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RADIOGRAPHIC QUALITY WORKFLOW

- IN THE DIGITIZED HEALTHCARE ENVIRONMENT

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“To Svea Andersson,
reg. nurse and radiographer. My first
manager who also became a good friend -
you have always been my role model.”

ABSTRACT

This thesis emphasizes two different aspects — how radiographers use knowledge in image production work and perceive a radiographic quality workflow in the digitized healthcare environment using PACS — both because these aspects are cornerstones in the delivery of radiographic work and because the two aspects are related to one another. The aim was to inform the field of radiography of changes related to digital imaging production work by understanding how radiographers use their knowledge in work and perceive a radiographic quality workflow in detail.

The study has been performed using a qualitative ethnographic approach with a combination of in-depth interviews and observations. In total 34 interviews and 15 observations were conducted at 5 different Swedish radiological departments. Analyses have been made by using content analysis. Six phases and aspects of work were identified in the analysis process of the studies: 1) the planning phase, 2) the performing phase 3) the evaluation phase, 4) image production, 5) communication in work and 6) feedback in work. To identify properties of radiographic knowledge and quality workflow Blackler's theory of knowledge components was applied.

The results illustrate that radiographic work is a complex activity, for which several different types of knowledge are needed to deliver quality workflow; embrained knowledge, encoded knowledge and embodied knowledge due to various situations in the examination process. The use of knowledge can also be a mixture of them. The results also show that the radiographers use their skills on two different levels, either routinely or reflective. In practice, the radiographer can be more reflective in one part of the image production and more routine-oriented in other parts. The study shows that when radiographers use their embrained knowledge, they are using their intelligence and their theoretical knowledge rather than their hands-on knowledge. When radiographers use encoded knowledge, they may use a range of different kinds of documentation. When radiographers use embodied knowledge, it is practical thinking and problem solving and often involves the handling of technological options for image production work, a "hands-on" approach.

This study also shows the need of new ways of informal learning in the radiographic quality workflow based on digital information. The change from an analogue to a digital workflow requires that the radiographer has new knowledge about diagnostic and image quality control work as well as "new knowledge" about information systems

use. They also need knowledge about modalities, methods and protocols as well as radiation protection. It was also shown that the radiographers need to communicate more among themselves when challenges in work arose. Further on it was illustrated that there is a desire among radiographers to find new fruitful ways of communication with physicians, colleagues and radiologists using IT. Finally it was shown that informal learning is a key factor in the radiographer's digital workflow.

This study concludes that in the digitized management of radiology examinations, changes have taken place both in feedback at work and in the use of information systems. It also concludes that working in a PACS environment a more flexible and reflective approach is required in the image production process. In work you need to analyze images - it is not enough to "check them off". Documents cannot merely be read, but must also be interpreted to optimize work performance. Overall, radiographers need to have a reflective mind in practice, because work is full of problem-solving actions; it is not enough to perform repetitive automatic actions. Knowledge about the aspects of routine-focused and reflective radiographers has shown to be important for an understanding of radiographic quality workflow. In conclusion, having a profound ability to reflect, learn and transform in work is more important in the digitized management of radiology, as radiographers have new responsibilities in work using PACS and other information systems.

Radiographers are early adopters of new communication- and information systems. Digital information and PACS provide the opportunity for radiographers and other healthcare professionals to implement new improved ways of working. In such new ways of working the use of additional work-integrated learning, communication and information systems will be a key feature. New work-integrated learning and communication systems such as Skype, FeedbackTM, EqualisTM, HAWA, MSN, Facebook, Twitter and App:s for smartphones has potential to become mature healthcare services and support reflective thinking and informal learning in work.

However, to further contribute to the radiographic professional knowledge and practice advancement more research need to be made within the areas of the implementation and use of; 1) think tanks such as collegial reviews, 2) reflection in groups at formal learning meetings with radiologists, 3) work-integrated learning tools in radiology, e.g. FeedbackTM and EqualisTM and 4) communication systems, e.g. Skype, Twitter and MSN for online feedback among radiographers and radiologists locally, regionally, nationally and internationally.

LIST OF PUBLICATIONS

I. Use your good judgement - Radiographers' knowledge in image production work

Larsson W, Lundberg N, Hillergård K

Radiography, Volume 15, Issue 3, August 2009, Pages e11–e21

II. Radiographic Quality Workflow - A definition grounded in an empirical study

Hillergård K, Aspelin P, Larsson W, Lundberg N

Submitted for publication in Radiography

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1 INTRODUCTION

"We can't solve problems by using the same kind of thinking we used when we created them." (Albert Einstein)

Yearly more than 5 million radiology examinations are performed in Sweden [1] at the estimated cost of 35 billion Swedish kronor. The majority of these are performed by radiographers. Within the scope of the radiographic practice one and the same radiographer performs many different radiology examinations, i.e. conventional radiography (CR), magnetic resonance imaging (MRI), computed tomography (CT), x-ray and ultrasound. The examinations grasp over different injuries, treatments, kinds of patients and ages. Patients examined vary from unborn babies, children, youngsters and adults to elderly. Work calls for high communication with patients as well as high communication between radiographers and other professions i.e. radiologists, clinicians, technical personal, medical secretaries and assistant nurses. The diagnostic procedure progresses from one activity to another and as the procedure progress the responsibility for the patient is transferred from one actor to another in the healthcare chain. This means that the work done by the radiographers is of great interest to a number of other actors in healthcare [2].

During the 1980s a new concept called picture archiving and communication system (PACS) was introduced, which allows continued handling of radiology images in their original digital form [3] [4]. Studies illustrate that utilization of digital data using PACS has had effects on clinical and radiology work, professional roles and the technology itself [2] [5] [6] [7]. More specifically, it leads to new activities, new ways of communicating and new responsibilities [6]. In reality this means for radiographers, doing their work in a totally new way. Performing work in new ways is likely to impact how radiographers use knowledge as well as perceive radiography quality work. Knowledge and quality are closely related to one another and cornerstones in the delivery of work.

The full potential of communication- and information systems in healthcare is not obtained, and the use of new systems and services are limited. Therefore, there is a need to more in detail study the effects that currently used communication and information systems have on different aspects of work, e.g. communication, learning, knowledge demands and quality of the delivered service. When these effects have been identified we gain ideas of how new communication and information systems may improve the potential of IT in radiology. This thesis focuses on and discusses how

radiographers use knowledge in image production work and perceive a radiography quality workflow using PACS.

Radiographic quality workflow is defined in this study as the interpersonal activities of the radiographer that are intended to assure or improve the quality of the production, processing and quality assurance of the radiology images. This focus highlights the social, communicative, knowledge and learning aspects of work and has nothing to do with work automation and Taylorism (time studies, just-in-time etc.).

This thesis is structured as follows: Section 1 is the introduction and section 2 presents the aim of the thesis. Section 3 provides a brief description of radiology services, radiographers' role, scope of work and workplace and how radiographers use PACS and RIS. Sections 4 present the theoretical background which is Blackler's knowledge organization theory. Section 5 describes the ethnographic method and the material used. This section also presents ethical considerations. Section 6 gives the main results from the two papers. Section 7 presents the discussion and finally, section 8 presents the conclusions of the thesis as well as lessons learned.

2 AIM OF THE STUDY

The main research question in this study was “How do radiographers use knowledge and perceive quality workflow in the image production work supported by PACS?”

The aim of this research was to inform the field of radiography of changes related to digital imaging production work and PACS use by understanding how radiographers use their knowledge and perceive radiographic quality workflow in detail.

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

1. How do radiographers use knowledge in image production work using PACS?
2. How has the use of PACS changed the radiographic quality workflow?

3 BACKGROUND

This section provides a brief description of radiology services, radiographers' scope of work and workplace, how radiographers use PACS and RIS (Radiology Information System), the different kinds of knowledge they need, radiographer's activities and quality in general.

3.1 RADIOLOGICAL SERVICES

X-ray radiation was discovered in 1895 by W C Rontgen, and its application was one of the greatest innovations in healthcare history [8]. The first x-ray examination in Sweden was conducted as early as 1896 (ibid). For many years, images were produced using analogue techniques with plain-film radiography. During the 1970s, digital technology was introduced and the use of computed tomography (CT) became common. Today, radiology services in most parts of the world have been digitized.

Radiology departments use medical imaging to diagnose and treat diseases, acting on requests from clinicians in both hospital and primary health care. The radiology departments are service units, usually located in hospitals, and they serve the full range of specialties such as surgery, orthopedics, oncology, cardiology and trauma. They are located in university, regional or local hospitals as well as in private practices and primary care centers. In hospitals, radiology services are usually available at all hours.

The images are created using technologies such as DR (digital radiography), CT (computed tomography), MRI (magnetic resonance imaging) and ultrasound. Depending on the size of the department, the hospital radiology service may provide from 20,000 to 200,000 or more examinations per year. The most common are chest examinations, closely followed by CT of the brain. Staff members working in radiology departments mainly include radiologists, radiographers, assistant nurses and medical secretaries. The number of staff may vary from a few employees to more than 200 at each site.

Work at radiology departments is highly structured, production-oriented, complex, distributed and technical [2]. The equipment is installed in x-ray laboratories. An operative area where the radiographer adjusts parameters before carrying out each examination is usually placed next to the laboratory. The diagnostic work progresses from one activity to another as the responsibility for the patient moves from the

administrative staff to radiographers and from radiographers to radiologists etc. This means that the work done by one actor is of interest to the next actor (ibid.).

3.2 PACS, RIS, RADIOLOGY MODALITIES, PACS QA-STATION

PACS is a digital image distributing computer system. It is a globally used application for electronic storage, retrieval, distribution, communication, display and processing of medical image data [9]. The use of PACS began in the 1980s and became common during the 1990s [10]. Today, almost every radiology department in the developed world uses PACS.

PACS are also designed to support other functionalities in radiological work [2]. For example, 1) users can manipulate the gray scale, size, and orientation of images, 2) users can create “electronic lists” that support the organization and management of work, 3) PACS support communication with other nodes in the network, 4) PACS support: image prefetching, display of historical images, image analyses and diagnosis; radiologists can measure angles and areas on the image and display images in stacks by scrolling between them, and finally 5) in clinical image demonstration, PACS are used to retrieve and display images (ibid).

PACS are closely related to RIS systems, which provide functions for patient management, scheduling, documentation, patient tracking, reporting, film tracking and billing. These systems are crucial to an efficient workflow in digital radiology practices.

The modalities that are used in the radiology department to produce diagnostic images and treat diseases include digital radiography, mammography, fluoroscopy, ultrasound, CT (computed tomography), NM (nuclear medicine), MRI (magnetic resonance imaging) and interventional radiology. Some radiology departments have facilities for PET (positron emission tomography) and SPECT (single photon emission computed tomography), but these are usually located in other departments such as clinical physiology and oncology.

A PACS QA- station is a quality assurance station between the modality workstation and the PACS, where the radiographer can make annotations and correct the digital image before passing it on to the radiologist.

3.3 THE ROLE OF THE RADIOGRAPHER

Radiographers play an essential role in the image production process and in the care of patients during their stay in the radiology department [6] [11]. In 2011, 2462 radiographers were working in Swedish health care [12]. The main responsibilities of the radiographer are to produce images and to ensure the patient's safety, security and well-being during the examination and visit.

The image production process consists of three phases. 1. The planning phase, where preparations are made for the image production. 2. The performance phase, which is the actual film/image production activity, when the patient is positioned for the examination in the radiology laboratory. 3. The evaluation phase, includes the completion of images, quality checks of images, and sending patients home [13].



In a longitudinal study of how PACS have influenced radiographers' work, Fridell [7] states that they have developed from image producers to "jacks of all trades", because the skills required by the radiographer have become multifaceted and complex (ibid.).

3.4 KNOWLEDGE

Cook and Brown [14] describe knowledge as "a tool for knowing" (p. 382), while knowing is defined as a human action dependent on knowledge of different kinds of things and personal behaviour in relation to the physical and social world (ibid.). Radiographers have different kinds of knowledge, which they use as tools in their image production work, on the basis that they can apply their knowing and know how to produce images in practice. Knowledge is the basic condition for the practice of knowing. The concept of knowledge is described in many different ways. Davenport and Prusak [15] described knowledge as a mixture of various elements; as a mix of framed experience, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences and new information (ibid.).

3.5 **QUALITY**

The word quality in the Greek language means the characteristics' of something. Quality is defined as "the ability to satisfy or even outdo" the needs of the customers, present and future [16]. Avedis Donabedian [17] states that quality in patient care has two components; technical and interpersonal.

3.6 **FEEDBACK™**

Feedback™ is a quality management system for increased image and diagnostic quality within radiology. Feedback to radiologists and radiographers provides the radiology organization with a tool for competence sharing and continuous learning. The system allows the radiographer to track information about a patient regarding the radiologist's diagnosis both internally and across departmental borders, in cases where a second opinion is sought.

Feedback™ provides immediate information, is inexpensive, and requires little preparation. Feedback™ is designed to influence, reinforce, or change behaviour, concepts or attitudes [18] and may be a useful tool to support high quality in image production. The Feedback™ web system is fully integrated with the local PACS systems i.e. it holds the same integration to PACS as the RIS system holds.

3.7 **EQUALIS™**

Equalis™, a provider of external quality assessment for clinical laboratory investigations based in Sweden, is working to improve the quality of the examinations that are used for diagnosis and treatment in health care. Equalis™ conducts external quality audits of diagnostic examinations by health care providers. The aim is to ensure that the results of these examinations are reliable and comparable regardless of where and by what method the examinations are carried out.

To my knowledge, this system is not yet used for radiology services, although it is used in other clinical areas that conduct examinations such as clinical physiology and laboratory medicine. Discussions among radiologists and radiographers indicate that it might also be useful within radiology, but only small trials have taken place so far.

3.8 **RELATED RESEARCH**

The evolution of radiographers work practice has been great during the last decades. RIS and PACS have been implemented and digital systems, such as CT and MRI, have developed. This has brought on many changes in work for the radiographer. Larsson [6]

describes that radiographers are working more independently and that this new way of working calls for higher level of professional skills. Fridell [7] describes the shifting of radiographer's professional role from image producers to jack of all trades and being early adopters of the new technology. Changes in radiographer's knowledge demands, work practice, professional roles and use of technology are bound to have an impact on radiographic quality work. Thus is an updated analysis of radiographic quality workflow needed.

The health care of today is focused upon quality assurance, constant improvement and informal learning - for example through feedback and quality audits which are also prescribed by Swedish law [19]. To enhance the quality of radiographic workflow in the digitized radiology environment it calls for a better understanding of the new image production processes. We agree with the general argumentation of this field that it is important to have a properly functioning technology. However, there are contextual aspects of the work practice that the technology will form part of, such as feedback, which is important as well.

A quick and dirty literature review was conducted to map related research concerning the core of radiography quality work. Two databases, PubMed and Google Scholar, were used in December 2009, with supplementary searches conducted in May 2010 and February 2013: PubMed to cover the overall medical field and the Google Scholar digital library to cover the quality field for radiographers at large. To identify the relevant articles for this study, certain medical subject headings (MeSH) inclusion criteria's were used. The following search terms were used 2009, 2010 and 2013: "radiographer and quality" and "radiographer and learning". In total 67 papers were identified, 20 2009 and 10 more 2010 and further 37 2013. Out of these 1) 15 addressed technical issues; 2) 23 addressed work related activities; 3) 16 addressed learning activities and 4) 13 addressed treatment evaluations.

The following six papers, related to the aim of this thesis, were identified from the categories work related and learning activities.

DeCann [20] describes what skills a "good" radiographer should possess to be professionally competent. His conclusion is that a radiographer needs to: 1. be a technical expert, 2. have a general attitude i.e. punctuality, appearance, attitude, enthusiasm and initiative, 3. have social skills i.e. attitude to staff, reaction to stress, ability to work in a team and 4. be able to take care of the patient i.e. attitude to the patient and ability to communicate with the patient.

Andersson [11] focus on radiographer's areas of professional competence related to good nursing care. She describes the radiographer's "nursing care" as 1. direct patient-related area of professional competence i.e. guiding, performing the examination, providing support and being vigilant, and 2. indirect patient-related area of professional competence i.e. organization, ensuring quality, handling the image and collaboration. Andersson's (ibid) study is focusing on radiographic nursing related issues but shows a variety of components in the work of the radiographer, from caring for the patient to maneuvering the technical equipment that is being used to conduct the examination. The study also talks about how the radiographers are facilitating good nursing care ensuring quality in terms of safety such as 1) checking identity of the patient, 2) checking the agreement between the referral and the patient's symptom, 3) checking the technical equipment and correcting errors and 4) taking responsibility of documentation during and after the examination (ibid).

A paper made by Fatahi et al [21] deals with the radiographers experiences of communication with patients who do not speak the native language. The results show that within some radiological examinations high quality communication between the radiographer and the patient is essential to increase the quality of the examination.

Woodford [22] describes a model for practice called the four-tier profession. The most senior grade is the consultant practitioner required to demonstrate clinical expertise, professional leadership, practice and service development, research and evaluation and education and professional development. Cowling [23] talks about the changing roles of radiographers globally. UK has defined the role of the consultant radiographer as the most advanced practitioner. Many other countries strive towards this level.

The concept informal learning and learning environment is often used but not often defined. European Commission [24] och OECD [25] points out the importance of creating learning organizations and environments. According to them, informal learning at the workplace is increasing and forms an integral part of lifelong learning. And informal learning, together with education and formal training, is seen as the key to competitiveness. Due to research made by Skule [26] one of seven conditions for informal learning is superior feedback.

Modern technologies such as smartphones, tablets and mobile applications for radiology may be used for example for learning activities within radiology [27]. A search was performed on iTunes, Android markets etc. found 81 applications in the

categories diagnostic reading, decision support applications, medical books, interactive encyclopedias and journal reading programs.

This study includes a view of radiography work seen from a quality perspective, including interpersonal activities and the use of IT technology.

3.9 ETHNOGRAPHY IN HEALTHCARE

Ethnography is particularly useful in understanding the organization of health care, for example communication and information management [28]. Ethnography can provide a nuanced understanding of an organization and allow comparison between what people say and what they do (ibid.).

Pugsley and Atkinson [29] points out that ethnographic research methods to study medicine has been used for more than 50 years. Pope [30] states that ethnographic research in medical settings can “provide a catalyst for reflection and opportunities to feedback” and is enriching.

Several ethnographic studies have been made to understand the translation from analogue to digital technique within radiology. A reason for choosing an ethnographic approach is its ability to make medical settings visible, to produce detailed descriptions of the radiological activities within medical contexts [2]. Since the aim was to present a picture of medical work as seen and understood by the radiological staff, ethnography represented a fruitful point of departure. Ethnography supports an in-depth real-life study of the processes taking place (ibid.)

Karasti [31] used the ethnography method to study the teleradiology system and changes in work practice. Lundberg [2] used ethnography to study how to improve design, implementation and use of PACS. Larsson used the same method [13] when studying the influence of digitalization on radiographers work practice and knowledge demands.

Cook [14] and Curtis [32] concludes that ethnographic methods can be used within radiography to study intra-professional issues, inter-professional issues and clinical practice and clinical practice, patient and health delivery issues. Qualitative research defining what radiographers do and how they do it is however limited. Adams [33] urged for a research framework focusing upon qualitative research due to radiographers work.

In order to make the radiographer's knowledge and quality workflow visible on a more detailed level we need to look deeper into the different kinds of knowledge used in the image production process. Descriptions of different kinds of knowledge can be found in Blackler's theory of knowledge organization. These will therefore be presented in the next section.

4 THEORY

Blackler's Theory of Knowledge Organization

In this thesis Blackler's [34] knowledge theory has been applied to enhance the interpretation of knowledge demands in radiographic work; Blackler's (ibid.) outlines five components of knowledge: *embrained*, *encoded*, *embodied*, *encultured* and *embedded* knowledge. Blacker described *embrained knowledge* as something that depends on people's conceptual skills and cognitive abilities. The knowledge is formal, abstract or theoretical. *Encoded knowledge* is conveyed by signs and symbols represented textually and digitally de-contextualized. It is knowledge that has been coded and stored in blueprints, receipts, written rules and procedures. It is public knowledge accessible to the wider organization and can be understood and used without a knowing subject. *Embodied knowledge* is described as action-oriented, context-specific and only partly explicit. It is acquired by doing and knowing how, including practical thinking and problem-solving which depends on an intimate knowledge of a situation rather than abstract rules. *Encultured knowledge* is the process of achieving shared understandings through socialization and acculturation and is being stored in the culture. *Embedded knowledge* relates to the relationships between roles, technologies, formal procedures and emergent routines within a complex system and is upheld because of routines and doing things in repeated way without thinking.

Further on, Blacker discusses knowledge in relation to work and through these components he makes the knowledge process in complex organizations visible. He further underscores that the implication is that not only limited groups are regarded as knowledge workers, but that all individuals and all organizations are knowledgeable (ibid.). He also points out that we shall not view these different forms of knowledge as separate ones but closely intertwined in work. This makes the division between the knowledge components not completely clear (ibid.). I have chosen Blackler's components as they make radiographic knowledge and quality workflow processes visible on both a more detailed and structured level.

In this thesis three of Blackler's knowledge theory components have been chosen: 1) *Embrained knowledge* which is dependent on conceptual skills and cognitive abilities. We could consider this to be practical, high-level knowledge, where objectives are met through constant recognition and constant improvement. 2) *Encoded knowledge* which is information that is conveyed in signs and symbols (books, manuals, data bases, etc.) and transformed into codes of practice. Rather than being a specific type of knowledge,

it deals more with the transformation, storage and formal systematic questioning of knowledge. 3) *Embodied knowledge* which is action oriented and consists of contextual practices. It is more of a social acquisition. It is how individuals interact in and interpret their environment that creates this non-explicit type of knowledge. It is knowledge how to do, it is knowledge acquired by doing and could be described as practical thinking [35].

The next section begins by presenting a methodological background, followed by a short summary of ethnography including in more detail why ethnography is used in this thesis, and finishes with a discussion of the criticism and shortcomings of ethnography.

5 METHOD

5.1 RESEARCH APPROACH

This research applies an interpretative approach. This section describes why this was chosen in the light of the research problem and the setting described in previous sections.

5.2 INTERPRETATIVE FIELD RESEARCH

Interpretative field research is part of the hermeneutic tradition. This methodology is also known as inductive. The hermeneutic tradition studies, interprets and tries to understand the context that is being studied and its basic items [36] [37]. Klein and Myers [38] have argued that the 7 principles for interpretative field research have their background in the hermeneutic circle. This means "...that all human understanding is achieved by iterating between considering the interdependent meaning of parts and the whole that they form" (ibid. pp. 72). The 7 principles are: 1) The fundamental principle of the hermeneutic cycle (overarching principle), meaning improving understanding of a complex whole by moving back and forth between the parts and the whole involving multiple researchers in the data analysis. 2) The principle of contextualization (emphasis on uniqueness of situation studied), meaning difference between interpreter (the present) and author of text (past) and clarify the findings. 3) The principle of interaction between the researcher(s) and the subjects (emphasis on uniqueness of situation studied), conducting interviews at several sites and making observations. 4) The principle of abstraction and generalization by analyzing the findings related to literature and abstract theoretical assumptions. 5) The principle of dialogical reasoning, meaning confronting the researcher's prejudices with the emerging data. 6) The principle of multiple interpretations, meaning that data have been collected from multiple data sources and authors having interacted as a team. 7) The principle of suspicion (critical perspective), meaning to discover false preconceptions.

In my interpretation of radiographic quality work, I have developed an understanding of the links between knowledge, communication and informal learning in radiographic practice as the radiographers interpret it. This has led to an understanding of what radiographic quality workflow is. The overall understanding of radiographic quality workflow has vice versa led to an improvement of my understanding of the entities included in radiographic quality work.

Other concerns, beyond the interdependent meaning of parts and the whole, of interpretative field studies relate to my overall research question – How has digitalization of radiology influenced radiographic quality workflow? Firstly, the point of departure of interpretative field studies is that it is concerned with the interpretation of meanings [39]. This is also a primary concern in this thesis: where different kinds of understandings of the content of radiographic quality workflow are identified and analysed. Secondly, another concern of interpretative field studies is that organizations are not static and that the relationship between people, organizations, and technology is not fixed but constantly changing (ibid.). This is also a basic premise of this research, which views the understanding of radiographic quality workflow as a never-ending improvement process. Thirdly, the principle of interaction that is based on interviews and observations is in alignment of both this study and the 7 principles of the interpretative research. Finally, a further key point of interpretative field research is that theory plays a crucial role (ibid.). One uses theory as a device, to view the world in a certain way. In this thesis, Blackler's theory of knowledge has been used.

Ethnography falls within the interpretative field research and will be described in the next section.

5.3 ETHNOGRAPHY

Of the interpretative field studies, I chose ethnography. The purpose of ethnography is to see what ordinary observers do not see and to seize the silent. The reasons for choosing ethnography are that qualitative research is suitable for studies where earlier research is scarce [40] and where the aim is to identify the understanding of the world as the observed individual sees it. In this study the ethnographic methods interviews and observations are used.

An ethnographic study is sometimes also described as a field study [41]. It has its origin in anthropology and ethnology. This is a qualitative research method, used in the social sciences, which focuses on investigating everyday activities, lifestyle or a specific culture [37]. The term 'anthropology' means the study of humans and it is derived from the Greek language. The term 'ethnography' also comes from the Greek language and refers to the scientific description of peoples and cultures. Ethnographic studies are usually holistic, which means that they are grounded in the idea that people are best understood in the fullest possible context. This is a naturalistic research method, focused on the study and observation of people in their natural environment and through their own perspectives [42]. It involves the researcher joining the everyday

activities of the group and, overtly or covertly, observing people's daily lives for an extended period: watching what happens, listening to what is said and asking questions through informal or formal interviews. It also tends to involve collecting documents and artefacts that might throw light on the issues in focus of the research [41]. People's actions and their account of their actions are studied in everyday contexts, and data are gathered from a range of sources. The data collection is often relatively unstructured, i.e. 1) it does not follow a fixed and detailed research design specified at the start; 2) the categories that are used for interpreting what people say or do are generated through the process of data analysis; 3) the focus is usually on a few cases, and a fairly small scale, such as a single setting or group of people; 4) the data analysis involves interpretation of the meanings, functions and consequences of human actions and institutional practices, and how these are implicated in local, and perhaps also the wider, context (ibid.) Ethnography is often used to create an inside perspective [43]. The researcher's goal is to see the world in the same way as the informants do (ibid).

Ethnography is often used to study complex situations. As a research method, ethnography relies heavily on up-close personal experience and possible participation, not just on observation [44]. To be able to understand what humans do and why, it is necessary to learn about the culture in which they are. The ultimate goal of ethnographic research is to form theories or models, which may be generally applicable [45]. The way in which ethnographic studies are conducted varies, but common to them all is that the researcher prepares some form of written reflection from episodes she or he has witnessed or been told about. This material forms the basis for abstraction and analysis.

The goal is not to measure, count or "prove", but to see and understand contexts, activities, values and standards. The individuals being observed each belong to a social and cultural context, usually workplaces or organizations [43].

Ethnographic methods are applied in healthcare as a way of understanding beliefs and practices, allowing them to be viewed in the context in which they occur [37].

5.4 CRITISISM OF THE ETHNOGRAPHIC METHOD

The ethnographic method used may be unfamiliar to many people working in the medical environment, and may prompt a number of questions. One of the disadvantages of ethnographic research is that it takes much longer time than most other kinds of research. Another disadvantage of ethnographic research is that it does

not have much breadth; the ethnographer usually studies just one organization or one culture in the here and now. However, as radiography work is delivered in a fairly similar way around the world, this should not be a disadvantage for this project.

It is important to highlight that ethnographic methods will elicit the opinions of the individuals interviewed and observed. Ethnography aims to collect the opinions and perceptions of individuals, rather than objective facts. The ways in which individuals interpret their milieu will affect how they perform, whom they talk to and how they think about their work. It is thus possible for the researcher to identify patterns of opinions. Issues of validity in qualitative studies should be linked not to ‘truth’ or ‘value’ as in a positivist study, but rather to ‘trustworthiness’ [46].

Like many other qualitative methods, ethnography is not tightly linked to one carefully identified way to analyze and describe the collected data upon. This opens up for not choosing the optimal analysis of collected data. If the ethnographic method was tighter linked to a carefully identified analysis methodology its application and purpose may be more immediately apparent for the traditional medical research field as well as for the outside world.

The next section describes more in detail how observations and interviews were conducted in this study.

5.5 METHODS OF DATA COLLECTION

The interpretative methods of data collection in this study are observations and interviews. The reason for this choice of methods arises from the purpose of the study, to describe and understand how radiographers use knowledge and perceive quality work in the image production work supported by PACS. Other methods, such as the use of focus groups, were also considered but due to the scope of study not included. The advantages of interviews and observations are that interviews offer an insight of a deeper understanding from each individual and observations offers an opportunity to study if people do what they say.

5.5.1 Observations

Two common ways of making observations are naturalistic observation [47] and participant observation [41]. The naturalistic observation involves observing subjects in their natural habitat. They can be “overt”, the participants are aware they are being observed, or “covert”, the participants do not know they are being observed. Naturalistic observation allows communication with the observing milieu. The

participating observation aims to gain a close and intimate familiarity with the population investigated. This means that you for example work together in the team as an equal and make your observations continuously.

The observations in the study were naturalistic and overt. The observers were placed in the control rooms, which provided a general view of the radiographers' image production work. Only radiographers (no radiologists) were observed at each site. The participants were informed of the purpose of the study, and they confirmed their willingness to participate, before the start of each observation period. Each radiographer was observed for two hours. The observer followed the trail of an examination request from initiation to conclusion. The observations were documented through a simultaneous mixture of formal and informal data collection, ensuring that everything that was seen and heard was documented. After the observation, the researcher added notes describing his or her own reflections. The combination of these two methods has provided the investigator with the material to discern both what is said and what is done. The field notes record where and when the observation was made, the type of activities observed, and what was said and done.

5.5.2 Interviews

The interviews resemble one of a normal conversation. The researcher sets the context but, at the same time, should not control the conversation. In qualitative interviews a topic divided list of general questions are prepared, to ensure that specific issues are addressed. Topics covered in the interviews conducted in this study were: 1) image production work, 2) communication at work 3) feedback in work and 4) knowledge used in work. During the interviews, the researcher has the opportunity to develop and adjust the interview schedule and to ask follow-up questions, depending on what is said during the interview. The researcher has to be attentive, alert and imaginative. The line of inquiry may develop during the conversation. What happens during the interview is partially dependent on the interaction between the interviewer and the respondent [48]. This indicates that the questions prepared in advance should be as open and general as possible. The skill of attentive listening is essential for the researcher.

The interviews conducted in this study were in-depth interviews with open-ended unstructured questions, so that if a saturation point was reached, a follow-up question was then skipped, and the interview might proceed with a new open-ended follow-up question. Unlike structured interviews, an open-ended interview may resemble a conversation between equals.

The interviews were held in a separate room at the selected departments, and they lasted between 30 minutes and two hours. They were recorded on audio, and were typed out as soon as possible after the interview sessions. When typed, they were sent to the respondents for them to read, check and accept.

The interviews in the **first study** focused on the professional role; how to know what to do, and what kind of knowledge might be seen as important in effective working practice. The interviews in the **second study** focused on image production, communication at work, feedback about the images made, and the differences in working practice in the technical environments associated with analogue and digital radiographic work.

6 MATERIAL

The empirical fieldwork began in September 2005 and was completed in August 2011. The investigations were conducted in three different levels of radiological departments in Sweden: university hospital, regional hospital and county hospital. In total, five hospitals were included in the study: three university hospitals (A, B, C) digitalized between 1997 and 2006, one county hospital (D) digitalized in 2003 and one local hospital (E) digitalized in 2003. These sites were chosen because they were early adopters of the new technology, and they were actively engaged with aspects of quality improvement and learning.

In total, 34 individuals were interviewed, including 30 radiographers and four radiologists; 15 radiographers were also observed. In the **first study**, 22 radiographers were interviewed and observed at five hospitals: site A) four interviews and two observations; site B) eight interviews and four observations; site C) four interviews and three observations; site D) three interviews and three observations, and finally site E) three interviews and three observations.

Table 1. Sites, numbers of informants and their years of post-qualification experience

Sites	Persons interviewed	Interviews for study 1	Additional interviews (for study 2)	Observations (for study 1)	Worked \pm 5 years	Worked between 6 and 10 years	Worked > 10 years
A	Radiographers	4		2	0	2	2
B	Radiographers	8		4	1	2	5
C	Radiographers	4		3	0	1	3
	Radiologists		2				2
D	Radiographers	3	8	3	1	2	8
	Radiologists		2			1	1
E	Radiographers	3		3	1	0	2
Total		22	12	15	3	8	23

In the **second study**, 12 additional interviews were undertaken at two of the original sites. At site C) two radiologists were interviewed, and at site D) two radiologist and eight radiographers were interviewed (Table 1).

6.1 SELECTION PROCESS

Permission to carry out the fieldwork was obtained through contacting the responsible managing radiographers in the different departments by telephone, and introducing ourselves, explaining our research topic and our methodology. Before contacting them, we had useful help from key informants who were ‘gatekeepers’ within the profession. They introduced us, told us whom to contact, and, once permission had been obtained, helped us arrange the interviews and observations.

The inclusion criteria for interview subjects were that the radiographers should have a variety of professional experience, that they were not confined to specialized work with only one modality, such as MRI and that they also undertook regular on-call duties. In addition, they should have worked with both analogue and digital technologies. At each site the local head nurse was the key contact. The local head nurse used the inclusion criteria to identify the radiographers who qualified to take part in the study. Subsequently, the researchers themselves contacted the potential respondents and asked them to participate in the study. In summary, both younger and older persons practising their profession were included, with working experience ranging from 3 to 30 years. The participants’ ages varied from 25 to 60. The youngest respondent had only worked with analogue technology during the course of her training.

One of the radiologists at site C was chosen and contacted by the local head nurse and the other radiologist interviewed at site C was identified and contacted by the researcher. At site D, the radiologists who participated in the study were identified and contacted by the researcher, who was also a manager at this site. All of the radiologists interviewed were chosen because they were senior, had taken an active role in the digitalization and/or learning process of the department, and were willing to participate in the study. All radiologists were informed of the study by the researcher.

6.2 ETHICAL CONSIDERATIONS

This research has only involved hospital staff, and no ethical approval was needed, as it did not include any patient data. However, ethical guidelines put forward by the Swedish Research Council [49] have been taken into account, to assure the participants that they have a right to withhold their consent to take part in the study, that any information they provide will be treated confidentially, that the researcher will make use of the information only for the purposes of the research described, and that the data will not be made public or passed on to other users.

Over several years, 34 interviews and 15 observations were made by two different interviewers, and the data were all analysed together. All of the informants provided consistent information, with no major divergence between different age groups, different occupations, or different workplaces (university hospitals, regional hospitals, or local hospitals). The respective interviewers also received consistent information.

The analysis and conclusion make use of data that have been collected by means of several different methods: interviews, observations and field notes. As the study was conducted at so many sites, interviewing a number of radiographers of different ages and with different length of working experience, it is most likely that we have been able to find a real recurrent pattern that is significant for the field under investigation.

The interviewers themselves are radiographers with long experience of the field, although they do not practice locally, thus ensuring that they have brought an outsider's perspective rather than an insider's perspective to their role in the study.

The findings from this study may be transferable to the examination of working practices in other areas in healthcare, for instance the situation of biomedical scientists working within physiology and pathology departments; nurses, midwives and sonographers working with ultrasound; and nurses whose extended scope of practice entails taking over tasks from doctors. In all of these situations, there is an increased need for feedback about their work.

7 ANALYSIS

Graneheim & Lundman [50] provide the following description of how content analyses of ethnographic work, including interviews, should be conducted: The whole text should be read over, several times, to enable the researcher to gain a feeling for the entirety of the text. Any sentence or a phrase including information that is relevant for formulating the question to be investigated should be identified and marked. These sentences or phrases are called ‘bearing units’. They are condensed in order to shorten the text yet keep the content as a whole. The condensed bearing units are coded and grouped into categories that reflect the central message from the interviews. These categories provide the manifest content. Finally, themes can be formulated, where the latent content of the interviews appears.

The goal of a qualitative content analysis is to gain an understanding of, and insight about, the assembled material [51].

The analysis began at once, after each interview was conducted, with reading and annotation of the transcripts. This gradually gave us, as researchers, an indication about how to proceed with the forthcoming interviews, and how the questions might fruitfully be adjusted. It also gave us an indication of when a saturation point had been reached. When the saturation point was reached, the material was taken forward to the next phase of the research work, the main analysis.

7.1 FIRST STUDY ANALYSES

Three **work phases** were identified in the analysis process: 1) the planning phase, 2) the performing phase and 3) the evaluation phase. The analysis showed that radiographers work with these three phases in both the analogue and the digitized environment. The interview material was classified into these three work phases. Secondly, the material was analysed in terms of the different phases, and the sentences were reduced to phrases. Thirdly, the material was condensed to words or phrases with the same context. Fourthly, the remaining words or phrases were sorted into the groups that had become clear during the analysis. Finally, analysis was undertaken to identify patterns and to determine purposeful, underlying meanings. Related codes were analysed to find or identify concepts that were typical of the results from the interviews, see Table 2 for more details.

Table 2. Example of the analysis process

Work phase	Phrase	Condensation	Groups	Concepts
Planning phase	<i>"I check what is to be examined, and compare data in the request with the booking"</i>	Needed control Embrained knowledge	Structure work	Routine actor
Evaluation phase	<i>"I want to look at the frontal spine so as to know which side the patient should lie on when I move on and take the lateral projection"</i>	Deep understanding Embrained knowledge	Analyse images	Reflective actor

7.2 SECOND STUDY ANALYSES

Three **work phases** were identified in the analysis process: 1) image production, 2) communication in work and 3) feedback in work. The analysis showed that the radiographers pass through these phases and that they described them as quality indicators in terms of their working practice, both in the analogue and in the digitized environment. Firstly the material was separated into categories relating to the three work phases. Secondly, the material in each work phase was analysed and the sentences were reduced to phrases. Thirdly, the phrases were condensed into words or shorter phrases. Fourthly, the remaining words or short phrases were sorted into groups and finally, analysis was undertaken to find patterns and concepts that illustrates the results, see table 3.

Table 3. Example of the analysis process

Work phase	Phrase	Condensation	Groups	Concepts
Image production	<i>"Well exposed, adequate collimation, correct projections, right angle, within the joint, that I have not cut the image"</i>	Perform correct projection	Use of technology	Knowledge
Feedback in work	<i>"Get some feedback, it is important, one learns from this....so one can do the same or even improve next time in the same situation"</i>	Feedback Reflect and learn	Feedback Reflection	Learning

8 RESULTS

The different types of knowledge that radiographers need in order to deliver quality workflow are shown graphically in Figures 1 and 2 below. These figures summarize the knowledge needed to conduct radiographic work and the components of radiographic activity. Radiographic work is a complex activity, for which several different types of knowledge are needed. These types can be defined as emtrained, encoded and embodied knowledge.

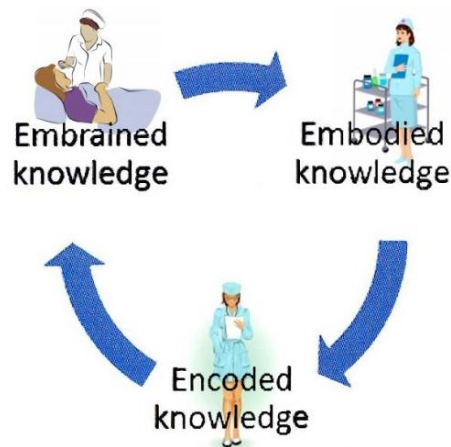


Figure 1. Different types of knowledge identified in radiographic work

Knowledge is a prerequisite for radiographic quality workflow, but it is not in itself sufficient. The radiographer also needs technical and interpersonal skills. Communication and learning are also important factors in the production of radiographic quality workflow.

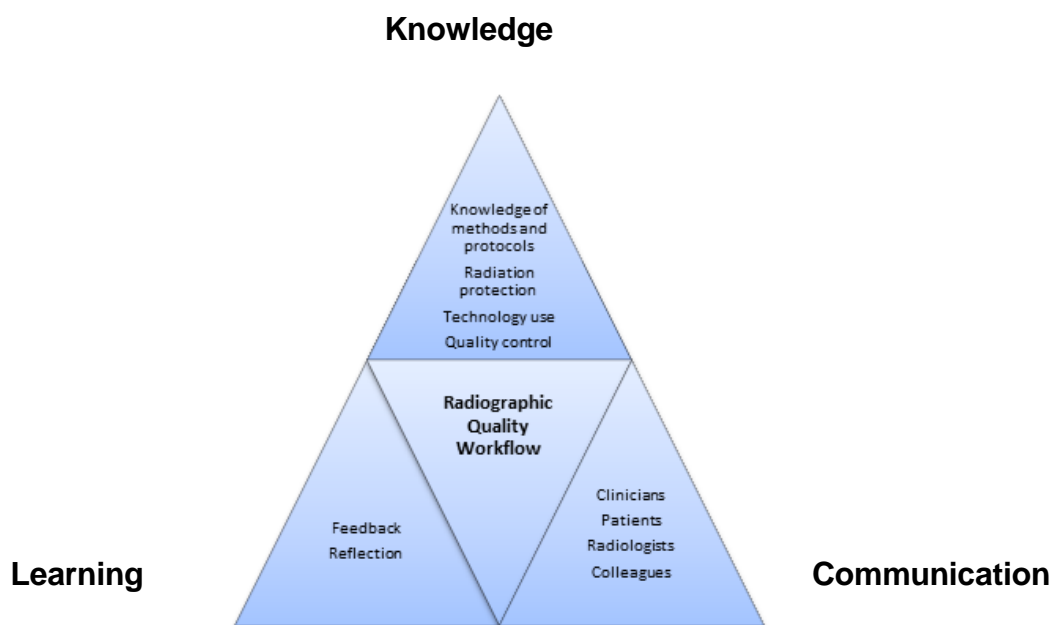


Figure 2. The content of radiographic quality workflow

We have analysed how knowledge, communication and learning are linked in the production of radiographic quality work, to identify how this work is achieved? The result from this analysis is summarized in figure 3.

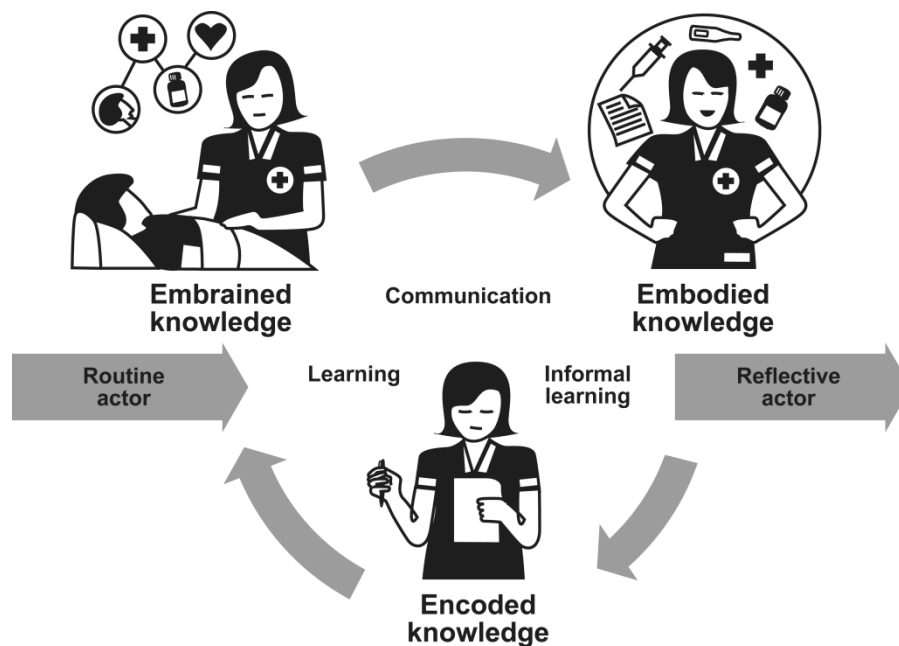


Figure 3. Radiographic quality workflow

8.1 KNOWLEDGE

8.1.1 Embrained knowledge

When radiographers use their *embrained knowledge*, they are using their intelligence and their theoretical knowledge rather than their hands-on knowledge. *Embrained knowledge* is used in the planning of activities in a functional and structured way. For example, the radiographers prepare the examination table for an angiography, knowing exactly what equipment that is required. *Embrained knowledge* is also used when radiographers prioritize their tasks, plan the order in which patients should be seen, the specific views that should be taken and the quantity and types of images to be produced. When radiographers check the images and send patients back to the wards or their homes, they also use their *embrained knowledge*. When reading the images, they need to decide whether the image criteria for the relevant examination have been fulfilled. Radiographers check the images by viewing them, and those functioning at a routine level explain their reading of images in the following way:

“ ...in part that I have captured the specified organ on the image... I check every image between exposures, or when the examination is finished. I make sure that the projection is OK and that everything that should be in the image is there.”

Reflective radiographers analyses the quality of the images in a more complex way. They can do this when they know more about the image criteria, and more about anatomy and physics, all of which helps them to feel more secure in their role. In this specific situation, deeper and more thorough embrained knowledge is required for the reading of images. The senior radiographer describes it in the following way:

“If I see a fracture, then I want to see that the views are in a straight line. I check that the image quality is good and I am satisfied...It’s important that the radiographer has reflective actor knowledge in the subject of anatomy... For example, I want to look at the frontal spine, to know which side the patient should lie on when I move on and take the lateral projection, or if any angle in the radiological equipment is required to get a proper angle between the vertebrae.”

In radiography, the fundamental difference between the routine actor and the reflective actor is that a routine actor applies a static thinking approach in planning and checking images, while a reflective actor applies a flexible thinking approach in the planning process, and actively analyses the images while viewing them.

8.1.2 Encoded knowledge

When radiographers use *encoded knowledge*, they may use a range of different kinds of documentation. In practice, the radiographers display the appropriate menus, for instance for a skeletal ankle injury. This will provide access to a menu identifying the projections required for that condition. This type of *encoded knowledge* helps them to do their day-to-day work through accessing and using different kinds of electronic and paper documentation systems. Applying *encoded knowledge* for the routine actor means that the radiographer knows just “to use” the documents and manuals at the department to conduct their work. At one of the hospitals that had feedback rounds for the radiographers, one of the reasons for recalling patients was that the method instructions were imprecise.

It is the routine actors, just starting their journey to become professionals, who follow the manuals, protocols and other documents closely, from A to Z, in order to perform an examination. The manuals become their lifeline, and they read the documentation in an unreflective way. A junior radiographer explains it as follows:

“I check the handbook every day. Everything I need to know is in there”

As the radiographers become more reflective actors, they still use manuals, protocols and other documents, but in a different way. Instead of simply reading the manual they are critically analyzing and even revising it. For examinations that they undertake rarely, they will consult the manual before performing the examination. Often, when reading the manual to check how to perform an examination, they end up checking and altering the documentation, sifting through the content selectively. Radiographers know “how to use and even develop” documents and manuals. An experienced radiographer describes it as follows:

“I prepare the control unit and sometimes use the organ keys for selection, or I check the specific radiological tubes, tables and exposure parameters”

8.1.3 Embodied knowledge

When radiographers use *embodied knowledge*, it is knowledge “in their hands” and often involves the handling of technological options for image production work, a “hands-on” approach. *Embodied knowledge* is originally built upon information, which is usually described and presented in textbooks. This information is interpreted by the individual radiographer in a learning process. Finally, through experience, it becomes *embodied knowledge*.

To obtain images in different projections, the radiographers have to place the patient in various positions. Routine actors do the examination in an automatic way, directly from their textbook knowledge and on the basis of documents and manuals. Reflective actors use their improvisational knowledge when it is difficult to do the examination in the way that they are used to, or by the book. In these situations, the radiographers demonstrated their capacity for flexible working, and their problem-solving competence. They solved problems in different ways when they were doing an examination. The senior radiographers stated that they:

“...need material that is good enough to be interpreted.. This isn’t always possible, but we have done our very best. Sometimes you just have to improvise; you can’t always do things by the book”

8.2 QUALITY WORKFLOW

8.2.1 Knowledge

Some of the radiographic quality workflow is described by the respondents as tasks related to protocols (method descriptions). The respondents explain that radiographers

often know these by heart, and in practice they develop a mental checklist that they go through to ensure that the examination is completed with the appropriate quality.

“Well exposed, right angle, into the joint, image sharp and not blurry, collimated to avoid unnecessary radiation dose. Image contrast and density are possible to manipulate in PACS”

During the observations, it became evident that the individual radiographers put considerable effort into following the protocols correctly. According to the respondents, it is not enough to have the theoretical knowledge. You also need to know how to perform examinations; this is really only achieved by having practiced the profession for some time.

“I fulfill the expected image criteria so that the radiologist can establish a diagnosis”

The combination of theoretical knowledge and knowing how to perform an examination makes it possible for the radiographer to judge whether an image is adequate for diagnostic use. This combination characterizes the property knowledge.

“I can immediately see whether it [the image] is sufficient or not. I have it in my backbone”

The routine actor did not put much effort into collimation whilst working with the patient, but instead performed collimation afterwards in the PACS. This means that if the examination was performed by a radiographer who was a routine actor rather than a reflective actor, the patient was likely to receive a higher dose of radiation.

“I display the images on the monitor, and do quality control”

Observations showed that the routine actor had to take several exposures before fulfilling the image criteria, again resulting in a higher radiation dose for the patient.

“She is performing a knee examination, and is trying to achieve a straight lateral projection. She is not satisfied, and makes nine exposures before she gives up”.

Field notes

The reflective actor made a great effort to collimate whilst working, with the aim of limiting the level of radiation as much as possible, for the benefit of the patient.

In addition to performing the examination according to the protocol, it was observed that a reflective radiographer was able to judge when it was simply not possible to achieve better images:

“It is an advantage that I can see directly if the result is sufficient or not, if the images are suitable to be digitally processed, or if they should be retaken”

The examination might sometimes be concluded by the reflective radiographer with images of less than ideal quality, and this was documented in the RIS patient record, explaining why images were of poorer quality.

“If the radiographer has written an explanation, such as ‘unable to hold breath’, I realize that it probably won’t be possible to achieve better images” (Radiologist)

In their interviews, the radiologists explained that the radiographer’s documentation about the reasons why the image was less than optimal could be of decisive importance in the radiologists’ willingness to accept and use an image that did not quite meet the criteria specified in the formal standards.

8.2.2 Communication

In the production of radiographic quality work, communication is an important factor. The need to communicate appropriately was emphasized by all respondents. The sequence of communication was described as including the initial request written by the clinician, describing the patients’ problem and the question that was to be answered by means of the radiographic image.

“I have to adjust the examination to the question raised by the clinician.”

Using the information provided by the clinician, the radiographer or radiologist often chooses an appropriate method for the examination. The description of the patients’ problem may or may not provide sufficient guidance. Whatever is stated in the request, the radiographer still needs to perform an examination that will enable the radiologist to make a relevant and appropriate diagnosis. In the observations, it was found that a reflective radiographer tended to pay more attention to preliminary research, checking the results of previous examinations, and the images produced, to obtain a better idea of how the new examination should be undertaken. In general, the more reflective radiographers made use of a wider variety of resources than did the routine radiographers, who generally just followed the prescribed protocols. This means that the interpretation of diagnostic quality may be wrong to a higher extent regarding the radiographer operating at a routine level of working, increasing the likelihood that images would need retaking.

The respondents believed that establishing a good relationship with the patient made it easier to convey the necessary information to the patient, and to obtain their cooperation in achieving the different poses necessary for obtaining the required quality of images.

“It is important to have good contact with the patient. The way in which the patient and I cooperate, and how the patient understands my instructions and the information I have provided, has an influence on the image outcome”

Reflectively working radiographers tend to add to their memory the specific needs and conditions of patients in each patient group, so the next time that they meet a similar patient, they start from the level at which they ended the last interaction with such patient(s). Radiographers, who work in a routine way, seem instead to view each patient as simply another line in a list to be worked through. It was observed that the ability to meet the patient at his or her level was essential for the outcome of the examination, and for achieving a high quality of radiographic workflow.

“I sometimes wonder if I have let through something that is not as good as it should be. I often look up the radiology report after a few days to see if anything has been written about the examination. I want to do the best I can. I want to develop professionally.”

Observations revealed that this behavior is typical of reflectively working radiographers. They will forego coffee breaks to make time to find feedback about their work through the RIS and PACS. For reflective radiographers, this kind of feedback compensated for dialogue with the radiologist. Such behavior was not reported by or observed among radiographers who worked in a routine way.

8.2.3 Learning

The radiographers emphasized the importance of being able to communicate with the radiologists in the course of their work. However, the respondents reported that this communication tended to disappear in the digital environment.

“The radiologists are always busy, they have no time for communication with me...”

It was observed that as less time was made available for face-to-face communication, the written documentation resource in the PACS became more important. The reflective radiographer knows how to write brief explanations about the reasons for the outcome of the images, so that the radiologist immediately understands why the images look as they do. In contrast, the routinely working radiographer usually does not write anything at all, or writes an essay that is too long for the radiologist to read.

All of the radiographers interviewed said that in the absence of a radiologist, they more frequently conferred with a colleague before deciding whether particular images were adequate or not.

"If I am uncertain, I often ask a colleague who might know more. They are more easily at hand"

It was observed that reflective radiographers accepted it as natural to be interrupted at their work by colleagues with questions. This meant that reflective radiographers had a high number of interactions with many other medical professionals in the course of their work. Conversely, it was observed that a routinely working radiographer made several retakes of images, without communicating with anyone.

8.2.4 Informal learning

It was observed that when working with PACS, the radiographer took the responsibility for initial approval of the examination, and sent the patient home. The opportunity to discuss the outcome with a radiologist seldom occurred. Radiographers who were interviewed described several attempts to book formal briefings between radiologists and radiographers, but these initiatives had fallen away due to lack of time:

"We had specially booked meetings at which the radiologists presented patient cases for us. However, these have drifted away due to the radiologists' lack of time"

For a radiographer to be able to make a transition from a routine way of working to a more reflective practice, learning through communication with more experienced radiographers and with radiologists is valuable. For the more reflective working radiographer, it is important to create new ways to continue learning.

8.2.5 Information and Communication Technologies (ICT)

According to the respondents interviewed, oral feedback was given almost immediately in the analogue workflow, as the radiologist made a quick evaluation before sending the patient home.

"We used to show all images [to the radiologist] before PACS. This also meant that we could always discuss whether the quality of the images was okay or not. Today I make the quality appraisal myself, and send the patients home"

In the PACS-enabled radiology department, the routinely working radiographers do not have the same opportunities that their colleagues used to have to use radiologists as a learning resource and a source of inspiration. In a film-based radiology department, there was continuous feedback and guidance from radiologists. Reflective radiographers also miss an important and continuous affirmation about the quality of work that they produce. This situation diminishes the opportunities for both routine and

reflectively working radiographers to develop and improve the quality of their workflow and to engage in continuous learning.

"Sometimes it feels as though you make one examination after another, pressing the exposure button, working as if you are on an assembly line, not knowing if the work you are doing is good."

For reflective radiographers, this way of working is not acceptable. It makes them search intensively for changes in working patterns that offer greater opportunities for communication and feedback. Routine radiographers are more likely to accept the situation, and just get the work done.

Radiographers are open-minded when it comes to new technology. All respondents indicated that electronic feedback would be appreciated, since work is already digitized.

"I would like to have a chat function when I quality assure images. We must have communication tools that meet the needs of our practice"

For the reflective radiographer this was a potential way of developing a new communication channel with radiologists. For the routinely working radiographer this new channel was seen as an unnecessary extra step in the work.

At some sites, the radiologists use an electronic feedback system between themselves.

"The radiologists have a feedback system that they use among themselves. It would be very good if we also could communicate using the same system"

For reflectively working radiographers, this would mean that they would not need to look up all the diagnoses made by the radiologists in quest of feedback on her work. Instead, the radiographers would be provided with any images that a radiologist had any feedback (both positive and negative) or comment upon. This would provide a more direct form of feedback, much easier to access and to learn from than the current practice of going through past examinations to find all diagnoses made by the radiologists. Routinely working radiographers would systematically obtain the regular and direct feedback needed to improve their quality of work, and they would also obtain a wider perspective about their work.

"If I was a newly qualified radiographer I would find it extremely difficult to learn and improve properly without direct feedback. A digitized feedback system would surely benefit the learning."

For the reflectively working radiographer, such a system would provide access to an information and communication tool that would enable her to give feedback, at any time, to any of the other radiographers.

9 DISCUSSION

In the use of digital imaging management and PACS, it is important to have knowledge about the changes in work to achieve radiographic quality workflow. This study illustrates that in the digitized management of radiology examinations, changes have taken place both in feedback at work and in the use of information systems, e.g. post-processing of images at the quality control station and sending images to PACS. Reflection and learning in work have also changed. Having a profound ability to reflect, learn and transform in work is more important in the digitized management of radiology than in working with films, as radiographers have new responsibilities in their work. With increased responsibility, radiographers make a first evaluation of the images and send the patients home. This calls for knowledge to handle method protocols and exposure parameters, skills to read and understand documents, e.g. clinical information given in requisitions, and skills to use the new information systems. Radiographers must have communication skills and activities that stimulate continuous learning at work. The study shows that radiology in a PACS environment requires a transition where radiographers must have a more reflective and flexible approach in the image production process. It is not enough to “check images off”; documents cannot merely be read, but must also be interpreted to optimize work performance. Knowledge about the aspects of routine-focused and reflective radiographers seems to be important for an understanding of the consequences of the radiographic quality workflow.

Because the radiographer in today’s digitized environment not only performs the first evaluation of the examination but also sends the patient home, there is a need for a new type of knowledge and radiographic quality workflow. In digitized radiology, the lack of communication with radiologists has emerged as a major problem for radiographers [6]. Digitization is not the only factor that has made the work more independent. Another factor is the shifting of tasks from radiologists to radiographers, which started before digitization due to the shortage of radiologists. Changes may also be due to the changes in society as a whole, demanding new ways of organizing work processes.

DeCann [20] focused on aspects of quality in radiographic workflow as long ago as 1986. His conclusion was that a radiographer needs to: 1) be a technical expert, 2) have a generally positive approach with regard to punctuality, appearance, attitude, enthusiasm and initiative, 3) have social skills in terms of attitude to staff, reaction to stress, and ability to work in a team, and 4) be able to take care of the patient, in terms

of attitude to the patient and ability to communicate with the patient. This study has complemented DeCann's study by adding three new aspects that are also needed to meet the new requirements in radiographic quality workflow. These aspects are communication, learning and the transition from routine to reflective acts in work. The radiographic quality workflow can thus be described in a more detailed and specific way. Knowledge about the aspects of a particular job is an important tool to develop such work.

PACS and digital image management create opportunities for many new ways of working, e.g. digital post-processing, fewer retakes, the ability to view images anywhere in the hospital and increased throughput [6]. If a radiographer needs support from a radiologist in evaluating the quality of images PACS have the theoretical potential to enable such support. The images could be sent over the PACS to a radiologist who is not nearby. The shortage of radiologists and the lack of contact with radiologists have led to closer contact with colleagues, as they are more readily available.

There are no sets of easily accessible indicators to illustrate the actions and contexts that differentiate routine-focused from reflective radiographic workflow. Quality in radiographic workflow has been shown to correspond to mindfulness at work. How to trigger the transition from routine-focused to reflective work by radiographers is a future challenge. Various quality assessment-, information- and communication technologies could support radiographic quality workflow including virtual communication and support between radiologists and radiographers, such as FeedbackTM, EqualisTM, HAWA and messaging systems such as MSN, Twitter, Facebook, or Apps for smartphones. These new technologies offer simple ways to give positive feedback to support and encourage learning in work. Radiographers must find fruitful new ways of communicating, not only with radiologists but also with clinicians, colleagues and even patients, as communication is one of the cornerstones in the quality of radiographic workflow. This study shows that communication with the patient is of great importance in medical work. New technologies create opportunities for new communication channels with patients.

9.1 FROM ROUTINE TO REFLECTIVE RADIOGRAPHIC WORKFLOW

9.1.1 Knowledge

When radiographers pass the undergraduate examination, they have basic knowledge of how to carry out radiological examinations. But do they have the knowledge to quality assure images, make the initial evaluation and send patients home? Using technologies such as PACS and RIS requires more detailed checking, preparation and accuracy before and after performing the examination [13]. Are radiographers sufficiently prepared for these activities?

Some radiographers mainly use a routine approach, while others are more reflective. If a routine approach predominates, a scenario in which work is more individual and involves more responsibility will present challenges. Radiographers therefore need to have knowledge that makes them “know how”, “know what” and “know why” in the image production process.

In society as a whole the developing trend of working life is that work becomes more complex and decentralized [24, 25, 52]. A Tayloristic principle means a bureaucratic way of organizing work practice with very limited demands on the individual's knowledge and abilities. According to Ellström [53], Tayloristic principles of organizations limit the development of daily learning. Unfortunately, these principles still influence the organizations of today to some extent. Today, there is a need for new ways to communicate and to organize work in integrated production systems, such as customer-oriented systems based on Japanese production philosophies including total quality management, lean production and continuous improvements. These systems demand increased theoretical knowledge and intellectual skills (ibid). This study has shown that radiographers need to detect, identify and solve problems in an independent way. A routine approach to work was usually adequate for radiographers in the analogue world, whilst greater complexity of work combined with increased decentralization and distribution of decision-making, as in the digitized radiology department, requires radiographers to work in a more reflective way.

This study shows that radiographers use *embrained, encoded and embodied knowledge* [34] in their workflow with radiographic services. *Embrained knowledge* is used in the image production work, i.e. when radiographers plan the examination and view the radiographic images in different ways. In this situation, radiographers use individual decision-making. *Embrained knowledge* is more central in situations where individuals

perform the work on their own. Other studies illustrate that radiographers work in greater isolation in digitized radiology departments [6] [7]. Radiographers' work has changed because they have new responsibilities, such as image quality assurance and deciding when patients can be sent home (ibid.). *Embrained knowledge* leads to a deeper understanding of specific image criteria essential for the quality assurance process and for producing an optimal examination.

Encoded knowledge is illustrated in this study by the way the radiographers use manuals, documents, etc. based on the department's rules for the processing of images. This study shows that when radiographers with a routine approach use *encoded knowledge*, they read the documents and manuals step-by-step and use them as the basis for their work, whilst radiographers who work reflectively are more focused on how to develop the workflow. Reflective radiographers can often produce unexpected but important new knowledge. This means that it is important that radiographers reflect critically on the manuals and other documents they read, and do not simply follow them slavishly like recipes from a cookbook.

Embodied knowledge is knowledge that manifests itself in the doing of something. This study showed that radiographers need to recall what they have learned in the past, both from formal learning and from previous clinical experiences. Radiographers applied *embodied knowledge* in different ways when they performed examinations. Whereas radiographers with a routine approach performed work automatically based on manuals, methods, protocols and rules, reflective radiographers solved problems through improvising, using their competence and experience.

9.1.2 Communication

The radiographers clearly expressed the need to communicate with clinicians, patients, colleagues and radiologists in order to produce an examination of good diagnostic quality. The communication may be needed for clarifications such as incomplete requests, uncertainty about which method to use or how to conduct the examination, and if the result is adequate. Lack of communication with radiologists has been described as a major problem for radiographers [6] [7]. In the analogue department, it was reported, that communication took place all the time because the radiographers met the radiologist after almost every examination. Today, this communication has almost disappeared. Instead, the radiographers said that they had new partners to communicate with, such as colleagues. Communication was expressed as a cornerstone in the radiographic quality workflow.

This study showed that radiographers with a routine approach were more focused on production without seeking communication and feedback, whilst reflective radiographers sought communication and feedback continuously. This means that routine-focused radiographers tended to maintain their routine approach, whilst reflective radiographers tend to remain reflective in their work.

One of the hospitals had feedback rounds for the radiographers. These meetings focused on examinations that were not consistent with the method descriptions. One might wonder why new “learning forums” have not been developed for radiographers to meet and learn from radiologists and other radiographers in the digitized working environment

Facebook could provide useful support to radiographers, as it is a social networking service and website. Facebook allows users to create and join common-interest user groups, organized by workplaces or universities. The development of radiography and radiology, which is a much wider concept, could be discussed over Facebook, with a focus on new methods and protocols, allowing fruitful discussions between radiographers and radiologists. Encouraging exchange of knowledge between workplaces and universities is also fruitful. It might be possible to create quizzes about different examinations, images and diagnoses using decoded and anonymized material

Another successful social network service is Twitter, which offers online communication, enabling radiographers to send questions to a larger community in real time. Radiographers could ask about problems that arise and might receive responses and suggestions immediately. Through Twitter, radiographers could also send out news or information about new methods, to a larger community of radiographers and radiologists. This information could be either in an open profile or in a private one, e.g. a postgraduate radiographer community, where followers have to ask for access. Another possibility is to let patients use Twitter to ask for information regarding examinations and their preparations. Open or private profiles can be created here as well.

MSN is another Internet online service for interactive multimedia content. This could be useful, as images can also be easily shared among radiographers. The service includes point-to-point discussion between two parties. For example, it could be used to send messages in real time to a radiologist located somewhere outside the departments and thereby to obtain a quick answer to an urgent question. In this way, one radiologist could staff a call-center service to answer questions from radiographers from an entire

region or nation. This service could be complemented by using web cameras on both sides.

A mobile application, or mobile **App** for smartphone, is a software application with multimedia support designed to run on smart telephones. It is an easy and effective way to reach various stakeholders. For example, an App could create a direct link between radiographers and their patients to provide support or to receive important information from them. It could also be used to help patients prepare for an examination or to inform patients about which departments have the best patient ratings and shortest queues. Today established and trustworthy high security technologies are available, e.g. OAuth 2.0 and API Gateway.

9.1.3 Learning

How can radiographers improve the quality and performance of their radiographic workflow? This study illustrates that learning is supported by of feedback and reflection. According to the Nordic Council of Ministers [52], professionals and organizations will not be able to solve future challenges without altered education. In parallel, according to reports from the European Commission [24] and OECD [25], informal learning together with teaching and formal training in practice is seen as the key to competitiveness. Skule [26] stated that one of seven conditions for informal learning was superior feedback. However, radiographers lack feedback from radiologists and it may be questioned whether learning from colleagues is in place and sufficient. One way to emphasize and stabilize collegial communication could be through “standardized collegial reviews”. In practice, feedback could be given by other radiographers on a regular basis.

9.1.3.1 FeedbackTM 2.0

Radiologists in Sweden have a quality assurance system, named FeedbackTM, designed to support the identification and classification of discrepancies in radiology diagnostics. It supports cross-organizational web communication between radiologists working at different radiology departments and hospitals. It is an easy-to-use web-system, designed to support radiology teaching, learning and research work.

Technically, FeedbackTM is a complex intermediate system that is fully integrated with local radiology information systems (RIS), picture archive and communication systems (PACS) and other feedback systems at different radiological departments and hospitals. Such a tool could just as easily be used for feedback to radiographers from radiologists

and colleagues. Managers need to step in and support use of the system by radiographers. The FeedbackTM system provides opportunities for radiographers to learn from their own as well as their colleagues' cases. This was previously not available. It thereby supports development of skills and encourages excellence in healthcare work. This means that it could also be used by “mentor radiographers” and their mentees to follow up performed workflow.

9.1.3.2 *EqualisTM*

This is a national quality assessment tool for laboratory, physiology and image reproductive examinations. Examinations are shared among the participants, giving them an idea of how their own results correspond with results from other participants and with predefined indicators. It helps the participants to evaluate the accuracy of their own result reliability. Although it is not frequently used for x-ray examinations, at least not by radiographers, the tool would give them a safe and reliable way to test and develop their knowledge. It is not, however, a method for instant and interactive feedback.

It is my belief that no other actor than the radiographers themselves have the responsibility and possibility to transform themselves. This mindset opens up for radiographer's new ways to communicate in practice over time with the aim to support and teach themselves and others in practice. There are mental frameworks that enhance how to become a reflective radiographer that focus on the support and teaching of others in practice these are summarized in the Ten Commandments for how to become a reflective radiographer below.

Ten Commandments for how to become a reflective radiographer

1. Continue to build on radiographers' strong willingness to do the best for the patient and their willingness to take on greater responsibilities. Work must continue to be fun and interesting and must provide opportunities and means to develop.
2. Establish an understanding of how important it is for radiographers to progress from a routine to a reflective orientation in their radiographic workflow.
3. Encourage reflection in groups at formal learning meetings with radiologists.
4. Engage radiographers in think tanks such as collegial reviews including both novice and experienced radiographers.

5. Ensure that each new radiographer has a formal mentor with informal and formal meetings to promote development in the radiographic workflow.
6. Ensure that management encourages a learning environment, giving radiographers time to communicate, reflect and learn.
7. Emphasize the necessity to implement feedback tools.
8. Develop a web-based communication tool such as MSN for online feedback among radiographers and radiologists locally, regionally, nationally and internationally.
9. Design better guidance and teaching material, for example by creating digital libraries for radiographers and digital links with effective and secure search tools for hospital work locally, regionally, nationally and worldwide presented in apps, on Facebook or other online digital services.
10. Create and establish more postdoc courses for radiographers.

10 CONCLUSION

In conclusion it is important to focus on the transformed need for knowledge and quality in radiographic workflow. Development of technology offers increased possibilities to solve clinical challenges and problems. However, such wanted development requires a curiosity, engagement and transformation by the radiographers. It is thus important for the radiographers to be open to the application of new information and communication technologies in work. In the reflection from the digitalization of radiology it has been shown that feedback and knowledge services have not been applied to its potential. According to the results from this study, recommendations for future practice highlight the need for new digital ways of communicating between radiographers and radiologists if radiographers are to meet new demands for quality in their workflow. Innovative information and communication tools are available on the market. There is thus no technical obstacle: the great challenge is to reflect, learn and transform with the support of innovative ways to communicate on.

11 FUTURE RESEARCH

Performing radiographic quality workflow using new tools is no simple task. The digitalization of healthcare has been a challenge and many of the IT implementations fail [54]. The potential of IT to support radiographic quality workflow has not yet been fully realized. New technology, on its own, does not cause transformation of radiographic work – also the radiographer needs to transform. It is the relationship between new technology, social factors and organizational aspects that causes change to occur [4].

It can, therefore, be of great interest to direct research of radiographic quality workflow into the adaptation and use of new work-integrated learning tools.

The overall aim will then be to develop radiographic quality workflow further, using new tools and demanding additional transformation of the radiographer.

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