accessible to orthopedic surgeons from everywhere where there is a connection to the hospital network. Over time, this has led to the development of new ways of using radiology information in orthopedic work, creating the potential for a more holistic and flexible approach.

"Now I as an orthopedist can work undisturbed in my office. I can go through a number of requests from other places (for instance the hematology department). I can retrieve the radiology images from the radiology work space and then approach radiologists and ask for their opinion at their and my convenience."

Spontaneously, new constellations of meetings arose.

"Now that we could access images anytime from anywhere, it was also the case that we could work from anywhere. We increased work at our offices and we increased the discussions with the orthopedic colleagues about tricky cases...this would not have been possible, before as the x-rays were only accessible from the radiology department."

Through the use of PACS, new ideas for improving PACS were realized. When these ideas were forwarded to vendors, the response was often a negative attitude and assertions that it was not possible to make changes. However, through their use of the systems, individuals realized that the technology itself had flexible features: instead of making changes in the PACS system, users could change the PACS implementation to create new ways of working and cooperating. Over time, users' dialogue with the vendors decreased. Instead, the discussions with vendors were carried out by a person responsible for information technology, who was not a health care professional.

''When we had used the system, sometimes we wanted to make changes in the system in order to improve the workflow. But we were usually told that such changes could not be made.''

In summary, the properties of the new PACS technology shaped and created the vision of the future. When individuals used the technology in new ways through improvisation, they also realized what they actually could do with the technology. The improvisation led to an understanding of the boundaries of the technology. Understanding that information technology is a technology without properties, but that their PACS was designed with fixed properties that vendors were not willing to change, they also understood the limits of their new technology, which was frustrating.

8. DISCUSSION

Most of the studies published so far about the introduction of PACS have focused on technological issues. For a long time, the introduction of PACS was seen simply as a technological project. This study, however, shows that the introduction of PACS can be understood as an organizational development process. One of the respondents interviewed described it very well:

"*… PACS is not a product, PACS is a process.*"

The organizational development process is very complex. It extends both horizontally across the organizations' boundaries, and vertically, as it affects the smallest details of an activity. The starting point of this study was to focus on how three professions understood the social aspects of this process, and how they conceptualized the introduction of PACS. One of the strengths of the design of this study is that it is longitudinal, so it is able to record changes in processes and perceptions over time.

8.1 PROFESSIONAL ROLE

Figure 9. Illustration of the changes in professional role for radiologists, radiographers and orthopedic surgeons

It has taken time to discover and to reflect on how the new distribution of activity and workflow in radiology has changed the professional role of the radiologist. As a consequence of the introduction of PACS, the radiologists have received, and have had to respond to, more questions than before from other clinicians, because their interest in the images and reports has increased due to the increasing ease of viewing digital images and to the more immediate availability of radiology reports. This is how the radiologist over time became more of a consultant to an actor in a network. From this, we might observe that the radiologists' roles are defined through their use of technology. This study shows that the way in which radiologists are distributed across the health service has changed, and that their roles as professionals have changed, with some activities becoming less time consuming, and with others taking up a much greater proportion of their time than in the past.

On the whole, the radiographers, as image producers, embarked on the process of digitalization with a positive attitude: *"It is a sign of the times to work with computers"*.

Their frame of mind was calm, and they did not perceive the coming changes as a threat to their professional community. However, they feared losing some of their core competencies, such as the computation of radiation doses, as well as losing the job security that had previously been associated with these competencies. In many fields, practical skills are developed gradually, and become more advanced as experience accumulates (Malterud, 2001). This had been true for the radiographers, who had each increased the level and range of their skills over time, gradually assembling competencies which enabled them to undertake more complex tasks and activities. As their work became more complex, involving more responsibility, the radiographers had needed to develop an increasingly broad range of skills.

In any process of change, a number of different factors affect the change. Technology is just one of these factors. However, it is suggested that information technology has the potential to support new professionals' roles and to create new opportunities for cooperation, as well as new ways of working. The present study demonstrates that the joint use of PACS technology made it possible for the radiologists and the orthopedic surgeons to move from their single-discipline professional roles to a multidisciplinary one, in which the boundaries between professional groups were no longer as strict they had been previously. It also made it possible for the orthopedic surgeons to extend their professional knowledge in a way which had been previously unimaginable. However, the availability of this wealth of new information has meant that it is simply not possible for any one individual to be an expert in every aspect of orthopedics. This has forced orthopedic surgeons to become more specialized, and they also have increasingly specialized roles when working together in a team.

In summary, where PACS has been implemented, the work of the health professionals has become more complex.

8.2 DIAGNOSTIC PRACTICE, IMAGE PRODUCTION PRACTICE, ORTHOPEDIC PRACTICE

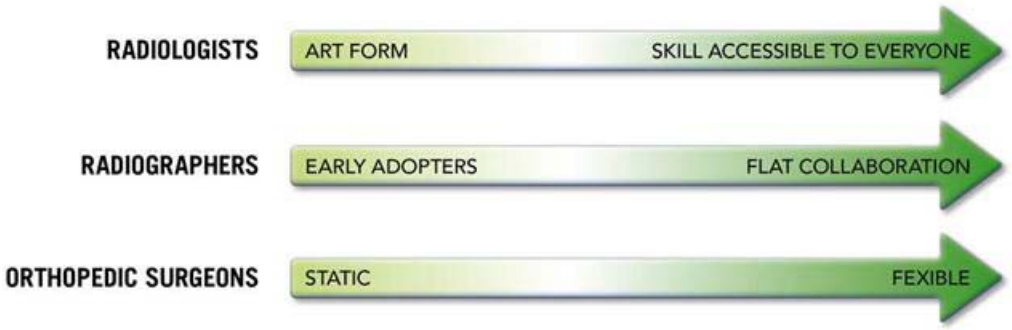

Figure 10. Illustration of the changes in practice for radiologists, radiographers and orthopedic surgeons

At the beginning of the project, the radiologists described the practice of reading x-ray films almost as if it were an art form. They explained that "becoming a skilled artist takes time". However, the introduction of digital images viewed on a computer shifted their practice towards more technical work, in which the focus was on their mastery of technology rather than on their diagnostic skills. The technology has improved access to radiology images from elsewhere, and from the local archives; it became increasingly easy to access a number of comparable cases, as well as the findings from any previous examinations of a specific patient. So, for example, the technology has made it possible for clinicians to maintain more frequent contact with radiologists, and to have a discussion about an image, or to obtain a second opinion, much more easily. What had previously been the highly specialized preserve of the radiologists became knowledge which was much more accessible to other practitioners.

Radiographers were early adopters of the new PACS system. These were the professionals who had to produce the images, so it is easy to understand their positive attitude to a system which made image production easier. The task of image production could be completed without any interruption or delay due, for instance, to the absence of a radiologist. At larger radiology institutions, one of the important objectives of the introduction of PACS was that all images would be accessible to any professional who might need them, wherever they were based. Radiographers expected that the future would involve many new ways of organizing and doing their work. Siegel et al (2002) wrote about the introduction of digital images and of PACS as an opportunity to reorganize the workflow associated with image production.

However, as time passed, new working routines developed, in a more open network, in contrast to the earlier, more hierarchical working structures. This led to the development of "flat" collaboration across professional disciplines and to closer cooperation between colleagues.

When they worked in the analogue environment, and with analogue films, there were fewer opportunities for discussion between orthopedic surgeons except at case conferences, which used to be an important forum for communication in orthopedic practice.

If the surgeon wanted to discuss a specific patient, the surgeon sent a request to the radiology department to have films from the relevant patient examinations shown at a forthcoming clinical meeting. The fixed properties of the film made practice more static. The present study indicates that there has been a shift in orthopedic practice from a static to a more flexible practice, as every orthopedic surgeon can now view and access images from anywhere, at any time. This new technology tool supported the development of new ways of working with orthopedic colleagues and radiologists. Work done in cooperation and in teams provided a way to optimize results (Aas, 2006, 2007).

In summary, when PACS was implemented, and used in clinical practice, the medical staff needed to have an open mind about their future practice, and to be willing to adapt to changes.

8.3 TECHNOLOGY IN USE

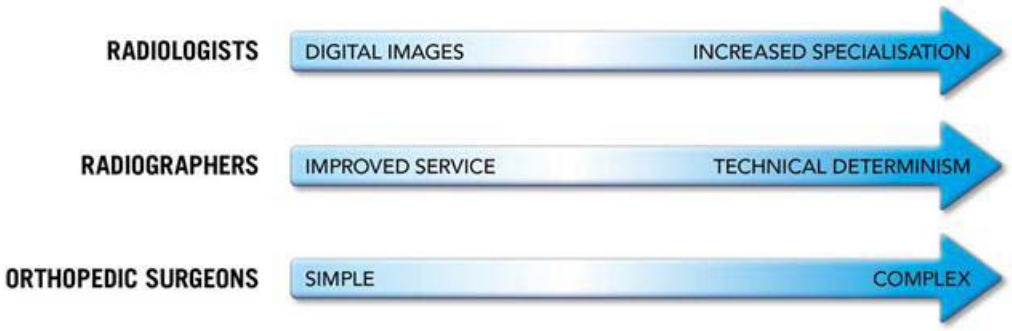

Figure 11. Illustration of the changes in technology in use for radiologists, radiographers and orthopedic surgeons

When the study started, the radiologists could hold x-ray films in their hands, feel them, and know that they were looking at the whole image. This allowed them to be relatively confident.

Reger, Mullane, Gustavsson & De Marie (1994) confirm what a time-consuming process it has been to change users' attitudes to digital images. They described in detail how mental barriers can make the adjustment more difficult.

Ramirez (1994) uses the term "reconfiguration" when discussing the development of new attitudes and concepts in a translation process. Radiological work has changed dramatically over the period of this study. This process of change is likely to continue in order for radiology to stay attractive to customers and to live up to the motto "any time, any place". Of course, within the range of the changes in diagnostic practice

observed in this study, there were marked variations between the ways in which individual radiologists had embraced the new opportunities. However, the similarities among the majority of radiologists reflect the trends that are being described. The radiologist needs to provide swift results, to be specialized, and to offer relevant, interesting and qualitative information to the users. The radiologist is a major contributor in the clinical process associated with treatment of the patient. Dalla Palma (2006) concluded that, in future, radiologists must increase their clinical knowledge and revisit their communication with the patient, i.e. they must "reinvent themselves"

Initially, the radiographers expected that the use of the new technology would improve the service to clinicians and to other actors who wanted to take part in processes involving both images and reports. Pilling (2003) reported that the majority of referring physicians reported positive experience of PACS/RIS. Among the advantages, they mentioned the increased accessibility of X-ray images, the opportunity to discuss the images on the telephone with the radiologist when the images were accessible at several locations simultaneously, and the decrease in response time for receiving the results of radiology examinations. Radiographers recognized that changes in the organization of their work could increase their efficiency. The findings of this study indicate that it would have been easier to carry out these changes in the organization of work patterns if they had been made in conjunction with the implementation of the PACS. This is one of the most common errors in introducing PACS, mentioned by both Bennett, Wasvani, Mendiola and Spigos (2002) and by Siegel et al (2002). In 2005, the radiographers concluded that the nature of the technology in use determined how their work was organized. Medical staff constantly had to adjust to the use of the new technology, and they regarded PACS more as a deterministic technology than as a socially constructive one. This is illustrated by the quotation from a radiographer who said emphatically that it had previously been much easier to understand the technology used. Today, problems are hidden within the technology and are not always understood by users, who simply have to adapt.

With PACS, images are immediately accessible to all of the orthopedic surgeons at the hospital, even before the radiologist has finalized the report on the examination. Diagnostic skills associated with the use of radiological images have become accessible to all clinicians at the hospital. The shared image and the text information may be discussed over the telephone and simultaneously demonstrated at a multidisciplinary meeting.

The present study shows that, as the technology in use takes on new properties, it triggers the development of new processes of working. For instance, at one hospital, changes have recently been proposed, to move the location of clinical conferences from the radiology department to the orthopedic department.

When images and 3D reconstructions became available, through the acquisition of new computer systems, the orthopedic surgeons were confronted with even more information and more options. This made much of their work more complex. This finding shows that the orthopedic surgeon has become less dependent on radiologists, secretaries, clerical staff and assistants at work. However, the transition from simple to

complex technology and practice increases the demands on the competence of the orthopedic surgeons.

In summary, when PACS has been implemented and used in practice, there is a driving force toward specialization.

8.4 PACS AND ORGANIZATIONAL IMPROVISATION

This study has identified a lack of vision in the implementation and initial use of PACS. An effect of this in practice is that further development has been dependent on improvisation by individuals.

Early findings indicated that the organizational outcome of the implementation of PACS might vary between the different sites. However, this longitudinal study has found that although the development at each site is often spontaneous rather than planned, and is driven by the individuals present at that site, the long-term outcome is similar at different sites. When PACS was introduced, it was certainly not intended that it would be driven by improvisation. This was a consequence of the lack of rigorous planning, vision, and objectives at the outset of the project. This “lack” was fortunate because PACS implementation is not a simple product implementation that can be planned in detail, but a process implementation with unpredictable effects, where the trajectory of events is not foreseen and where its results affect people, workflow, communication, spaces, and technology—in other words, the entire organization. In the process of implementing PACS, it is the individual’s own initiatives which have been the driving force for the development of the organization.

The implications of computing technology can be considered in a variety of ways (Dahlbom & Mathiassen, 1993). While computers, and their uses, have been radically transformed over the last 50 years, various insights into their implications for work have been developed. These implications have developed in an unplanned way. What makes these technologies develop in a certain direction? What are the driving forces in such change? How might changes in work and technology be explained? In this paper, the concept of improvisation will be used as a tool to understand the implementation of PACS in healthcare work.

Conceptualizing the change process in terms of the concept of improvisation encourages a focus on practical ways of performing work and on “practical thinking” in work. It recognizes that in real life, social orders change; outcomes are related to the capacity for imagination which is present, in terms of how to solve various emerging problems and how to take advantage of opportunities (Ciborra, 1999). According to Ciborra (1996) some of the key components of improvisation are immediacy, situatedness, idiosyncrasy, local knowledge, and access to and deployment of the resources at hand.

The concept of improvisation highlights the need for longitudinal studies to make it possible to see the real changes which occur in organizations (Ciborra, 1996). Quick fixes are not completely representative in any analyses of the implementation strategies. The time aspect is crucial in order to identify real changes, as changes take time (Fridell, 2007).

This study illustrates that implementation of information and communication technologies, such as PACS:
1) takes a long time— at least seven years to fully implement in practice;
2) needs to have a guiding vision;
3) is dependent on open-minded and flexible negotiations related to roles and work practices; and
4) needs to focus on the technology use and not on the technology.

As has been shown above, these features of improvisation are all necessary conditions for an organization to lay the ground for individuals to improvise. In this study, the practice of improvisation is found to have led to a process of "deep ecological penetration" (Joerges, 1988). This means that over time it has changed fundamentals of the work practice.

This study contributes to the development of the improvisation concept, by identifying important aspects of improvisation in practice, i.e. what needs to be in place in order to encourage individuals to take responsive, improvised, strategic actions in work. These important aspects of improvisation are:
1) **Vision**: the work practice in the healthcare process needs to have a vision (direction). The healthcare organization needs to hold on to its vision and discuss it on a regular basis. In this study, it was "anytime—any place". In a process without a direction, individuals cannot differentiate between responsive strategic action and action that is purely ad hoc. To realize a vision, a responsive strategic action is needed in practice.
2) **Time:** a long time, ten years at least, is needed to try out ways to make large IT implementation projects work in practice in healthcare; this means having the time to develop both new professional roles and new work practices. Many meetings need to take place in work practice; problems at hand need to be considered from a wide variety of perspectives.
3) **Negotiations**: to achieve a stable and robust work practice, negotiations are needed. Negotiations lead to a step-by-step innovation process. In practice, this involves numerous ad hoc face-to-face meetings and negotiations to develop new professional roles, work rules and work practices. The professionals need to be open to negotiations of changes in the implementation of large IT projects such as PACS.
4) **ICT use**: organizational changes require various resources, including new information and communication technology. In practice, this means focusing on the technology with regard to its use and its ability to support actors with relevant information in various contexts. Development depends on new standardized ways to access relevant information and to collaborate.

8.5 ACCELERATORS AND DECELERATORS IN ORGANIZATIONAL CHANGE PROCESSES

When new technology is introduced, there is always debate about which problems it is intended to solve and how (Obstfelder et al, 2007). One factor that may influence the outcome of the implementation is an understanding of how the players involved perceive the changes that occur or will take place. By comparing the different studies included in this thesis, we found occurrences over the period of the study that may have

been significant to the continued development. These occurrences have been termed "accelerators" and "decelerators". The effects of computerizing are often different from those that were expected or foreseen (Gäre, 1999).

How radiologists and radiographers understand that their professional role, practice and technology in use have changed with the implementation of PACS will be described below in terms of three themes. The first focuses on the differences in accelerators and decelerators between small and large radiography departments. The second focuses on differences between radiologists and radiographers, whilst the third focuses on differences depending on management strategy with regard to the introduction of PACS.

8.6 ACCELERATORS AND DECELERATORS IN RELATION TO WORK PRACTICE DEVELOPMENT

The study shows significant differences between small and large departments in the inclination to change. This can be explained by the fact that small departments have been threatened with closure for a longer period. The introduction of PACS enabled them to continue operating. The reason behind this was that distributed radiology allowed for the diagnosis, and even specialized diagnosis, of radiography images. Through the introduction of PACS, the work organization could operate without the physical presence of radiologists on a daily basis. This allowed for very rapid organizational change and, according to them, increased productivity.

The threat of closure that was hanging over the small departments can even be viewed as an accelerator for the implementation of PACS. Distributed radiology, with the use of PACS, helped to make it possible to dissolve the previous organization structure. For the small departments, there was also a "decelerator" in the form of a potential reduction in the quality of the diagnostic service in the long term. The background to this decelerator was that the radiographer did not have the radiologist's anatomical competence and was therefore unable to make the same judgments regarding which investigations should be selected for a patient. The possibility that one would miss an area for investigation would arise, leading to a risk of an incorrect diagnosis resulting from inadequate investigation. Distributed radiology therefore requires more proficient investigators. The answer will never be better than the foundation from which it comes and, if the foundation is weakened because of the lack of access to a radiologist, the end result may be worse in the long run. By taking into consideration that it is not a radiologist who will lead the investigation, one can limit adverse effects from this decelerator by only allowing simpler skeletal investigations at these departments.

The larger departments' strategy for the introduction of PACS was both to ensure that the organization did not change and that the new technique could be incorporated into the existing routines and processes. As PACS, with its digital limitations, did not have the same characteristics as analogue film, it did not fit in with the existing routines for film and processes became decelerators for the introduction process. In practice, radiographers were given more responsibility in certain respects and radiologists more work in others. Both workgroups and their individual members were geared to a system workflow and had to change their work in order to fit the new technique into their

existing routines. The fact that the change process was tied to increased responsibility for radiographers was an accelerator**,** while the upward delegation of work responsibility for radiologists was a decelerator. If, at the time, it had been possible for radiologists to work from home, this might have acted as an accelerator and not as the technical deterministic system, as it was viewed by many.

8.7 ACCELERATORS AND DECELERATORS IN RELATION TO PROFESSIONAL ROLES AND INFORMATION TECHNOLOGY DEVELOPMENT

The findings of the study are based on a total of 46 interviews with radiologists and a total of 73 with radiographers. The selection of respondents for the interviews was designed to enable wide-ranging exploration of the issue. It is important to note that no general conclusions will be drawn, but the results give substance to the conceptions that were described during the interviews and how these conceptions change over time. The result covers respondents from different areas; although many of them worked in more general areas, there are respondents from a variety of specialized and management positions as well. One of the strengths in the design of the study is that it is longitudinal and changes take time.

Radiographers stated that they had not felt a threat to the continued existence of their profession resulting from the implementation of PACS. This meant that they had a positive base position, which can be viewed as an accelerator**.** They understood that they would always be included in the operation, as their services could not be transferred to other workgroups. One can imagine that secretaries saw it differently, as there is a general debate regarding their inclusion, or exclusion, in the digital health organization. Radiographers understood that, as image producers, they had specialized skills and that in terms of guidelines on radiation they were the only ones who could undertake these tasks. In this respect, the radiographers, as well as younger radiologists, were early adopters. One can notice that the radiographers relate the areas of questioning more to digital images than to PACS. This may be because digital images are seen to have greater significance for any possible changes in work practice for the radiographers. When radiographers describe their work, one of the aspects they mention is image production practice. The radiologists instead refer to diagnostic practice. This shows that image production is an important component for the radiographers.

The radiographers' positive attitude toward impending changes made them "early adopters". The junior radiologists also saw positive effects of the possibilities offered by PACS and this could have made it easier for them, too, to be "early adopters". Early adopters trigger commitment, which in itself has a positive effect on the introduction and is therefore an accelerator for the introduction process. It is therefore important to identify early adopters in a change process and allow them to develop; in other words, give them the authority to take up new work tasks with increased responsibility (Rogers, 2003).

The new technique became an accelerator for radiographers in that it placed quality examination of radiography investigations, especially skeletal investigations, which had previously been in the hands of radiologists, into their field of responsibility.

This study does not provide evidence of the extent to which these findings also reflect changes in diagnostic practice from other specialities or modalities. Those radiographers who achieved this major change in competence developed a very positive attitude to these new opportunities.

The long-term effects on diagnostic quality when there is no radiologist present during the examination are open to debate. The communication between the interpreting radiologist and the radiographer performing the examination is vital. The findings show that the radiographers miss their former close contact with the radiologist. If a new working practice is to develop, it is very important that the radiographer receives appropriate education and training. Future research will show how these changes have affected both individuals and the organization.

Change always includes a learning process. It may involve learning new work tasks, formal competencies development, but also changes to professional roles or new attitudes (Thor & Södergren, 2002).

Radiologists described a greater preoccupation with the introduction of PACS. They understood that radiography images would be accessible by all, including clinicians, as soon as they were exposed. Previously, radiography images could only be found at the radiography department and could not be sent out from the department without authorization by the radiologist. There was a strong feeling of individual professional expertise among radiologists. When this foundation was changed, a certain preoccupation regarding the future need for their services arose. Those who felt threatened by the new technique or other changes became a decelerator in the actual process of introduction and use of the new technique. Groups opposing the use of the new technique were formed among some senior radiologists. It is important to identify how they could strengthen their roles or facilitate a factor in their work.

Radiologists found that the “material” used for diagnosis had changed. It can take time to reverse mental barriers and this, too, became a decelerator. This has been described by several authors, for example, Reger et al (1994). Reger et al. (1994) aptly described how mental barriers can make adjustment more difficult. Normann and Ramirez (1995) use the term reconfiguration when discussing the development of new attitudes and concepts. The issue here is a significant reformation of occupational practice, which is not easy to describe.

It took some time before radiologists fully accepted the new technique. What changed radiologists’ view of PACS was the possibility of explaining the radiological investigation material at the clinical conference meetings? The new technique made it possible to show the images in an enlarged format, which enabled everyone at the meeting to see the images. This meant that discussions increased, first between clinicians, but then between clinicians and radiologists. With PACS came the possibility to reconstruct images in three dimensions instead of two, making the

examination easier for the clinicians to understand. Future research may reveal the implications of this for the different radiological specialties. In specialties such as gastroenterology and orthopedics, clinicians appreciated this new way of interpreting the images in an examination when the question was very specific. The study, however, shows that radiologists reclaimed their role as experts and could take part in discussions, being able to become one of the team serving the patient. This clearly became an accelerator for the radiologists' continued development.

8.8 GROUNDED THEORY IN MANAGEMENT RESEARCH

According to Van der Wetering et al (2010) achieving optimal usage of PACS in hospitals is a long, complex and poorly examined process.

Large-scale information technology such as PACS has been implemented in many different organizations over the past decades (Hagland, 2007). In the field of radiology and the implementation of PACS, researchers' focus has shifted from technology to organizational issues (Duyck et al, 2010), in order for managers not simply to implement a new technology, but also to get the most out of it. The findings from this study show that there is a great need to focus not only on the technology and economics, but also to focus on work practices, individual roles and the way in which the technology is used.

There is a growing interest in the use of a more theoretical perspective on implementation (Carlfjord et al, 2010, Murray et al, 2011). What one can conclude is that the implementation of large computer systems is complex, as it includes many actors and working methods. Managers need to be consciously prepared for the implementation of information technology in particular of large, complex, systems such as PACS. Traditionally, managers focus on factors such as productivity, efficiency, quality and costs, and somehow neglecting the contextual interactions, actions, adaptation of processes, and intentions of individuals and groups. Managers need to understand the potential effects that these information technology changes are likely to have on work practices, cooperation, workflows, etc. One of the recommendations of this study is therefore that managers should formalize their understanding of the possible effects of the new technology on working processes and relationships, and also, understand their potential benefits. These benefits could be increased through recognizing the new opportunities for service improvement and communication, new potential ways of working and cooperating, logistical improvements, saving of time, increasing patient safety and learning in practice, less time needed for administrative work, increased autonomy, decreased costs, greater access to relevant information, increased patient safety, more efficient decision process, increased control over research data. The identification of possible effects and benefits formalized prior to the investment in the new information technology should be followed up one, three, six, and ten years afterwards; as changes take time, and it cannot be accurately predicted when they will occur. Both effects and benefits should be documented in a systematic model, which, if necessary, could be modified for each new project.

When it comes to the implementation of complex information technology, this research project illustrates that successful implementation of new information technology

requires a certain amount of time and negotiations. It is the role of the managers to ensure that this happens in practice. The PACS project has shown that if this occurs, a more or less self-developed implementation process takes over, in which the need for interference and control of managers is less needed. The managers in these situations have assumed a supportive role. If managers had had the vision in place at the beginning of the process, saying "we are doing this because we want to create an 'Anywhere—Anytime' working environment", this would have made life easier for the staff. As the managers' role is to get everyone to work towards the same goals, it should therefore be their responsibility to have created the social processes of a vision. Luckily, this vision was formalized anyway, partly in response to staff anxiety about whether they would be needed in the future. Creating a vision became everyone's problem in this case. However, working out how this vision should be realized in practice may be a question either for managers or for other members of staff, or both, depending upon the organization in question and its characteristics.

Implementation is always local, by its nature. However, complex technologies such as PACS are usually constructed globally. This creates a natural gap. There should always be an expectation that there will be local problems in the implementation of global technologies. Grounded Theory is a way to locally trace and contextualize individual and group interactions, processes and adoptions, as well as the intentions associated with the implementation. It provides a way to identify the problems that arise and present them from a bottom-up perspective. *One could thus describe Grounded Theory as the bridge which enables organizations to take the walk into the global digital world in an aware and structured way. The walk has shown to be taken on a long and winding road.*

Grounded Theory has been shown to be very useful in management research on topics such as decision-making, socialization and change (Locke, 2001). Management research includes the study of individuals, groups and their interactions. This is referred to in Grounded Theory as an interactional focus, and is identified by Glaser (1992) as a useful perspective. This study also confirms the importance of studying individuals, groups and their interactions in practice.

Grounded Theory adapts well to capturing *complexities* in the context where actions are taking place. Orlikowski (1993) pursued a Grounded Theory approach to better understand organizations' adoption and use of a tool called CASE (computer aided software engineering). The idea was to use a research plan which could help focus on the contextual and processual adaptation in the implementation and use of CASE. But it was also found helpful to support the identification of the important key actors for initiating changes in work-related cooperation. This study confirms Orlikowski's (1993) findings, as it identifies both junior radiologists and radiographers as key actors who initiated change, especially in the initial phase of the use of PACS (early adopters).

Grounded Theory is useful for managers, as it links well to practice by creating a bridge between academic theories and models and the real world, thereby expanding the usefulness of the theories in daily workplace practice. Partington (2000) has used the approach to develop a grounded model that accounts for the actions of managers

seeking to implement organizational change through the implementation of new information technology.

In summary, this study illustrates that the inductive qualitative approach in Grounded Theory increases the chance of discovery and analysis of change and development in the workplace. It also concludes that it is advisable that managers should include attention to the social processes of work, especially during periods of change, as part of the managerial workload.

8.9 MANAGEMENT STRATEGY AND ACCELERATORS AS WELL AS DECELERATORS

When introducing a new technology, management can follow a variety of strategies. These may be described as either top-down or bottom-up (Gell, 2006), depending on how management takes the initiative for the process. In the case in question, several perspectives were chosen. At larger departments, management chose to implement the introduction without changing the workflow. At the smaller departments, implementation was undertaken with a strategy supporting organizational changes in work from the beginning. The strategy chosen became a decelerator for the larger departments, because it focused on the success of the technology. In hindsight, one can understand the choice made by management: the project had only recently been planned and there were no other studies of work organization change due to PACS implementation from which to learn.

A general problem was that management was not fully successful in communicating the objective of the change that was to take place. Staff members who were interviewed said that, because of this lack of clarity, they were often unsure about why the change was taking place and were of the opinion that "*it was working fine as it was...*". If management had been more aware of this earlier on, then perhaps it would have been understood that this was not solely a technical project. It would have been possible to implement the project in a different manner. The management's process-oriented point of view may, in itself, be an accelerator because it makes it possible for the personnel to share their experiences and ideas in a broader manner. By sharing information one can identify how processes develop on several levels. One can discuss and present how orders emerge, and in these discussions it is possible to create feedback processes that are able to create positive changes. In summary, the sharing of information regarding the development of organizational processes can, in itself, create attractive new ways of working. The management strategy of maintaining old routines could be responsible for less inclination to change and could hinder the optimization of PACS use.

In the study, the system for the larger departments had to be adapted to the organization's existing workflows. As the PACS system was limited and rigid, problems arose in the adaptation of the system. Energy was expended on finding ways to come up with work-around solutions that would make the system function in the same way as the previous analogue one. The fact that the system was rigid and determined how the work should be organized made it a decelerator in practice. If the focus had been on the optimization of the work organization based on the system's characteristics and possibilities, that is, on openness to changing ideas, it is possible that the implementation would instead have constituted an accelerator.

9. CONCLUSION

Grounded Theory is well suited to capturing complexities in the context where actions are taking place. This study illustrates that the inductive qualitative approach in Grounded Theory increases the potential for discovering and understanding changes in work and development of organizations in connection with the implementation and use of new information and communication technology.

The study also shows that the introduction of PACS was not solely a technical project, but also, or primarily, an organizational development project. It bears all the hallmarks of a so-called change project. This means that for implementation of PACS it is important to have information about the dynamics between the individuals, work practice, organization and technique. This study illustrates that the way in which this change is perceived by different health professionals may vary.

The radiologists perceived a shift in their professional role from a more individual-centered competency, via a consultant role, to becoming an active part of the patient diagnosis and treatment as an actor in a network. The diagnostic work changed from being an art form, at the beginning of the study, which was dependent on individuals, to being distributed and therefore enabling more people to take part. The digital image technique opened new diagnostic possibilities. Based on this, it was easier to present images during case conferences and the discovery of the 3D tool led, over time, to the need for ever greater specialization of radiologists.

The focus of the radiographers' professional role shifted from image production to how the images were taken. By the end of the study, radiographers had incorporated this as well as diagnostic knowledge in their jack of all trades professional role. With regards to the context in which radiographers worked, they quickly became positive regarding the new technology and so were early adopters who came to support the technique and the changes that could be effected over time. They came to lose touch with radiologists but showed, by the end of the study, the beginning of a new way of interacting with colleagues in a flat collaboration. At the start of the study, the new technology allowed for radiographers to have visions of a new way of working for a better service. However, over time the system instead determined how working routines should build up technical determinism. The implementation of new technology does not automatically change the organization. The organization can change if this is the management's strategy. However, it may be postulated that individuals always change when technology changes.

The trend indicated a shift in the perceived professional role of orthopedists from single-disciplinary to multi-disciplinary, and from a more static practice in interpretation of images to a more flexible practice, where every orthopedist could view and access images from anywhere at any time, including 3-dimensional technology. It was easier for orthopedists to see and interpret the images, and their diagnostic skills became accessible to everyone. The transition from simple to complex technology and practice increased the demands of competence of the orthopedic surgeons.

The study highlights the need for longitudinal studies to make it possible to see the real changes. The time aspect is crucial in order to identify real changes, as changes take time. The study contributes to an understanding of the improvisation concept by identifying important aspects of improvisation in practice. On the basis of empirical analysis, four main aspects of improvisation were defined: vision, time, negotiations and information technology use.

In relation to new information technology implementation there is always a debate about which problems it is intended to solve and how this could be done. There are factors in the implementation and use of the information technology that may accelerate or decelerate the organizational development process. In this study, the medical profession's new knowledge of PACS properties in use has been of importance for the development of the healthcare organization. This new knowledge contributes to both "accelerators" and "decelerators" of the development.

This study concludes that when PACS is implemented and used, professionals become more specialized, work becomes more complex, and there is a need for an open mind because the system is a constant driver for making both minor and major changes in work over time. Often these changes are triggered by a vision, new use of information technology, and negotiations, given reasonable time.

10. FUTURE RESEARCH

The successful implementation of IT is no simple process. Many of these implementations fail or do not meet expectations (Obstfelder, 2007). The findings of this study show that the introduction of PACS does not follow previous models for the introduction of a new technology. For example, according to the model proposed by Rogers (1983), the introduction of technology entails a relatively static process with intervention, diffusion and routine. New technology, on its own, does not cause change. It is the relationship between new technology, social factors and organizational aspects that causes change to occur.

It may, therefore, be of great interest to conduct further research into the process of adaptation between technology, individuals, organizations, clinical challenges, and outcomes.

The overall aim for future research would then be to develop a method for change management for similar types of change processes when implementing and using new information technology.

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- När smakar honungen som bäst?
- Precis innan…, svarade Nalle Phu

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-

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