Impacts of the Re-Engineering Process on Radiological Work

A comparative study between traditional/non PACS based and networked/PACS based radiology departments in Austria, Sweden, and Denmark

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ABSTRACT

The objective of this study is to illustrate in which respects particular work practices have been changed in a PACS based environment/networked setting. Consequently the study illustrates impacts on work practices when introducing PACS. The study is based on six papers submitted to conferences and journals by the authors.

INTRODUCTION

In order to evaluate the impact of the re-engineering process on radiology departments when introducing PACS, we have made a comparison between the traditional radiological setting [2,3,4] and the networked/PACS based radiological setting [3,9] by analysing our documentation of how work cooperation is achieved and in what context, i.e. what is done, how, where, when, by whom and by which means. Similar theories and methods have been used in our studies. The main objective of this study is to illustrate in which respects particular work practices have been changed in a PACS based setting.

MATERIALS AND METHODS

The study is based on several papers written by both authors. The materials and methods used in the six involved papers are divided into two categories; studies in 1) traditional and 2) PACS based radiology departments:

1. The traditional setting focused on the entire medical staff in the radiology department at Helsingborg community hospital (Sweden) and in the Paediatric Radiology Department at the Sahlgrenska University Hospital East (Sweden) [2,3,4]. This was done within a theoretical framework build upon the actor network theory [1]. The empirical data from these studies were collected via case studies, i.e. a questionnaire, participatory observations and semi-structured interviews.

2. The networked setting focused on the analysis of health workers’ experiences with PACS at the Viennese SMZO community hospital, at the Lorenz Böhler Casualty Hospital, at the county hospital in Steyr (Austria), at the Skejby university hospital (Denmark) [5,6,7,8,9], and at the Sahlgrenska University hospital (Sweden) [3]. This was done within a theoretical framework build upon the actor network theory [1] and the connection between space and time. Case
studies on work practices were done through participatory observations and semi-structured interviews.

RESULTS

- **Work Practices**

The comparison between the traditional and networked settings illustrates that the cooperation between different specialists is not so tightly coupled to a specific physical space [2,3]. It has instead been replaced by an electronic space¹, independent of time and place [9]. In the traditional departments, the never ending manual distribution of information was found to play a great role for the social contact between medical staff and for the additional distribution of informal news [3]. The diagnostic and reporting area is a place where all medical staff meet. On the other hand, in a networked setting the diagnosis and reporting space is a space of intense cooperation which can be reserved for radiologists only like in SMZO or can be an open space that radiographers, secretaries and clinicians can enter easily like in Skejby Sygehus. Although the quality of the digital images is high, the radiologists in SMZO need to pool their knowledge for solving complex problems [9]. For this, they need mutual support. Connections to the spaces outside are mainly activated through phone calls.

In the traditional setting, work is built up by a chain of mainly complementary aligned translations, where the “chain of action” is constructed according to the translations own logic [3]. The request form acts as a trigger for action, but also maps out the trajectory of work. It was also found that the internal dynamics of the traditional setting are irreversible translations being characterised by an increased convergence containing long-term boundaries in a most durable and robust environment. In the networked setting, the otherwise so robust environment is exposed to uncertainty, i.e. uncertainty to carry out work technically, uncertainty of functions content, fear of system breakdown, lack of experience, lack of computer and network knowledge and skills. The convergence has increased mainly due to gained efficiency effects introducing PACS [3,9].

When shifting from a traditional setting to a networked setting it was found that 58 % of the human actors have been replaced by computer actors (see Table) [2]. However, in the networked setting there is still a large amount of people involved, working in a less synchronously coordinated way, now instead moving towards more parallel processes [3,9]. The number of activities is the same in both settings, although some of them have become less visible in the networked setting, where they have been moved up to an electronic space [2,9]. The number of artefacts used to perform work by human actors has increased making medical staff even more “machine-dependent” [2]. When introducing a networked environment, the computer and networks take over the majority of manual repetitive routine work, i.e. manual distribution of requests and films, manual prefetching of films, mounting and demounting films, etc., while for instance image reading remains partly “manual” [2,3,9]. It was also found that activities have been merged in the PACS environment, thus in a networked setting a

¹ Electronic space contains admin space, machine space, image distribution space, diagnosis and reporting space and clinical space [8].
single human actor performs what in a traditional setting was performed by a series of actors. The comparison between the activities of human and computer actors in the coordinated processes is illustrated in the following table.

<table>
<thead>
<tr>
<th>Activities</th>
<th>Traditional Setting Activities performed by</th>
<th>Networked Setting Activities performed by</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Humans</td>
<td>Computers</td>
</tr>
<tr>
<td>Communicate the examination requests</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Registration in the radiology department</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Image/film production</td>
<td>yes</td>
<td>(yes)</td>
</tr>
<tr>
<td>Image/film saving and archiving</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Combine images/films with RIS data</td>
<td>yes</td>
<td>(yes)</td>
</tr>
<tr>
<td>Image/film distribution to radiologists</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Image/film prefetching</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Display of old images/films</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Image/Film observation and diagnosis</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Reporting</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Transcription of reports</td>
<td>yes</td>
<td>(yes)</td>
</tr>
<tr>
<td>Control of transcribed reports and sign off</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Sending of reports to clinicians</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Clinical image/film demonstration</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Treatment and final report</td>
<td>yes</td>
<td></td>
</tr>
</tbody>
</table>

The diagnostic and reporting have experienced a shift in media, i.e. the swap from handling films to handling images. Thus the PACS environment requires increased computer and network knowledge and skills [4]. Only a minority of radiologists have had any computer or network experience prior to PACS introduction [4]. The knowledge among radiologists differs widely, i.e. junior and senior radiologists are called in at and carry out different activities [3,9]. PACS also requires health workers to adopt and realign their work practices and social relations [9]. In SMZO, PACS causes a shift of responsibilities from the radiographers to the higher qualified and better PACS-trained radiologists which can be interpreted as a dequalification of the radiographers [5]. More activities are forced upon the radiologists. The radiologists have to "push the button" or give the network certain "commands" in order to make the computed system carry out particular activities, i.e. fetch, mount, distribute images, etc.. In Skejby, however, this is not the case. Even if they use the same system, the radiology department in Skejby uses PACS as a supporting tool and does not identify itself with PACS as much as SMZO radiologists do.

**Intermediaries – Moving from a paperworked to a networked department**

In a traditionally working radiology department, there are mainly things, i.e. request forms and films which bring actors into action, while in the networked setting these are mainly computers and the network\(^3\) [3]. In the networked setting, one activity leads to another activity located in the same physical place; the actor may move between

\(^2\) These activities must be seen as activities initiated by human actors and performed by computers.

\(^3\) In some hospitals, like Skejby Sygehus, paperbased forms are still used to manage the work flow within the radiology department.
various electronic spaces [9]. This is contradictory to the traditional setting where
information is available at a particular physical place and users have to move to obtain
information [3].

The cooperation in a traditional setting has a built-in flexibility, e.g. radiologists have
developed their own style of communicating their diagnosis, i.e. personal use of
words, personal handwriting, etc. which radiographers and secretaries have to be able
to interpret. The flexibility of the paper requests is removed in a networked setting and
replaced by a standardised and limited way of taking action [3]. Some networked
hospitals (like Skejby Sygehus) try to combine paperbased forms with PACS
environment in order to keep the flexibility and to create an overview of work
processes: examination requests are on forms that accompany the entire radiological
work and report the actions carried out by humans [7]. At the same time the electronic
space allows an increased flexibility for time and place of action, i.e. when and where
a radiologist can take action, allowing new conditions for sharing of information
which may create parallel work processes [2,3,7]. Thus PACS solutions may increase
actor flexibility to take actions at different spaces and times, when it, at the same time,
may decrease actor flexibility during action [3].

The paper request allows a high degree of informal information, i.e. write informal
information on the paper margins/border or on the back of the paper, the possibility to
add stickers on the paper request, additional notations through paper clips, etc.. In
addition, the circulation of request forms allow/create several ad hoc face-to-face
meetings [3]. However, the inscriptions on the paper request have drawbacks (weak
inscriptions), i.e. stickers or paperclips might fall off/get lost, handwriting may be hard
to interpret, etc. [3]. In the networked setting, inscriptions are stronger and less
flexible. Radiologists must take actions because the computer programs do not allow
to skip some of the steps or jump easily to a later one. On the other hand, in a
networked environment (if it is configured or implemented) notes, remarks and
annotations of all actors to the common documents, i.e. images and reports, are
transparent and available to all actors involved, and all these simultaneously from
different places [7].

DISCUSSION
This study shows that computer and network technology have become indispensable
parts of radiological work, irrespective if PACS so far has been implemented or not.
This will create an even greater need for the understanding of impacts and learning
capabilities required. The cost-effectiveness of the networked setting is hard to
estimate. What are the costs for implementation and usage of PACS, and what are the
costs for qualified radiologists with additional computed competence?

CONCLUSION
From this study it could be concluded that the gains from the introduction of PACS not
only decreased the complexity of work, but also increased the quality of patient
treatment. However, there is a transformation process towards the networked
department, where an obvious social behavioural change is the new learning
capabilities required from the medical staff. These learning capabilities are a prerequisite to gain quality of work in the PACS based departments. It appears as if the following pros and cons have been found in the networked setting regarding work practices:

1. **Social effects.** An increased networked contact and a decreased physical social contact between medical staff due to merged activities. Decrease of the number of medical staff and secretaries. A less flexible and standardised way to take action. PACS usability requires a continuously increased computer and network knowledge. There is an uncertainty to carry out computed work activities and functions content due to insufficient computed and networked knowledge and skills. It may be postulated that the networked capabilities develop through a continuous increasing learning path, and that the learning paths presently have been found to be insufficient.

2. **Efficiency effects.** An increased flexibility for time and place of action. The possibility to share information allowing parallel work processes. Through networked distribution of information shorter radiological work flow. No lost images. Risk of network breakdown.

3. **Cost effects.** It is very hard to estimate total costs for PACS and there have been no results illustrating short and long term cost effectiveness of PACS usability.

**REFERENCES**

4. Lundberg N. Integrating Various Learning Contexts in a One Year Medical Informatics Program. Proceedings of the IMIA 1997b