A COMPARATIVE
THEORETICAL AND
EMPIRICAL ANALYSIS OF
THREE METHODS FOR
WORKPLACE STUDIES

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A comparative theoretical and empirical analysis of three methods for workplace studies

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I hereby certify that all material in this dissertation which is not my own work has been identified and that no work is included for which a degree has already been conferred on me.

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Abstract

Workplace studies in Human-Computer Interaction (HCI) is a research field that has expanded in an explosive way during the recent years. Today there is a wide range of theoretical approaches and methods to choose from, which makes it problematic to make methodological choices both in research and system design. While there have been several studies that assess the different approaches to workplace studies, there seems to be a lack of studies that explore the theoretical and methodological differences between more structured methods within the research field. In this thesis, a comparative theoretical and empirical analysis of three methods for workplace studies is being conducted to deal with the following research problem: What level of theoretical depth and methodological structure is appropriate when conducting methods for workplace studies to inform design of complex socio-technical systems? When using the two criterions descriptive power and application power, to assess Contextual Design (CD), Determining Information Flow Breakdown (DIB), and Capturing Semi-Automated Decision-Making (CASADEMA), important lessons are learned about which methods are acceptable and useful when the purpose is to inform system design.

Key words: Human-Computer Interaction, Workplace studies, Method comparison, Contextual Design, Determining Information Flow Breakdown, Capturing Semi-Automated Decision-Making, Dental Informatics.
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1 Introduction

The practice of workplace studies in Human-Computer Interaction (HCI) emerged from a number of issues and concerns regarding design and deployment of advanced technologies (Luff, Hindmarsh & Heath, 2000). Workplace studies have been driven by a concern to gain in-depth understanding of how people use technologies in their day-to-day activities, taking the social and situated aspects of work seriously. Luff et al. (2000) suggest that these more practical concerns and implications of workplace studies derive from an analytical agenda, and describe how workplace studies in HCI emerged from a broad range of disciplines; sociology, social anthropology, cognitive science, and computer science. Different conceptual approaches to workplace studies include, for example, Distributed Cognition (DC), Activity Theory (AT), symbolic interactionism, and ethnomethodology (Bannon, 2000). Despite the different approaches and different concerns in terms of substantive domains and analytic disposition, there are some common characteristics that inform workplace studies according to Luff et al. (2000). First, workplace studies are concerned with the situated organization of collaborative activities, and how the users interact with tools, artefacts, objects and technologies during work. Second, the studies are naturalistic and ethnographic, leading to so called “thick-descriptions” of work practices in complex socio-technological environments. Third, many workplace studies strive to reconsider and respecify concepts and theories that infuse the understanding of technologies.

Workplace studies have often been conducted when designing and evaluating Computer-Supported Cooperative Work (CSCW) (Luff et al., 2000). Grudin (1994) defines CSCW as software designed and used to support groups, for example video conference systems, meeting support systems, e-mail or group calendars. But as workplace studies go beyond the human-computer dyad as a unit of analysis, taking a holistic view on the entire work process, workplace studies are suitable for studies of other socio-technical systems as well. Whitworth (2006, pp. 533) describes how “socio-technical systems arise when cognitive and social interaction is mediated by information technology rather than the natural world”. Complex socio-technical systems can include both information systems and organizational settings. In these settings, users may interact with each other and individuals outside of the domain and at the scene where various tools and technologies are available or needed in order to deal with a complex and dynamic work environment.

Such complex socio-technical systems can be found in dentistry where a major challenge in system design is to incorporate clinical evidence based on dentists’ information needs and then integrate the system as seamlessly as possible into the complex workflow in the work environment of the dentists’ practice (Song, Spallek, Polk, Schleyer & Wali, 2010). Dentistry is an information-intense activity with constantly evolving requirements, therefore the systems to support this information need to be highly flexible and easily accessible (Irwin, Torres-Urquidy, Schleyer & Monaco, 2008). There are also several contextual challenges in the dental work environment. For example, Irwin et al. (2008) found that clinical work during dental examination is a highly collaborative activity, involving personnel with multiple overlapping roles, as well as a wide range of equipment, artefacts and technologies. Since new technological implementation in highly complex and collaborative work environments can disrupt the delicate operational balance, and in fact have a negative impact on work flow and productivity, the deployment of new technologies is a major concern in domains like Dental Informatics (Irwin et al., 2008). According to
Reynolds, Harper and Dunne (2008) the users have been unwilling to adapt the systems due to usability issues. In order to meet these challenges in designing useful dental information systems, Irwin et al. (2008) call for more in-depth understanding of the socio-technical context prior to design. Koch (2010) also emphasizes the importance of continuous holistic understanding of a clinical situation in clinical management. Variables such as work space, organizational hierarchies, union policies, compatibility issues between technologies and so on are important to explore in systems design, because these variables can affect if new technologies are being deployed or rejected by users (Nardi, 1997). In the following sections of the introduction the scope of the thesis, research aims, research approach, and a brief overview of the chapters in the thesis are presented.

1.1 The scope of this thesis

“A problem with allowing a field to expand in this eclectic way is that it can easily get out of control. No-one really knows what its purpose is anymore or indeed what criteria to use to assess its contribution and value to knowledge and practice. For example, of all the many new approaches, ideas, methods and goals that are now being proposed how do we know which are acceptable, reliable, useful and generalisable? Moreover, how do researchers and designers, alike, know which of the many tools and techniques to use when doing design and research? What do they use to help make such judgments?” (Rogers, 2004, p. 88 on HCI and workplace studies)

It is apparent that there is a wide range of theoretical approaches and methods to choose from in the HCI field, and it is problematic to make methodological choices both in research and system design. While the different theoretical approaches in workplace studies have been analysed and compared in several studies including, for example, Nardi (1996), Halverson (2002), as well as Decortis, Noirfalise and Saudelli (2000) there seems to be a lack of work that compares and analyses the more structured methods that have arisen as an answer to a need for methods that handle context at a practical level. In this thesis a comparative theoretical and empirical analysis of three methods for workplace studies are being conducted to deal with the following research problem; What level of theoretical depth and methodological structure is appropriate when conducting methods for workplace studies to inform design of complex socio-technical systems?


CD is a well-known user-centered design process in HCI, and widely used by practitioners in HCI. CD was developed by Beyer and Holtzblatt (1998) to meet the practical need for more usable technologies, drawing on the authors experience as consultants in the HCI field rather than a theoretical framework. The method is a serious attempt to make products that fit into work practices, as usability testing in the mid-1980s was only bringing a 15-20% improvement of the user experience, according to Holtzblatt (2008). CD can be viewed as a series of different techniques with a specific intent, with the aim to have a data-driven process that smoothly takes designers in cross-functional teams from collecting data, to interpretation and consolidation, to design of the systems structure and more detailed design elements (Holtzblatt, 2008). While the CD methodology has a high focus on workflow, the method would be beneficial for capturing these aspects in dentistry. According to Button, Doyle, Karitis and Selhorst (1991), Dental Informatics systems have to
support the special reimbursement policies in dentistry, as well as the routines during examinations, diagnosis, and treatment planning. These routines differ from the routines in general healthcare regarding sequencing and need to be examined further to inform system design in Dental Informatics.

DIB is a method for analyzing adverse events in clinical environments from the perspective of breakdowns in information flow by building a model that includes all facets of the socio-technical system and the interrelationships between these (Galliers et al., 2007). DIB is influenced by DC, therefore the view of the whole system is different from the separate cognition of its parts; cognition arises out of the interactions between people and the artefacts in their environment. Galliers et al. (2007) describe how the aim for the DIB method is to locate the causes for breakdowns of information flow in medical systems, in both a reactive and a proactive way, rather than just in the reactive way as in some previous methods used in the healthcare domain. Since DIB is developed for use in healthcare, the method would be appropriate for analysis of work environments in dentistry. Dental Informatics can be seen as a speciality of Healthcare Informatics, and thus can draw advantages from the healthcare domain (Schleyer & Spallek, 2001). However, it is important to note that there are a number of aspects that separate these two research fields, as dentists collect, display, and analyze data differently than practitioners in the medical domain, according to Schleyer and Spallek (2001).

CASADEMA is a new method, also with roots in DC, developed in the domain of information fusion decision support systems to capture the information flow between the users, a system, and other cognitive artefacts that play a role in the interaction between the user and a computer system (Nilsson, 2010). Nilsson (2010) identifies three main aspects that makes the CASADEMA method special; its definition of interaction, the focus of representational states, and trajectories of propagation to visualise cooperation between user and technology as well as the utilisation of notation to represent representational states. As in DIB, the unit of analysis consists of the socio-technical system, and the analysis of information flow and information transformation is emphasised. Although Nilsson (2010) developed CASADEMA for use in the Information Fusion domain, the method could also be appropriate for analysis in complex socio-technical systems outside of this domain. According to Nilsson (2010) the method has been shown to capture the interaction between users and physical and digital artefacts, as well as the cognitive support function of the artefacts, aspects of interaction that will be of interest when investigating the dentistry setting in this thesis.

These three different methods were chosen because each is claimed to be useful in analysis of the complexity of socio-technical systems. Another aspect is the level of theoretical foundation and structure each of the methods provide for its user. When viewing these aspects as a continuum, starting from CD; a highly structured practical method with a shallow theoretical foundation on one end, and more unstructured, theoretical methods at the other end, it would be possible to investigate what theoretical and empirical implications these aspects of the methods have when applied to a real work setting. Structure can be both an aid and a constraint in research and system design. Nilsson (2010) describes how an approach like DC have been applied rather freely by researchers and appreciated for its flexibility. On the other hand, the lack of structured methodology in DC also had a negative impact on its practical aim of informing system design (Perry, 2003; Rogers, 1997). Hazlehurst, Gorman and MacMullen (2008) suggest that DC would be an appropriate approach to take research and system design in the medical domain further. However, it has been argued that
DC is not a methodology that can easily be applied to a design problem (Rogers, 1997). Moore and Rocklin (1998) also argued that it would be necessary to structure DC further in order to apply it to new domains in a successful manner. This claim is interesting for this thesis, where two of the different methods that are being analysed are DIB and CASADEMA, which both have DC as a theoretical foundation.

The research field of Dental Informatics is a new but growing discipline (Schleyer & Spallek, 2001; Schleyer, 2003a; Schleyer, 2003b; Reynolds et al., 2008). It seems that only a limited amount of work has been done from a HCI-perspective, and even less is going on in the field to actually study dentists at work (Irwin et al., 2008). This makes the domain particularly interesting for this comparative analysis, because it would be beneficial to test how well the applied methods can contribute to a new understanding of technology and social action in dentistry. The domain should also be appropriate for this study because of the complex nature of the Dental Informatics systems and the dentists working environment, putting each of the methods to the test in its promise to capture the complexity of socio-technical systems.

1.2 Research aim and objectives

The aim in this thesis is to contribute to the understanding of theoretical and methodological differences in workplace studies. In order to do this a comparative analysis of three methods for workplace studies are conducted. First the methods will be compared and analyzed theoretically, in order to explore how the methods are described in the literature. The theoretical comparison and analysis are followed by empirical work; the methods are applied in the same setting in dentistry. During comparison and analysis two main criteria formulated by Halverson (2002) are considered to answer the research problem addressed in this thesis, since they both address aspects that are closely related to the structure of methods:

- The descriptive power of each method, i.e., the ability to define theoretical constructs as well as the relationships. How can each method contribute to research in the domain, building a new theoretical foundation for understanding of technology and social action?

- The application power of each method, i.e., how well the results from each method can be used to guide system design.

There are several criteria that need to be considered when doing a comparative analysis of analytic methods (Nilsson, 2010). One of the limitations in this study is that two main points have been singled out for further analysis, since it would be too exhaustive to apply all of the possible criteria on the three methods, given the time limit of this thesis project. Another limitation related to time is the number of methods that are being compared and analyzed in this thesis. As it would take a long time, probably many years, to empirically test, compare, and analyze all of the methods used to structure workplace studies this is not the aim in this thesis. However, several new methods have been developed within workplace studies during the last years. These new methods might add to the theoretical and methodological differences in workplace studies and thus need to be analyzed further in order to create an in-depth understanding of the use of workplace studies in HCI. By actually conducting an empirical test of the different methods, a first hand experience of their application is achieved, which will lead to deeper insights than if they were only studied theoretically.
The intended contribution of the thesis is to inform both scholars and practitioners in HCI how to make appropriate choices of methods in workplace studies for their particular aim. A second contribution is that this work further validates the methods, in particular DIB and CASADEMA that are new methods and not (yet) as well know and widely used as CD. A contribution can also be made to Dental Informatics, in validating and elaborating the preliminary work models in general dentistry developed by Irwin et al. (2008), but also in providing new knowledge of how the applied methods for workplace studies can contribute to a novel understanding of technology and social action in dentistry.

1.3 Research approach

As mentioned in the previous section, the comparison and analysis of the methods CD, DIB, and CASADEMA in this thesis include both theoretical and empirical work. First the methods are compared and analyzed theoretically, using the two different criteria introduced in the previous section: descriptive power and application power. In the next step of the study the methods are assessed empirically.

The present thesis is part of a larger research project in dentistry, with an aim to inform redesign of a Dental Informatics system. As a part of the project, workplace studies are being conducted in a case study. Well constructed case studies are holistic and context sensitive according to Patton (2002), describing systems that are specific, unique and bounded, which suits the purpose of the Dental Informatics project well. After the case study is conducted, the three different methods will be applied on the same data from the case study, performing the process steps of data gathering, modelling, and analysis for each method. The objective is to handle the different methods, and thus three different viewpoints, in the same setting. When applying these methods on the same data, interpretations are broadened and an ontological illusion is avoided, i.e., an illusion that there might be one pure theory or method, according to Decortis et al. (2000).

The process steps and the empirical results from the three methods will be compared and analysed using the same criteria as the theoretical assessment: descriptive power and application power. Hence, it would be possible to investigate how these methods differ and how they can complement each other in a system design project. Finally, a synthesis of the results from both the theoretical and the empirical comparison and analysis will offer a meta-perspective on the results from the study.

1.4 Overview of the thesis

Chapter 1 introduces the motivation for this thesis, as well as the research aims and the research design. Chapter 2 provides a literature review which explores the role of workplace studies in HCI, the naturalistic and ethnographic nature of workplace studies, but also different approaches and methods to perform workplace studies. In Chapter 2 the three different methods; CD, DIB and CASADEMA, are also described further. In Chapter 3 a theoretical comparison and analysis of the three methods are made, and in Chapter 4 the empirical work is presented, and an empirical comparison and analysis is conducted. In this chapter the results are also presented and synthesized. Finally, in Chapter 5, the study and the results are discussed further.
2 Workplace studies in HCI

In various ways workplace studies have been building a new foundation for an understanding of technology and social action, taking traditional concepts like “information”, “cognition”, “collaboration”, “communication” and “technology” into questioning and reconsideration (Luff et al. 2000). Luff et al. (2000) describe how workplace studies have demonstrated how individual activities are coordinated with others in real-time, how work procedures and routines are produced, as well as how the use of technologies in organizations are inseparable from a body of local knowledge and reasoning. These empirical contributions are also of some practical relevance and have implications for how to design, evaluate and deploy technological systems to support interaction and cooperation in the workplace according to Luff et al. (2000).

There is a wide range of different theoretical frameworks in workplace studies in HCI, including DC, AT, actor-network theory and ethnomethodology according to Bannon (2000). Luff et al. (2000) also mentions course-of-action analysis, conversation analyses and symbolic interactionism in addition to the previous approaches. Nilsson (2010) makes a clear distinction between these theoretical frameworks and methods; a framework should function as a lose structure that guides the researcher, but at the same time it should be as flexible as to allows for new findings. A method on the other hand is described by Nilsson (2010) as more structured, often providing “how to” knowledge for its user. Since a method is more formal, it can restrict new ideas and findings, because the scope of interest is more rigid and defined according to Nilsson (2010). When comparing and analyzing the three different analytical methods in this thesis, the theoretical framework and structure of each method is in focus and will be discussed further in this chapter. The next section will describe how workplace studies emerged in HCI in the late 1980s, shifting the focus from single user interaction with technology towards a more holistic view on HCI.

2.1 The emergence of workplace studies in HCI

“Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them” (The ACM SIGCHI group, 1992)

Bannon (2000) tells the story how HCI developed out of human factors, a research field established early in the twentieth century. Human factors is concerned with the fit between people and machines, often by measuring physical and physiological aspects of work like work pace, fatigue and so on. The field of HCI had a much later start. When personal computers were put on the open market in the early 1980s, new demands on the developers of both software and interfaces emerged. Carroll and Tech (2003) describes how methods and theories from cognitive science influenced HCI during the early 1980s, and that the goal was to have cognitive theories such as visual perception or decision-making influence and guide software development at an early stage in the development process. The main focus was on the individual user and the interaction with technologies, a view on cognition and interaction that seemed too constrained to capture the collaborative, social and organizational nature of how technologies are used in everyday settings (Luff et al. 2000). For example Thomas and Kellogg (1989) discuss what they refer to as the ecological gaps between testing in the laboratory and real world context. These gaps can be caused by both the omission of factors in the real world, like social and cultural contexts, and by the addition of new elements in the laboratory testing environment that do not
corresponding to real world eventualities. These gaps can be motivational because when tests are done in the laboratory subjects are not discretionary users, but are also related to the nature of tasks in different settings. In a usability laboratory setting, subjects are often presented with both the tool and the task and are told to use the tool to solve the task. In real work situations users may have a variety of software tools that might be useful to solve the task. Another important issue addressed by Thomas and Kellogg (1989) is how the artifact is used over time. In laboratory settings subjects use the artefact for a short period of time, while users in real working environments sometimes use the same artefacts for years. Factors like screen size or colour may have a small impact on short-term performance, but may have significant effects on users in real world environments over time.

Growing dissatisfaction with the more traditional research methods in HCI played an important part in the emergence of workplace studies in the research field during the late 1980s and early 1990s, according to Luff et al. (2000). The multidisciplinary nature of HCI also played an important role in this paradigm shift. Carroll and Tech (2003) describes how social psychologists, anthropologists and sociologists entered the research field, bringing field-study concepts, techniques, and sensibilities from anthropology, ethnomethodology and sociology into HCI research. Ideas from Scandinavia, where researchers used AT to study work and information technology also contributed to a more integrated view of individual behaviour, cooperation and culture. At the same time new technologies to support collaborative work had an increasing impact on the research field as networked computing became more sophisticated in the 1990s, bringing new challenges to the research field (Carroll & Tech, 2003).

Although workplace studies can contribute to a more holistic view on work practices, it is no panacea for system design. Workplace studies often generate descriptive models of work practices, which can be challenging to translate into concrete design guidelines. Another issue in workplace studies is that every work environment is unique, work practices are highly situated and specific design solutions are needed for specific situations, making it hard to generalize results from one context to another (Plowman, Rogers & Ramage, 1995). Plowman et al. (1995) are in fact addressing the lack of detailed design guidelines from workplace studies in CSCW conference or journal papers. These papers rather “tend to offer a description of a case study, followed by an implications for system design section at the end of the paper in which a number of highly generalisable or semi-intuitive recommendations are made” according to Plowman et al. (1995, p. 312). Instead it is important to create the conditions where design can take advantage of the ethnographic insights according to Blomberg, Burell and Guest (2008). In the next section of this thesis the ethnographic nature of workplace studies in system design is described further.

2.2 The naturalistic and ethnographic nature of workplace studies

As mentioned before, there is a wide range of different theoretical frameworks in workplace studies in HCI, including for example DC and AT (Bannon, 2000). Regardless of the theoretical foundation there are some common characteristics that inform workplace studies (Luff et al., 2000). Workplace studies are concerned with the situated organization of collaborative activities, the studies are naturalistic and ethnographic and often strive to reconsider and respecify concepts and theories that infuse the understanding of technologies. This section aims at describing the
naturalistic and ethnographic nature of workplace studies, where field observations are the core principle for examining the context of work.

Patton (2002) describes the central assumption of ethnography as the notion that any groups of people interacting together over time will evolve a culture. Culture is explained to be a collection of behavioural patterns and beliefs; a sort of standard interpretation of events, procedures and norms, and the ethnographer’s main goal is to study culture. In the traditional anthropology study this means the ethnographer spends a long time, possibly months or years, totally immersed in a culture (Nardi, 1997). In system design it is often necessary to compromise the purity of the ethnographic method to make the results useful, as time and money are important aspects in system design (Plowman et al., 1995). This has lead to the use of “quick and dirty” studies in HCI, which are much shorter than traditional ethnographical studies, according to Plowman et al. (1995). However, these short and highly focused studies can produce very good results in informing design according to Nardi (1997). In the aim to understand work procedures, ethnographers do not face the same constraints as in the classical anthropology study, where the anthropologist often has to learn a new language, a totally different culture and face challenges of dirt, diet, climate, and illnesses in the process.

Naturalistic observations take place in the field, but there are many terms for field-based observations including participant observation, qualitative observation, direct observation and field research. These terms all refer to studying work and life in the on-going context, for the purpose of doing a qualitative analysis of the setting (Patton, 2002). Patton (2002) also describes that there might be variations in the observer’s involvement in the setting during a field study, ranging from being a full participant to merely being a spectator. Social, cultural, political and interpersonal factors can limit the degree of participation in workplace studies, and are important to consider.

The field observation’s main goal is to gain insight into every aspect of the user experience as experienced and understood in the context of use, using direct observations of people in an inductive and explorative research style (Kuniavsky, 2008). Kuniavsky (2008) suggests that examining the context of work produces a richer understanding of the relationships between preference, behaviour, problems and values.

> “Direct observation removes much of the bias that creeps into research when people or tasks are isolated. Outside of the environment that triggers them, our explanations of desires, values, reactions and behaviors, especially in routine events, lose critical details by our tendency to simplify, idealize, and project.” (Kuniavsky, 2008, p. 907)

Another value of direct observations is that the ethnographer may learn things that subjects are unwilling to talk about in an interview (Patton, 2002).

When going to observe a real world setting, it is necessary to filter and focus (Nardi, 1997). Thus it is impossible to conduct an ethnographic study without a theoretical perspective. Nardi (1997) explains that those who lack theoretical perspective probably will cobble together a perspective on the fly, a perspective that might be uninformed and fraught with investigator bias. Dix (2010) also argues that there needs to be a theoretical argument in justification of empirical work in HCI. However, one of the strengths in HCI is the closeness between theory and practice. At the same time, this closeness can lead to a dangerous confusion of these dimensions according to Dix (2010). In this thesis, where the methods of DIB and CASADEMA are being compared and analyzed, it is especially the theoretical framework of DC that is of further interest, and will be described in the next section.
2.2.1 Distributed Cognition

DC has its roots in anthropology and cultural psychology. The approach has gained attention in the field of cognitive science and is an attempt to understand and portray human cognitive processes on a system level rather than on an individual level, taking into consideration the distributed nature of human cognition (Hutchins, 1995a; 1995b). DC can be distinguished from other approaches in workplace studies by its commitment to two related theoretical principles. Holland, Hutchins and Kirsh (2000) describe the first of these principles as a concern of the boundaries of the unit-of-analysis for cognition. In DC the functional relationships between the entities in the cognitive system is the unit-of-analysis, making the approach especially fruitful for studies of whole socio-technical systems according to Hollan et al. (2000). The second theoretical principle concerns the range of mechanisms that may be assumed to participate in cognitive processes. Hollan et al. (2000) explain how DC considers cognitive processes as both internal and external, extending the notion of cognition to expand outside an individual actor’s skull. Cognition involves a rich interaction between internal processes, manipulation of objects and propagation of representations among the entities as they travel in the system (Hutchins, 1995b).

When these principles are applied to the observation of human activity “in the wild”, three kinds of distributed cognitive processes become apparent (Hollan et al. 2000, p. 176):

- Cognitive processes may be distributed across the members of a social group.
- Cognitive processes may involve coordination between internal (mental) and external (material or environmental) structure.
- Processes may be distributed through time in such a way that the products of earlier events can transform the nature of later events.

Although Hutchins (1995a) argues that DC is the theory and cognitive ethnography is the method, the theoretical framework has been applied rather freely in various studies, both concerning the unit-of-analysis and during analysis, due to the lack of methodology in DC (Nilsson, 2010). However, Perry (2003) argues that there should be four areas of focus when collecting data in a DC study in order to look for information-representation transitions in the functional system. The first area of interest is how the working environment is structured to support work practices. The second area of interest should be changes within the representational media. The interactions of the individuals with each other should be the third area of interest, and the interactions of the individuals with system artefacts should be the fourth. During the DC analysis, the following four aspects need to be described according to Perry, 2003, pp. 213-214):

1. The background to the activity; the goals of and the resources available to the functional system
2. Identify the inputs and outputs to the functional system
3. The representations and processes that are available in the functional system
4. The transformational activities that take place in the problem solving when achieving the functional system’s goal

Even though DC has gained popularity as an analytical tool in HCI since it was first introduced, there has been some debate to the provenance of the approach and what it actually involves (Luff et al. 2000). For example, Perry (2003) argues that DC had
limited success in developing practical applications and guidelines for system
designers, mostly due to the narrative descriptions the DC analyses produce. Another
concern, according to Rogers (1997), is that DC is not a “off the shelf” method that
easily can be applied to a design problem. Since a lot of time needs to be spent
understanding the concepts and learning to interpret and represent data captured in the
field, the approach will be too time-consuming for applied means according to Rogers
(1997). Moore and Rocklin (1998) have also argued that it would be necessary to
structure DC further in order to apply it to new domains in a successful manner. This
is particularly interesting in the present study where two methods with theoretical
roots in DC are applied on Dental Informatics, which can indeed be considered a new
domain. More structured methods for workplace studies and DC will be further
discussed in the next section.

2.3 Methods to structure workplace studies

The lack of structure in ethnography and DC can be a great strength, offering a very
flexible research design, which has been appreciated by researchers (Nilsson, 2010).
On the other hand flexibility also puts a lot of strain on the investigator, as the quality
of the results of the study relies heavily on the investigator’s skill as an ethnographer.
A method can be regarded as many different things according to Nilsson (2010). It
can be an aid to structure the process, to organise activities and results, to make
progress or to plan a project. However, Nilsson (2010) emphasises that it is important
to keep in mind that a method is not a simple recipe for success, and should be used
with good judgement.

There have been several attempts to develop methods that take context into account in
system design, including for example task analysis, participatory design and
Contextual Design (CD) (Kaptelinin, Nardi & MacAulay, 1999). But as contextual
factors are “notoriously elusive and difficult to pin down”, there is still a need for
methods, tools and techniques that deal with context at a practical level according to
Kaptelinin et al. (1999, pp. 28). Several attempts to structure DC into step-by-step
methods have been developed in recent years according to Nilsson (2010). These new
methods include both DIB and CASADEMA, but also methods like the resource
model, a methodology to analyze the interaction between the agents of a activity
system (MAIA), Distributed Cognition for Teamwork (DiCoT), Human centered
Distributed Information Design (HCDID), Distributed Cognitive Walkthrough
(DCW) and Event Analysis for Systematic Teamwork (EAST). Although these
methods differ in data gathering methods, purpose and focus, they all have in
common that they are analytical tools and that they all produce textual descriptions
(Nilsson, 2010).

One could argue that any of these methods would be appropriate choices for the
comparison and analysis in this thesis. However, there are some aspects of the
methods’ construct that are of importance here. First, the method should gather data
from users in their real work context, which leaves out both MAIA and DCW as these
methods gather data through expert evaluation (Nilsson, 2010). Second, the methods
should be able to capture interactions in complex socio-technical systems, which
leave out the recourse model, DCoT and EAST. In the recourse model the main focus
is on a single user and technology. Thus the method fails to capture complex
behaviour and interdependencies between entities in the system according to Nilsson
(2010). Although DCoT would be an interesting method for this study, it was mainly
developed to study small teams rather than the large clinics under study in the present
thesis. In EAST the supporting functions of the artefacts are somewhat overlooked in Nilsson’s (2010) view, an aspect of the socio-technical system that is important in this study. As the different methods will be applied in dentistry different tools and artefacts play an important role in work practices in the domain. Third, in order to do be able to compare and analyze the process stages for each method, they should be similar. Although CD, DIB, and CASADEMA seem to have different levels of structure, they all have in common the three stages of data collection, modelling and analysis. This is not the case for all the methods mentioned above, and leaves out, for example, HCDID which does not include a modelling phase.

But what constitutes a “good” method? There seems to be several aspects to take into consideration when assessing a methodology. The *effectiveness* of a method depends on its ability to fulfil its promises in terms of purpose and goal (Nilsson, 2010). Other aspects to consider when analyzing analytical methods are *construct validity* and *reliability* according to Nilsson (2010). While the construct validity is related to the provenance of the underlying theoretical framework, the reliability is related to the repeatability of the results. Is it possible for different researchers using the same method to obtain the same results?

Four criteria for evaluation were defined by Halverson (2002), when assessing the abilities of DC and AT. The first criterion is *descriptive power*, i.e. the ability to define theoretical constructs as well as the relationships. The second criterion is the *rhetorical power*, i.e. the ability to construct and communicate a structure that can be mapped to the real world. The third criterion is *inferential power*, i.e. the ability to make inferences about different phenomena under study. The fourth criterion is the *application power*, i.e. how well the results from each method can be used to guide system design.

So, back to the question of what constitutes a “good” method. The answer depends on the purpose of the study, but in the present thesis two main criterions was chosen to assess the methods: *descriptive power* and *application power*. In order to fulfil the promise of workplace studies in HCI a method for analyzing work practices should be able to produce an in-depth understanding of complex socio-technical systems, and should have power to inform system design.

In the next sections of the thesis, CD, DIB and CASADEMA will be described further, starting with CD and the different techniques utilised to create a data driven design process.

### 2.4 Contextual Design

CD is a user-centered design process, developed by Beyer and Holtzblatt (1998) with the aim to understand work practices and to incorporate these into design to develop usable technologies. As CD was developed to meet the practical need for more usable technologies, drawing on Beyer and Holtzblatts’ experience as consultants in the HCI field rather than a theoretical framework, CD utilises a mixture of different techniques (Benyon, Turner & Turner, 2005). Some of these techniques were already familiar in the field of user-centered design at the time according to Benyon et al. (2005), for example the contextual interviews, scenarios and paper-prototypes. Others were new techniques to model work practices, like flow models and the Used Environment Design. However, ethnography can be said to be major theoretical influence in CD, because of its dedication in examining work in context and to let the collected data drive the design process, even if Beyer and Holtzblatt (1998) never seem to make an explicit commitment to any theoretical framework.
CD consists of a series of different techniques with a specific intent (Holtzblatt, 2008), including techniques such as contextual inquiry, graphical work models, work model consolidation, visioning and storyboarding, User Environment Design and paper prototyping. These techniques will be described further in section 2.4.1-2.4.6. Holtzblatt, Burns-Wendell and Wood (2005) developed these series of different techniques further in Rapid Contextual Design (Rapid CD), in order to create a design process that fits into the existing structures in organizations in a timely manner, as time is always a concern in systems design. Rapid CD focuses on gathering data and organizing of data to reveal key issues, and taking away the steps of the design process that are not of great importance in the project (Holtzblatt et al., 2005). This can mean that data is gathered from a smaller number of users, and that only the most important models are created, like the affinity diagram and the sequence model. These models are particularly important to describe the users work practices according to Holtzblatt et al. (2005). When speeding up the design process, users can be included in the design of new systems, without adding significant time to the process. The flexibility of Rapid CD also makes it suitable for adaption with existing methods for developing IT solutions used in organizations, like for example Rational Unified Process (RUP) or Agile techniques (Holtzblatt et al., 2005).

2.4.1 The Contextual Inquiry

“The core premise of Contextual Inquiry is very simple; go were the customer works, observe the customer as he or she works, and talk to the customer about the work. Do that and you can’t help but gain a better understanding of your customer.” (Beyer & Holtzblatt, 1998, p. 41.)

This can be said to be the most basic value behind CD; design from data that represents the actual things people do rather than just someone’s opinion about what they do (Holtzblatt, 2008). Holtzblatt (2008) argues that when data is collected from somebody’s opinion, the validity and quality of the data are always arguable, no matter how much experience behind it. People are not aware of everything they do, and each step of performing a task reminds them of the next step and of previous actions. Beyer and Holtzblatt (1998) even describe how some people do not remember how to do some of their work. Instead they depend on the environment and things in it to tell them what to do, for example using an old report as a template to fill out a new one. The CD techniques of field data collection and consolidation ensure that the collected data that guides the design process is reliable and that the rules for interpretation of data are clear (Holtzblatt, 2008).

Another core principle of contextual inquiry is the relationship model used when collecting the field data. The master/apprentice model has its roots in ethnography, and is an efficient way of learning about work practices (Beyer & Holtzblatt, 1998). The model allows both an opportunity for researchers to learn about work through observation and participation, as well as an opportunity to ask and reflect about work practices in a natural way. Unlike apprentices, designers are learning about work in order to support it with technology, they can not take the same time to learn as an apprentice. Often the designers have to learn about work from many different people in different roles in an organization, and often contribute their own knowledge about technology in the process. To meet these needs, Beyer and Holtzblatt (1998)

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1 Beyer and Holtzblatt (1998) utilize the term customer when referring to the end-user of a system. In this thesis, the term user will be utilized throughout the text. The term user is widely accepted in HCI and clarifies the differences between end-users of a system and the actors that order and pay for system evaluation and design.
modified the master/apprentice model, using four principles to guide the design team; context, partnership, interpretations and focus.

The first principle is context. The idea is to go where the work is being done and stay there, in order to gather ongoing experience and concrete data (Beyer & Holzblatt, 1998). The next principle described by Beyer and Holzblatt (1998) is partnership. This means that the researcher and the user collaborate in understanding work, and that the researcher helps he user articulate their work experience. To make use of the collected data and create meaning, interpretations must be made. Beyer and Holzblatt (1998) describe interpretation as the chain of reasoning that turns a fact (here an observable event) into a hypothesis that has an implication for design; leading to a specific design idea for the system. This chain of reasoning during the design process often happen so fast that only the last step is made explicit, but as design is built upon interpretations of facts, the interpretation need to be right (Beyer & Holzblatt, 1998). In order to ensure that interpretations are right, they should be validated towards the users, creating an opportunity for users to make changes in emphasis to make the interpretation more precise. The last of the four principles is focus. To keep focus Holtzblatt (2008) advises the investigator to steer the interviews to meaningful topics within the projects scope, ignoring things that are outside focus. Holtzblatt (2008) also advises investigators to let the users know the focus, so they can steer conversations too. Having focus means that the investigator sees more; it conceals the unexpected and reveals details (Beyer & Holzblatt, 1998).

2.4.2 Graphical work models

Contextual inquiry produces large amounts of data, data that must be shared across the design team in order to bring the perspectives to a shared understanding (Holtzblatt, 2008). Holtzblatt (2008) recommends that data is shared orally only a day or two after the interviews with users, in a meeting where design team members have an opportunity to ask questions about the interview important for their perspective. In the session participants have different roles; model builder, recorder, moderator or participant. The model builder hand sketch up to five work models, models that each describes a different perspective of work:

- The flow model describes the users’ responsibilities, communication and coordination required in work.
- The cultural model reveals cultural and organizational influences on the users.
- The sequence model describes each step to perform a task.
- The physical model shows a layout of the work environment and the constraints it imposes on design. The model should also show how the users structure their work environment to support work.
- The artefact model shows how different artefacts are structured and used, and also suggesting how their work could be extended in the future.

In this way the graphical models organize large amounts of data, providing a coherent view of work practice (Beyer & Holzblatt, 1998). The five different perspectives aim at making the complexity of work comprehensible, and are in most cases sufficient to support all the design conversations a team need to have according to Beyer and Holzblatt (1998).
2.4.3 Work model consolidation

Consolidation means seeing the work patterns as a whole, and in order to do that designers need a guide to systemic thinking. The first step is to develop a coherent understanding of work, recognizing people’s different work styles and strategies, balancing needs against each other and recognizing which need that would have the biggest impact of work as a whole (Beyer & Holtzblatt, 1998). This could not be achieved by creating a list of needs or requirements according to Beyer and Holtzblatt (1998) because a simple list would not reveal how the requirements interrelate.

Systems are usually not designed for individuals; they are designed for whole populations of customers. Yet, the systems need to meet the requirements of individual users. Consolidated models can be built from small samples, and still represent markets of millions of customers, because they identify a large percentage of key issues and basic structure of work according to Holtzblatt (2008). Thus every user is different, they are also a lot alike each other. In Holtzblatt’s (2008) view the variation in work structure between individuals is small, and people use the same software systems with slight preferences and options between users. When collecting data from three to six people doing the same task, the work patterns start to overlap again and again.

2.4.4 Visioning and storyboarding

“Design of technology is first design of the story showing how manual practices, human interactions, and other tools come together with your product to better support the whole practice. Visioning is the Contextual Design technique to help teams tell a story. Visioning is a vehicle to identify needed function in the context of the larger work practice. Visioning ensures that teams postpone lower level decisions about implementation, platform, and user interface until they have a clear picture of how their solution will fit into the whole of the practice.” (Holtzblatt, 2008, p. 953.)

Holtzblatt (2008) describes that the primary intent of visioning is to redesign work practice, rather than to design a user interface. The first step in a visioning session is to “walk the data”, a step that Holtzblatt (2008) argues is crucial in order to have a data driven design process. During the session, one person is in charge of drawing the story describing the new work practices; showing roles, systems and so on. All ideas are included at this point in the design process, and several visions can be created. In the next step visions are evaluated towards the data, in order to meet the needs of the users, but also to throw out ideas that might not be possible to implement in the system because of technical constraints or other issues. The goal is to produce one, synthesized work practice solution (Holtzblatt, 2008).

2.4.5 User Environment Design

User Environment Design represents the structure, function and flow of the system (Beyer & Holtzblatt, 1998). This step of the design process enables the design team to view the whole system and the relationship between the different parts, showing how the system will structure the users work and how the system will interact with other systems. It forces the design team to focus on the structure and functionality of the system, rather than to jump ahead to details of interface design and implementation according to Beyer and Holtzblatt (1998).

“Once people see their product structurally, they often realize why people have a hard time with it.” (Holtzblatt, 2008, p. 958.)

User Environment Design works well for new products, but can also be used when modifying existing products, using what Beyer and Holzblatt (1998) call a Reverse
User Environment Design (Reverse UED). With Reverse UED designers can start by looking for structural problems when gathering field data and then using the Reverse UED with the storyboards to make sure that the new version deals with version-to-version compatibility and constrain future design. The User Environment Design step should always be completed with a walkthrough, where the whole design team can check the design. The walkthrough ensures that the whole team is clear on what they intend by the design and the functionality, ensuring a base structure that will support many users (Beyer & Holtzblatt, 1998).

2.4.6 Paper prototyping

The last step of the CD process is the user interface design, using simple paper prototypes to drive design and test ideas on users (Beyer & Holtzblatt, 1998). The goal is to achieve continuous iteration and extension. Mock-up interviews with users help designers to understand why design elements work or fail, and reveal new functions or unexpected work patterns. Holtzblatt (2008) describes how the prototypes should be tested with users in their work context, to keep them grounded in their work practices. Users are allowed to freely manipulate and modify the prototypes, writing in their own content. The idea is that the users should be co-designing the prototypes during the sessions, uncovering problems and adjusting them together with a member of the design team. The mock-ups should be tested on between two to four users for each iteration; each iteration adding a new level of detail. First structure should be tested, then the general user interface theme and layout, moving on to more detailed user interaction issues (Holtzblatt, 2008).

2.4.7 Summary

It is interesting to note that the initial steps of CD have been applied to a setting in dentistry previously. Irwin et al. (2008) conducted a Contextual Inquiry and a survey study to gather data (see Schleyer et al., 2006), and a preliminary model of work during examination, and planning of appointments in general dentistry were developed. In the study, Irwin et al. (2008) specifically wanted to gain knowledge on how dental clinicians work together, how they communicate, how they interact with their environment and how technology is integrated into the workflow. Although Irwin et al. (2008) put much emphasis on the fact that the results from the study only are preliminary and in need of further validation and refinement, the observations revealed the dental office as a highly complex and collaborative work environment. Even though Irwin et al. (2008) consider the developed models to be preliminary, they suggest that the models can inform design in Dental Informatics as the results offer a rich description of workflow and information management.

Button et al. (1991) found significant differences in workflow between the medical domain and dentistry when conducting contextual interviews. However, Irwin et al. (2008) argue that Button et al. (1991) did not use a systematic method such as Contextual Inquiry in the study, and that the results therefore are incomplete. On the other hand, Nardi (1997) argues that results can be valuable even when ethnography is “quick and dirty”. Anyway, Button et al. (1991) found that Dental Informatics systems have to support the special reimbursement policies in dentistry, as well as the routines during examinations and diagnosis. These routines in dentistry differ from the routines in healthcare in several ways. First, there is a difference in the way information about a patient is communicated and recorded during an examination:

"During a medical exam, a physician will generally note a finding such as pain or swelling first, and then note its location such as “left lower extremity.” During a dental
Second, the dentists rely heavily on graphical images during diagnosis, while textual documentation is of secondary importance in this process (Button et al., 1991). A third difference between diagnosis in dentistry and healthcare was found in regard to sequencing. Button et al. (1991) describe how problems in dentistry are identified on a “per tooth” basis. In general medicine, the patient’s entire body is examined and problems identified after the patient encounter. Another important aspect to consider is the role of the treatment plan in dentistry. According to Button et al. (1991), the treatment plan is a cornerstone in dentistry, and is developed during the initial examination, guiding the dentist which treatment that should be performed next at every patient encounter. In healthcare, a treatment plan is generally a plan for care that the patient will follow. These aspects of workflow and sequencing in dentistry are important to acknowledge when designing Dental Informatics systems, and CD should be an appropriate method to do so, because of the flow model and sequence model used in the method’s modelling phase.

2.5 Determining Information Flow Breakdown

DIB is a method for analyzing actual or potential adverse events in clinical environments (Galliers et al., 2007). With the method’s theoretical roots in DC, Galliers et al. (2007) put much emphasis on information flow and breakdowns in the flow, viewing adverse events as failures of the entire socio-technical system. Galliers et al. (2007) argue that when analyzing a clinical environment from a DC perspective, the search for causes of adverse events is focused on breaks in the information flow that can happen during the propagation of information between multiple agents and artefacts.

Since clinical environments are large and complex socio-technical systems, adverse events in these systems can cause serious safety issues. As it is important to address these issues in the case of patient safety in healthcare, Galliers et al. (2007) developed DIB with the aim to identify adverse events in both a reactive and a proactive way. In previously used methods, such as for example Root Cause Analysis (RCA), adverse events were analysed in a reactive way, after an incident had already occurred according to Galliers et al. (2007). Another aim of DIB is to facilitate double-loop learning. Galliers et al. (2007) describe double-loop learning as a generative solution (as opposed to an adaptive solution) because it is concerned with the redefinition of prevailing norms, values and procedures and thus have a potential to change the culture and practices in an organization.

2.5.1 Data gathering

DIB uses standard ethnographical data collection techniques like observations and interviews; techniques that are tailored in line with the distributed cognition perspective according to Galliers et al. (2007). During this step, data is collected about the socio-technical system as a whole, taking into account cultural, political and organizational factors. More specifically, the following aspects are of interest during data gathering in Galliers et al. (2007, p. 114):

- The information resources in the system and their content, form, location, movements and transformations
- The individual agents or actors in the system
• The goals of the system; both the prescribed goals and the non-prescribed
• Goals and how they are achieved through the activities of agents in the system
• Activities of the agents in the system and the sequences of events
• Constraints and strategies in the system

2.5.2 Modelling the distributed system

In the next step of DIB, a model is created from the data. Galliers et al. (2007) describe how this model should comprise all, or a few, of the following four elements; an activity template, textual descriptions, scenarios and diagrams, depending on whether the element is important for the particular aim.

The first element is an activity template, which is an obligatory element of the model according to Galliers et al. (2007). The activity template is a tabular model influenced by well-know models in HCI, such as task analysis, cognitive task analysis and cognitive work analysis, following the Unified Modeling Language (UML) style. The activity template summarizes all the different aspects of patient care being modelled. This includes both prescribed current practice and the practices that have evolved in the culture over time. Every alternative that is observed during the period of data collection should also be included in the model according to Galliers et al. (2007), including the relationships between the primary entities of the system. The model also includes system goals and sub-goals, primary and secondary actors, information resources and their transitions and location, locus of the activity, dates and times for adverse events, preconditions, triggering event, duration, strategies used, intrinsic constraints, potential problems and accident barriers (Galliers et al. (2007).

The second element is textual descriptions. They complement the activity template model by giving a richer description and explanation of elements. A textual description can be useful if there is too much detail to represent fully in a table, or if several variations are observed in the way the activity is performed. Thus, this step is not obligatory in order to do a DIB analysis.

The third element is scenarios, which is also an obligatory element in DIB. Scenarios describe the precise details of each instance of the activity according to Galliers et al. (2007) and may be presented in a tabular or textual form. The focus of the scenario is adverse events, or potentially adverse events, and the details surrounding those events.

The fourth and last element is diagrams. These can be used to provide a more instant, graphic view of the interactions between system elements involved in the aspect of patient care, but are optional in the DIB analyses according to Galliers et al. (2007).

2.5.3 A checklist analysis

Galliers et al. (2007) developed a checklist of questions to analyze the model, using various examples of adverse events as a foundation for the questions. The questions focus on information flow and how cognition might be distributed in the system. The questions used in analysis in Galliers et al. (2007, p. 115) are:

1. Is information where it should be according to current practice?
2. Could information usefully be anywhere else in the system?
3. Has information not been communicated / transmitted effectively?
4. Is any necessary information missing from the system?
5. Is there incorrect information in the system?
6. Is there inconsistent information in the system?
7. Has action been taken on the basis of incomplete, incorrect or inconsistent information?

The answers to these questions should paint a picture about the nature and location of actual or potential information flow failures, and can be used to create a requirements list that can inform system design according to Galliers et al. (2007).

2.5.4 Summary

As DIB is developed for use in healthcare, the method could be well-suited for analysis of work environments in dentistry as Dental Informatics could draw advantages from the Healthcare Informatics field (Schleyer & Spallek, 2001). Dental Informatics can be seen as a speciality of Healthcare Informatics according to Schleyer and Spallek (2001), but they also emphasize that there are a number of aspects that separate these two research fields, even if there is much common ground. For example, Schleyer and Spallek (2001) argue that design work that informs medical records are not applicable on dental records. According to Schleyer and Spallek (2001) dentists collect, display, and analyze data differently than practitioners in the medical domain.

One of the aims in DIB is to facilitate double-loop learning, since double-loop learning has a potential to change the culture and practices in an organization (Galliers et al., 2007). This aspect is certainly both interesting and important in healthcare domains such as dentistry, where much of the work practices are determined by governmental rules and regulations for clinical care. As governments and politics change, so do the rules and regulations healthcare personnel have to consider during work, an important aspect that sometimes can cause great changes in work practices. Thus the DIB focus to model both the prescribed current practice and the practices that have evolved in the culture over time, would be one of the method’s strengths. DIB is also of interest in this study because it is taking the aspect of safety seriously, which is important to consider when investigating a Dental Informatics system.

2.6 Capturing Semi-Automated Decision-Making

CASADEMA is a method which captures the interaction between humans and technology, with a great deal of focus on decision-making and how cognition is supported by technologies and artefacts (Nilsson, 2010). As in DIB, CASADEMA has its theoretical roots in DC, to identify properties of the interaction and thus gain understanding and describe the process of the socio-technical system and the interdependencies of the process and decisions-making. Nilsson (2010) argues that CASADEMA is not a design method that should be used by engineers; instead the method was structured to provide researchers with an understanding of the work situation, but with little focus on providing an explicit guidance for system design. However, Nilsson (2010) is concerned with bridging the gap between data collection and system design, i.e. the gap between the understanding of the usage of a system and actual design proposals. Nilsson (2010) also argues that when formalizing DC into a method, it opens up possibilities to inform system design, but also to possibilities to learn about cognition.
There are three main aspects that make the CASADEMA method special according to Nilsson (2010). Those are the definition of interaction, the focus of representational states and trajectories of propagation to visualise cooperation between user and technology as well as the utilisation of notation to represent representational states. CASADEMA consists of three main interrelated parts, or sequential steps, which mutually can inform each other throughout what can be described as an iterative process where the process steps sometimes overlap (Nilsson, 2010). These steps of data collection, modelling and analysis will be described further in section 2.6.1-2.6.3.

2.6.1 Data collection

The first step described by Nilsson (2010) is data collection, which primarily involves observations of the socio-technical system using ethnographically influenced techniques to gather data, including naturalistic or participatory observations, video recordings and interviews. Nilsson (2010) recommends that at least two of the methods described above should be used in order to be able to collect all the relevant data, and that recordings and transcriptions of interviews should be made, in order to increase the validity and objectivity of data as well as open up for possibilities of triangulation.

The focus when gathering data in the CASADEMA process relies heavily upon the principles of DC according to Nilsson (2010). This should imply that the functional relationship between entities in the socio-technical system is the unit of analysis, as well as information propagation; the information flow between entities and the changes in representational states during that flow (see section 2.2.1). Nilsson (2010) also suggests data should be gathered at different abstraction levels; both on the process level and on the informational level. On the process level the overall process as it is distributed over the socio-technical level is captured, enabling identification of the main activities, artefacts and actors. This can mean that textual description, illustrations and physical layouts of tasks, artefacts and users are made (Nilsson, 2010). The informational level of the process is re-examined to further detail the process. This includes identification of the entities in the socio-technical system, and the information mediated between these entities. The various inputs to the socio-technical system should also be identified, and more importantly how these inputs activate the socio-technical system. The main representational stage of the entities in the system should also be identified, as well as how these representational stages change when information flows between entities. In this way, preliminary analysis and description is made already in the initial step of the process.

2.6.2 Data modelling

Data modelling in CASADEMA is done in order to provide a notation to formalize the gathered data (Nilsson, 2010). The notation is designed to capture interaction between users and technology as they go through the work procedures, and thus enables identification of patters of propagation of information in the information flow (see Figure 1). The notation also enables identification of human-technology mediated transformations, human-artifact transformations and artifact-artifact transformations throughout the socio-technical system to capture representational states.
2.6.3 Data analysis

In the third and last step of the CASADEMA process, the purpose is to understand the nature of the components in the socio-technical system, as well as the interaction between them (Nilsson, 2010). The goal is to identify properties of interactions, which emerge when considering the purpose of interaction. Nilsson (2010) describes how some of these properties are obvious and explicit, while others are more implicit and go beyond the data stored in different artefacts. To find these, the investigator needs to examine the different connections in the models created together with the text descriptions of the artefacts for patterns. The analysis is guided by these questions (Nilsson, 2010, pp. 161):

1. What additional property is added (or removed) by changing a representational state?
2. What role does an information recourse provide for the overall process and interacting recourses (e.g. humans or artefacts)?
3. In what way is information transferred between humans and technology?

According to Nilsson (2010), these questions help identifying interaction properties, such as for example feedback, communication, driving decisions and escalating stop.

2.6.4 Summary

While Nilsson (2010) developed CASADEMA for use in the Information Fusion (IF) domain, it would be of interest to investigate if the method can be applied to any kind of complex socio-technical system in order to capture decision-making processes or cognition in general. As CASADEMA is a brand new method, it has not been used outside the IF domain yet, and has only been applied on a limited number of case studies. As Nilsson (2010) argues that the method is well-suited for a DC-inspired analysis in systems that involve a large number of interactions between different
components in a system, humans and artefacts, CASADEMA would be well-suited for analysis of complex socio-technical systems in dentistry as well.

2.7 Reflective summary

As seen in this chapter, workplace studies have emerged from a growing dissatisfaction with the more traditional research methods as well as new demands in system design, new theoretical influences, and technology that could support collaboration in a new way. As a result there has been a rapid, almost explosive growth of different approaches and methods in the field of workplace studies in HCI (Rogers, 2004). In this chapter the DC approach to workplace studies has been described in further detail, as the approach is the theoretical foundation for two of the three methods compared and analysed in this thesis. However, it is important to point out that during recent years a number of new methods to structure DC into a method have appeared. DC, DIB, and CASADEMA were chosen for this comparison and analysis because all of the methods gather data in the field; all of the methods show promises in capturing the complexity of interactions in socio-technical systems, and all of the methods have similar structure and process stages. In the next chapter a theoretical comparison and analysis is described.
3 Theoretical work

This chapter is concerned with the theoretical comparison and analysis of the three methods, and builds heavily on the literature review in the previous chapter. Two main criteria were singled out for further analysis: descriptive power and application power, in order to answer the research question about the appropriate level of theoretical depth and methodological structure to inform design of complex socio-technical systems. As mentioned before, CD, DIB, and CASADEMA were chosen because each can be used to analyse the complexity of socio-technical systems, investigating the work practices under study, in context. Another aspect is the level of theoretical depth each of the methods provide for its user. When comparing theoretical depth between methods there are some aspects that are essential to take into consideration; the domain the method is developed in and intended for, the theoretical foundation of the method, and the purpose and focus of the method. In this thesis, the level of structure each of the methods provide is also of interest, making aspects of the process steps important. This involves the types of data collection techniques, models, and analysis that are prescribed in the methods. While the descriptive power of each method is closely linked to the method’s theoretical foundation, the application power of each method is highly linked to the kind of results that the method produces. Consequently, when comparing these methods theoretically, aspects like documents produced, outcome, and utilization are important to recognize. The results from the theoretical comparison of the methods are presented in Table 1.

3.1 Theoretical analysis of CD

Nardi (1997) claims that it is impossible to conduct an ethnographic study without a theoretical perspective to provide filter and focus. This might be the major concern in CD, where the theoretical foundation is unclear and weak, as Beyer and Holtzblatt (1998) drew from their own experience, rather than theory, when creating the method. Beyer and Holtzblatt (1998) suggest that the project’s aim set the scope for the unit-of-analysis and the CD process, but as Nardi (1997) argues, the lack of theoretical perspective can lead to results that might be uninformed and fraught with investigator bias. Beyer and Holtzblatt (1998) argue that design is built upon interpretations of facts, so the interpretation has to be right. To validate the results towards the users might help to ensure that the data and the interpretations are correct, which is heavily emphasized in DC. When considering these aspects of the method, it is interesting to explore how the lack of theoretical foundation might affect the descriptive power of the method and if validating the results towards the users might add to the descriptive power.

Another issue to consider is the reality of work in system design. The strongly team-based process of CD is important in order to be able to collect data from many perspectives and for consolidation across organizations, according to Beyer and Holtzblatt (1998). Hence, one might claim that the descriptive power is somewhat depending on the team and the multiple viewpoints of team members. However, it is important to note that many practitioners in the HCI-field work as single consultants. On the other hand, Benyon et al. (2005) declare that they experienced the method as successful when applied to small, single-person projects.

In theory, CD can be viewed as a serious attempt to bridge the gap between descriptive models of work and actual design, but also addressing the issue of the
problem of generalization across contexts by careful consolidation of the work models created. Thus it seems like the method should have strong application power. However, Luff et al. (2000) argue that workflow technologies aim to support asynchronous collaboration between physically dispersed members rather than synchronous collaboration. Furthermore, workflow technologies support sequential relationships between activities, creating models that can be too constraining for describing how multiple participants perform tasks. It is careful preparation and consolidation that to some extent can allow for more flexibility to the ways the workflow is accomplished, according to Luff et al. (2000). However, the explicit definition of tasks may itself be problematic for the users. Specifying a task might gloss critical features of work, particularly with respects to the users’ collaborative accomplishment. This may actually interfere with the smooth performance of workplace activities (Luff et al. 2000).

3.2 Theoretical analysis of DIB

Directly concerned with the research question in this thesis is each method’s theoretical foundation. While Galliers et al. (2007) seem to have an intention to keep a DC focus on the system view, information flow and transformations, it is peculiar why they chose an UML-style use case specification template to represent these aspects of an activity. Although UML can be viewed as a standardized general-purpose modelling language, it was developed for object-oriented software engineering (OOSE) (Eriksson & Penker, 2000). As UML has completely different theoretical roots than DC, it is an interesting question for the empirical analysis whether these different HCI paradigms can have a successful marriage in the DIB method, i.e., can a DC focus successfully be implemented in the activity template?

Another aspect of the DIB method’s theoretical roots in DC is the unit-of-analysis. In DIB much emphasis is on breakdowns in information flow. However, the focus on propagation of representations, or on representational states, is mainly left out in the DIB analysis, but highly emphasized in DC. According to Perry (2003), a DC analysis needs to describe the background of the activity, identify the inputs and outputs of the functional system, as well as the representations and processes that are available in the functional system. There should also be a focus on the transformational activities that take place in the problem solving when achieving the functional system’s goal, as propagation of information is an important element of DC, but that is overlooked in the DIB analysis. Taking these aspects under consideration, the checklist analysis in DIB might be too limited from a DC perspective. Thus, this might affect the method’s descriptive power, and should be investigated further in the next chapter of this thesis where the methods are tested empirically.

Another aspect of the checklist analysis is its utility, which is directly connected to the application power of the method. Galliers et al. (2007) suggest that it would be useful for creating a requirements list, which can be used for redesign of the system. However, a requirement list might not be an ideal way to create a coherent understanding of work, according to Beyer and Holtzblatt, since a simple list would not reveal how the requirements are interrelated (see section 2.4.3).

3.3 Theoretical analysis of CASADEMA

As mentioned before, Nilsson (2010) has taken a literal interpretation of DC when developing the CASADEMA method. This is one of the main strengths of the CASADEMA method, because of the underlying theoretical framework’s ability to
describe and interpret what is being observed. Thus, the strong theoretical foundation in DC can impose that the method has descriptive power. The new notation developed by Nilsson (2010) also would add to the method’s descriptive power, because the notation captures the interaction between humans and technology and enables the identification of patterns in information flow and propagation between entities, keeping a strong DC focus. On the other hand, Nilsson (2010) argues that the notation can be further developed and refined in order to provide more information.

Nilsson (2010) had the ambition to present a simple method to provide structured knowledge regarding both the humans and the artefacts in a complex socio-technical system. However, there is some concern that CASADEMA might be too theory-grounded for, e.g., practitioners in the field, without previous knowledge in HCI, cognitive science, human factors, or related fields. For example, it seems that the questions during the analysis stage of the method could be rather abstract and hard to answer without an understanding of the theoretical framework.

As described in section 2.6, CASADEMA is not a design method. Instead the aim is to provide researchers with an understanding of the work situation (Nilsson, 2010). However, Nilsson (2010) argues that the method’s ability to describe the world at a detailed level has possibilities of aiding system design. Nilsson (2010) also argues that the method’s focus on actions, in terms of propagation of representational states between humans and artefacts, enables more quantitative analysis, which can be transformed into formal computational structures. In this way, the CASADEMA method shows promise in having application power. On the other hand, the literal interpretation of CD might not be ideal for practical use in HCI. When the trajectories of information propagation are identified, the relationship between external and internal processes becomes apparent (Hollan et al., 2000). The DC focus on cognitive processes as both external and internal is obvious in the CASADEMA method, where Nilsson (2010) identifies and analyzes both the external and the internal cognitive structures in depth. However, the in-depth analysis of internal structures might not be the right level of description when the aim is to inform system design. As Plowman et al. (1985) argues, designers might be unable to implement such findings into design of systems. Instead most designers probably prefer more concrete data, e.g., step-by-step instructions or guidelines to be able to incorporate findings from ethnography into design.

### 3.4 Theoretical results

When conducting a theoretical comparison and analysis of CD, DIB, and CASADEMA regarding each method’s descriptive power and application power, some of the strengths and weaknesses of the methods appear. While the highly structured CD method seems concerned with bridging the gap between workplace studies and design, the method seems to have strong application power. However, there are some concerns that the lack of theoretical foundation and clear unit-of-analysis might lead to results that are fraught and biased, which would have a negative effect on the methods descriptive power. Actually, if the facts that guide design are fraught, the design will not be the right design, according to Beyer and Holtzblatt (1998), and consequently the application power will also be weakened.

In the DIB method, the main strength seems to be the method’s theoretical foundation in DC, viewing adverse events as breakdowns in information flow of the whole system. As DC has shown provenance in capturing interactions in complex socio-technical systems, the theoretical foundation of DIB, in DC, could imply descriptive
power. During the theoretical analysis there were some concerns that the DIB structure, which uses UML-type models and a checklist analysis, are too constraining to capture the different aspects of DC. The application power of DIB is also questioned in the theoretical analysis. While the results in DIB can be used to create a requirements list, there are some concerns that such a list is too constrained to show how requirements are interrelated, and that a holistic view of work is lost.

As CASADEMA takes a more literal interpretation of DC through the process, using both a DC-notation and an analysis heavily influenced by DC, it seems the method has an ability to describe interactions both at a detailed level as well as the system level. Hence it seems that CASADEMA has descriptive power. While Nilsson (2010) argues that CASADEMA was not developed as a design tool, there is some hope that the method can inform design, because of the method’s ability to describe the world. However, it is a well known problem in system design how to implement qualitative results into detailed design ideas (see section 2.1). Thus it seems like CASADEMA lacks application power.

Table 1. Overview of theoretical comparison between CD, DIB, and CASADEMA.

<table>
<thead>
<tr>
<th>Aspect</th>
<th>CD</th>
<th>DIB</th>
<th>CASADEMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain</td>
<td>Human-computer interaction</td>
<td>Clinical systems</td>
<td>Information Fusion</td>
</tr>
<tr>
<td>Theoretical foundation</td>
<td>Missing</td>
<td>Distributed Cognition</td>
<td>Distributed Cognition</td>
</tr>
<tr>
<td>Purpose</td>
<td>User-centered design</td>
<td>Identify adverse events</td>
<td>Understanding and description of socio-technical systems</td>
</tr>
<tr>
<td>Focus</td>
<td>Depending on projects scope</td>
<td>Information flow</td>
<td>Information flow, propagation of information</td>
</tr>
<tr>
<td>Type of process</td>
<td>Step-by-step procedure</td>
<td>Iterative process</td>
<td>Iterative process</td>
</tr>
<tr>
<td>Data collection</td>
<td>Observations, interviews</td>
<td>Observations, interviews</td>
<td>Observations, video-recordings, interviews</td>
</tr>
<tr>
<td>Types of models</td>
<td>Models of flow, sequence, artefacts, cultural, and physical aspects of work</td>
<td>UML-type activity template, UML-type diagrams</td>
<td>Figures, tabular data using a DC notation</td>
</tr>
<tr>
<td>Data analysis method</td>
<td>Work model consolidation</td>
<td>Checklist analysis</td>
<td>Guiding questions</td>
</tr>
<tr>
<td>Documents produced</td>
<td>Work models, storyboards, paper prototypes</td>
<td>Text descriptions, activity template, scenarios, diagrams</td>
<td>Text descriptions, illustrations, models</td>
</tr>
<tr>
<td>Outcome</td>
<td>Paper prototypes</td>
<td>List of requirements</td>
<td>Identification of processes in the socio-technical system</td>
</tr>
<tr>
<td>Utilization</td>
<td>Analysis, design</td>
<td>Analysis</td>
<td>Analysis</td>
</tr>
</tbody>
</table>

In the next chapter the empirical work and assessment of the methods will be described.
4 Empirical work

In this chapter all the methods will be applied in the same setting in dentistry, in order to answer the research problem in this thesis, concerning the appropriate level of theoretical depth and structure for different aims. Hence, the process steps of each method are of interest. However, when going forward with an empirical comparison and analysis, there are two main points that are important to take into consideration. In order to fulfil the promise of workplace studies, a method for analyzing work practices should be able to produce an in-depth understanding of complex socio-technical systems to inform system design. Consequently, what Halverson (2002) describes as descriptive power and application power are important criteria when assessing the methods.

As the empirical results will be utilized to inform redesign of a Dental Informatics system, it will be of interest to further investigate how these methods differ and how they may complement each other in the Dental Informatics project. In this chapter the project is presented (in section 4.1), as well as the empirical work of this thesis. First, data is collected through a case study, where focus is on the Dental Informatics system and how it is used in the context of work (see Section 4.2). In the next step, the three different methods are applied on the same data, following the modelling and analysis step of each method (Section 4.4-4.6). The results from the empirical comparison and analysis are presented in Section 4.7. Finally, in Section 4.8, the results from both the theoretical and the empirical comparison and analysis is synthesized, in order to discuss the results from the study at a meta-level.

4.1 The Dental Informatics project

The present thesis is part of a unique dental informatics project in Sweden; a collaboration between the public dental services in the region of Västra Götaland (VG) and the research group MedView. MedView consists of participants from the University of Skövde, Chalmers University of Technology, Gothenburg University, and the Sahlgrenska Academy. The Dental Informatics system under study in the project is an electronic journal system where dental records, scheduling, patient administration, and clinical management are integrated. The system is the largest of its kind in Sweden, used in thirteen of the twenty regions in the country, as well as in dental education at Malmoe University. It was first introduced in the VG region approximately around year 2000 as support for the entire workflow; from the patient checking in at the front desk until payment is made after completion of treatment. Over the years the system has evolved in several steps in order to fulfill the requirements of modern dentistry, but in the process the initial goals for the system have been compromised. The system is described as highly flexible, and can be customized to fit into the work practices of different users. However, the region is concerned that the users of the system is experiencing the system as non-intuitive and difficult to use. The purpose of the first phase of the project is to evaluate the Dental Informatics system and thereby develop a basis for decisions about the program; can the Dental Informatics system be revised to meet the obligations required of a proper medical record or does a new electronic medical record need to be developed?

This thesis is a part of the evaluation’s first phase, were a case study is being conducted by a research team from the University of Skövde to identify the work situation in the different clinics. The team consists of four members; two senior researchers and two master students, all with a background in cognitive science and
HCI, and with experience in doing field work. The three different methods for workplace studies are then applied on the data from the case study in order to generate structured results to inform redesign of the Dental Informatics system. The objective is that the next version of the system should be usable, support processes and work flow, as well as decision-making.

A short introduction to two of the central parts of the system, *dental records* and *scheduling*, follows.

The *dental records* are divided into four main areas: *administration*, *attachments*, *economics*, and *treatment*. In the *administration* part, information about patients such as, for example, name, date of birth, address, and so on, is displayed. In this part different reimbursement models can be chosen, as well as different clinicians to treat the patient. *Attachments* refers to a part of the system where different documents of interest such as, for example, x-ray pictures, can be attached to the patient’s record. In the *economics* part of the dental records, reimbursements for completed treatments can be made, but also debit for sold products such as toothbrushes, dental floss, or mouthwash. The *treatment* part of the dental records contains *treatment plans*, as well as additional information that is important for the treatment plan, for example, information about referrals and insurances. In the treatment part *diagnoses* are also made, using a graphical view of the patient’s dental status (see Figure 2). The graphical view is also central to the *therapy* section of the treatment part, which is a section where clinicians document the measures taken during treatment.

The *scheduling* part of the system is used to plan patient visits at an intended date and time. It is also used to display the staff assigned to patient visits, as well as information on the facilities and equipment which have been booked for the visit. Appointments can be viewed both from the scheduling part of the system and from the dental records (see Figure 3). A warning system for double bookings is included.
in the system, and appears if a reservation is made at a time that is busy, out of hours, at lunch or break, on a non-bookable activity, or when the clinician is working at another clinic. However, the system does not alert for all types of double bookings. For example, a warning is not sent out if two users book an appointment for the same period at the same time.

![Figure 3. A view on a patient’s appointments in the scheduling part of the system. The picture is from the system manual and does not reflect real patient’s appointments.](image)

In the next section, the case study that was conducted in the public dental services in the region is presented.

### 4.2 A case study of public dental services in Sweden

As all three methods in this thesis’ comparison and analysis have a similar ethnographic approach in the phase of data gathering, the same data could be collected for all three methods, which is a major strength in this thesis. As mentioned before, applying the different methods on the same setting can help to avoid an illusion that there is one perfect method (Decortis et al., 2000). The data used in this thesis was gathered during five visits at three different dental clinics, approximately about 30 hours of observations in all, over a period of three months. This kind of prolonged engagement and persistent observations are preferred in ethnographical studies in order to establish credibility, according to Lincoln and Guba (1985). Prolonged engagement enables the researchers to become oriented in a situation so that the context can be appreciated and understood, and helps researchers to rise above preconceptions one might have. When being persistent in observations, characteristics and elements in the situation that are relevant to the study can be identified. Lincoln and Guba (1985) argue that while prolonged engagement provides scope, persistent observations provide depth. These aspects of field studies seemed
especially important in this study, because of the lack of holistic, in-depth understanding of dentistry and Dental Informatics systems in previous research.

Case studies is a qualitative research method designed to gather comprehensive, systematic in-depth information on each case of interest, and then make a holistic analysis with sensitivity to the importance of context (Patton, 2002). A case study is a unit-of-analysis, a choice of what should be studied rather than a methodology (Stake, 2000). Furthermore, Stake (2000) describes the case study as a process of inquiry of the particular case as well as a product of that inquiry. In this case study, all the dental clinics are part of the Swedish public dental service in the same region. As the aim is to gain better knowledge about this particular case, the term intrinsic case study can be used to describe this type of research design (Stake, 2000). The clinics were selected in consultation with the dental administration of the region in order to find information-rich cases, i.e., cases that will illuminate the questions under study (Patton, 2002). While the main focus in the study is on general dentistry, two of the three clinics provide generic care. However, one of the clinics in this study is specialised in odontology, mainly treating patients with different physical and psychological disabilities, fear of dental treatment, geriatrics, and other special cases. Including a specialist clinic in the case study added to the variability of work processes, artefacts, and culture observed, but as the specialists had a lot of complaints about the system the clinic seemed like a critical case. In critical case sampling cases that can make a point in a dramatic way, and thus have an ability to yield the most information, are selected (Patton, 2002). Patton (2002) argues that critical sampling is suitable when studying only a limited amount of cases because some logical generalizations can be made from critical cases, which seemed important in this project where results will inform redesign of a system that should work for clinics in the whole region.

In the public dental services there are several different professions and work roles: the receptionists working at the front desk, the dentists and the dental nurses assisting them, and the hygienists and dental nurses specialized in prophylactic care working unassisted with patients during treatment. The different work roles are described in further detail in the flow model (see Figure 2). One might say that the case study in this thesis consists of four different layers; the public dental services in the region, the different clinics, the different work roles and teams at the clinics, and the different individuals performing activities. Patton (2002) argues that this kind of layering recognizes that larger case units can be built from smaller ones and that each layer provides different possibilities for analysis. However, in order to succeed in analysis, the analyst has to do justice to each individual case, according to Patton (2002).

4.2.1 Video recordings, direct observations, and interviews

Three different techniques for data gathering in the field were chosen because they are recommended in the CD, DIB, and CASADEMA literature. These techniques were video recordings, direct observations, and interviews. However, there are some differences in the data gathering phase of the different methods that is important to recognize. First, it is important to acknowledge that Holtzblatt et al. (2005) generally do not recommend videotaping to get detailed data unless it is critical in design to see exactly how people are moving, for example, when dexterity is an important factor. Another exception is when there is a need to communicate problems and issues in a convincing way to, e.g., management and developers. On the other hand, Nilsson (2010) recommends recording devices as a way to increase the validity and objectivity of the data captured, opening up to the possibility for triangulation. In this study
where multiple perspectives are being applied on the same data, video recordings are especially useful, because the records enable revisiting the events captured on video with different “glasses” on because of the different focus of the inquiry between methods. As seen in the previous chapter, the foci in CD is depending on the project’s scope, in this study an aim to capture the workflow and sequencing in dentistry. In DIB and CASADEMA, the focus during the data gathering phase is more theory driven, as DC influences the unit-of-analysis. While the scope in DIB is the information flow in the socio-technical system, the scope in CASADEMA is both the information flow as well as the propagation of information during that flow.

However, it is important to note that not all observations were video recorded. During initial visits at the clinics, field notes were taken by hand, with the intent to capture the context in a detailed and descriptive way, as recommended by Patton (2002). As a video camera may seem intimidating and create distance between observer and informant, the aim was to build trust and partnership before filming. Nilsson (2010) recommends that data is gathered at two different levels of abstraction; the process level and the informal level (see section 2.6.1). Thus the observer starts developing an overview of work before going into detail, and does not need the detailed information that video tapes provide in an early stage of the study.

It also seemed important to gather data about the system as a whole in this study, as Galliers et al. (2007) emphasize that activities under study in healthcare are influenced by a number of aspects of the wider system, such as managerial constraints, healthcare policies, and so on. As these structures can be hard to observe, interviews were conducted as prescribed in all three methods. Beyer and Holtzblatt (1998) describe the contextual interview as an observation and questioning of the ongoing work. While the user performs the work task, the observer watches, interprets and asks questions. The observer should be persistent and interested according to Beyer and Holtzblatt (1998), following the user around wherever he or she goes during observation. These interviews were conducted in an informal, conversational way, where questions were allowed to emerge from the context and asked in the natural course of events. The strength with this kind of interview instrumentation is that it increases the salience and relevance of questions asked and the interview can be matched to informants and circumstances (Patton, 2002).

4.3 Considerations for empirical work

During the different modelling sessions in the project, three to four of the four team members were present, because each team member brought a different perspective to the data. Although Holtzblatt (2008) recommends that each team member has different roles during these sessions, roles such as moderator, model builder, recorder, or participant, the team did not follow this recommendation. Instead all team members had an opportunity to interact with the models, to go back to the literature, or to the field study data base to reflect and to think out loud. Even though the modelling sessions were somewhat unstructured, the atmosphere was positive and creative. However, it is important to recognize that while some of the models included in this thesis to some extent build upon models created within the Dental Informatics project, e.g., the flow model in CD and the activity template in DIB, others were created exclusively for this thesis by the author.

While some of the models are big-picture models, like the flow model and the cultural model in CD, these models do not represent a specific clinic, individual, activity, or breakdown. To create these models, the team had to draw from all the collected data,
to build a coherent view on work practices and culture in the public dental services in the region. For the more detailed models, like the sequence model in CD, the activity template and scenarios in DIB, and the different CASADEMA models, one single work activity was chosen.

4.3.1 A study of the front desk and the activity rescheduling patients

During the case study, the front desk emerged as a crucial part of the clinics; a place where information, activities, and schedules are coordinated, reimbursements are regulated, and problems are rectified. The activity chosen for comparison and analysis in this thesis, rescheduling patients, appear to be less complex than, for example, the dentists’ documentation during treatment of patients. However, it is an activity that is central to the front desk. As most of the scheduling of appointments is handled by dentists, hygienists, and dental nurses in the operatories, the receptionist mostly handles rescheduling of appointments as patients regularly call in to cancel appointments, and because it seems that patients frequently get double booked. The problem with double booking of patients affect the entire organization; patients, front desk, clinicians, and ultimately the entire region in terms of increased costs and reduced accessibility.

For this activity, one of the video recorded bookings from the front desk was of particular interest, as the structure of the telephone conversation between the receptionist and the patient, and the problems that occurred, seemed typical. In the video a patient makes a phone call to the clinic, because she had two scheduled appointments the same week to different hygienists, but was unable to attend any of them. This kind of double booking of patients occurred repeatedly during observations, a problem that the receptionists explained happens due to lack of overview in the system. The video recording also shows how the receptionist has to gain support from a colleague in order to solve problems whilst working in the system. These kinds of social scaffolding also seem typical for work in the front desk and with the system in general, since the staff describes the system as complicated and non-intuitive. The video also shows ways in which the staffs in the dental clinics work around some of the problems in the Dental Informatics system, such as the lack of support for communication between staff members. For a detailed walkthrough of the video see section 4.6.1.

In the next section the modelling of the five different CD models will be described, in the order they were created.

4.4 Applying CD in dentistry

When going from the data gathering phase to the modelling phase in DC, an interpretation session should be held in order to make sense of the data and choose which models to create (Holtzblatt, 2008). During this session all four of the team members from the project were present as recommended in the CD literature. However, the CD literature suggests different models and different ordering in which to create the models between publications. After some discussion it was decided to follow the recommendations in Beyer and Holtzblatt (1998) since the descriptions on how to perform each step is thoroughly described in the book, and the procedure seems more structured than in Holtzblatt et al. (2005) where the method is applied in an ad-hoc manner. Hence, the modelling process in this thesis constitutes the following steps; the flow model, the sequence model, the artefact model, the cultural model, and the physical model.
4.4.1 The flow model from the front desk perspective

The modelling phase started with an attempt to create a *flow model* of the work flow in the dentists’ office. According to Beyer and Holtzblatt (1998) the flow model offers a “bird’s-eye view” on the organization, showing the people and their responsibilities as well as the communication between people, including, for example, phone calls, e-mails, and conversations. Beyer and Holtzblatt (1998) also emphasize that the flow model should capture coordination through artefacts, strategies, roles, and informal structures in the organization. While Beyer and Holtzblatt (1998) give a thorough description of what should be included in the flow model, the team was missing concrete instructions on how to create this intricate model. The flow model notation was of some help in the actual modelling, as well as the figures of flow models in Beyer and Holtzblatt (1998, p. 92; 93), but as the work flow in the dentists’ office was a lot more complex than in the exemplary figures, the team felt some confusion about what level of detail that was the most appropriate when modelling the work flow. Unfortunately, the team could not find any answers to this question in the CD literature.

![Flow Model Diagram](image)

*Figure 4. The consolidated flow model, focusing on the front desk and scheduling activities.*

The team also felt it would be easier to start the modelling phase with a less complex model, but in the view of Beyer and Holtzblatt (1998) the flow model should be the first model to create. However, it is interesting to note that the flow model is completely left out in Rapid CD. While the flow model probably is the hardest and most time consuming model to create, it is not hard to understand why Holtzblatt et al. (2005) made this choice when creating a “quick and dirty” method. On the other hand, when excluding the flow model, an important holistic view on the work practices might get lost. In Holtzblatt (2008), the modelling phase starts with the affinity diagram and it is recommended that work models should be chosen depending
on the project’s scope. The flow model should be used when the aim is to create a new product or completely reinvent an existing product, because the less detailed models can push to more innovative design according to Holtzblatt (2008). In this project, where results should inform designers of a Dental Informatics system, the flow model is included as it seems important to capture the special workflow in dentistry. Although this inconsistent information in the literature caused even more confusion amongst team members during the initial work with the flow model, the modelling process triggered important questions about work flow, people’s responsibilities, and artefacts used. Thus it seems like CD should be considered to be an iterative process rather than a step-by-step method as it often is described as in the literature.

4.4.2 The sequence model

The next model to create according, to Beyer and Holtzblatt (1998), is the sequence model. If the flow model provides a birds-eye-view of the organization, the intent of the sequence model is to reveal the detailed structure of work. Beyer and Holtzblatt (1998) argue that all work, as it unfolds over time, is a sequence of actions and that the sequence model should represent the action steps, the triggers that kick off the steps, and the overall intent of the action. Any step in the sequence that causes a problem should be highlighted with a lightning bolt that represents breakdowns.

Table 2. Consolidated sequence model for rescheduling appointment.

<table>
<thead>
<tr>
<th>Trigger: Pt calls clinic</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pt wants to cancel appointment</td>
<td>Sometimes pts cancel too late</td>
</tr>
<tr>
<td>FD logs into pt’s record</td>
<td></td>
</tr>
<tr>
<td>FD views pt’s scheduled appointments</td>
<td>An overview of pt’s schedule is not easily available</td>
</tr>
<tr>
<td>FD cancels unwanted appointment</td>
<td></td>
</tr>
<tr>
<td>FD asks pt about appropriate date and time for new appointment</td>
<td></td>
</tr>
<tr>
<td>FD searches for free period in schedule</td>
<td>Free periods can be hard to find</td>
</tr>
<tr>
<td>FD schedules new appointment</td>
<td></td>
</tr>
<tr>
<td>FD gives pt a notice about new appointment</td>
<td></td>
</tr>
<tr>
<td>FD makes note in pt’s record about action</td>
<td></td>
</tr>
<tr>
<td>FD signs the actions in pt’s record</td>
<td>Sometimes FD forgets to sign</td>
</tr>
<tr>
<td>FD communicates changes in schedule to clinicians on paper note</td>
<td>Paper note can be missed</td>
</tr>
</tbody>
</table>

During field work the team found significant differences in work structure and sequencing between different clinics, but also between different individuals, and thus found it hard to handle this complexity of real life work in the sequence model in the way that the CD literature recommends. The course of action is also situation dependant; due to a number of different circumstances, the process steps can differ in a number of ways. Another reason for these differences in work structure is the Dental Informatics system itself; there are numerous different options in the system on how to achieve the same tasks. Because these differences have a big impact on the interactions with the system and also influence patient care they are important to capture. However, the sequence model, as it is described by Beyer and Holtzblatt (1998) does not capture these variations. As described in section 2.4.3, Holtzblatt
(2008) views the variation in work structure between individuals as small, arguing that people use the same software systems with only slight preferences and options between users. Galliers et al. (2007), on the other hand, emphasize that there might be a discrepancy between prescribed work practices and current practices, a view on work structure that is more in line with the findings of this study.

4.4.3 The artefact model

During work on the flow model it soon became apparent that there was a wide range of paper based information circulating in the dentists’ office, and that information was often stored both in digital form and on paper. To create an overview of the artefacts used in the dentistry setting the team started to work on artefact models by first identifying the different artefacts used in the workplace. More than twenty different forms and templates were identified from the gathered data during the initial artefact modelling session, but it is important to keep in mind that a lot of these artefacts are associated with the specialist clinic, and thus do not reflect work in general dentistry. Since only a few key artefacts can be chosen for further modelling, the artefacts of interest for this thesis are artefacts used when scheduling appointments from the front desk, such as the printed copy of the schedule, checklist for booking of emergencies, list of children’s ages and the dental care required for each age, list of routines for booking hygienists’ patients or the “who-takes-whom” patients list, and so on.

![Figure 5. Consolidated artefact model of routine lists.](image)

According to Beyer and Holtzblatt (1998) artefacts show what people think about during work and also how they think, revealing assumptions, concepts, strategies, and structure of work. An artefact model is a drawing or photocopy of an artefact, and should highlight structure with lines and labels, annotate locations and intents, and also show breakdowns, such as when information is missing or does not match work. Since the double booking incident involves two different hygienists at the clinic, the list of routines for booking hygienists’ patients seems relevant to the case. However,
the routine list is not used in this specific case, which can mean that the knowledge has become internalized. After consolidation, the artefact model came to represent lists of routines in general. These lists are either sent out by the region in order to enforce the laws that regulate dentistry in Sweden, or internal documents to maintain work structure at the clinics. Hence, these lists are important pieces of information that have a profound impact on work routines.

4.4.4 The cultural model

Similar to the flow model, the cultural model is a big picture model. When beginning to model the different influences on dentistry, it soon became apparent that reality in the dental clinic seemed more complex than in the cultural models provided as examples in Beyer and Holtzblatt (1998), or in Holtzblatt (2008). In the Swedish public dental service there are many influencers, i.e. individuals or formal groups that affect or constrain work, both within the organization and externally. Influences include, for example, national healthcare laws to enforce high quality in dentistry, safety, and patients’ rights, but also actors such as the dentists union or the administration in the region. In order to be able to grasp all of these aspects in dentistry, the team members had to go beyond the data gathered in the field and seek information from official documents and web pages. Although this seems to go beyond the recommended procedure in the CD literature, it was necessary in order to create a cultural model that actually describes the organizational culture in the public dental service and to make sense of the different policies and work routines observed in the field.

![Figure 6. The consolidated cultural model in CD. Focus is on how authority is experienced by people.](image)

As Beyer and Holtzblatt (1998) emphasize that the cultural model should not map the organizations chart, the cultural model should instead show how authority is experienced by people. However, the team observed several other cultural aspects which did not seem to fit into the cultural model, such as different cultures and
attitudes between clinics and individuals. These differences in culture and attitude include, for example, the view on patients, their own professional roles, hygiene routines, and safety issues as well as the attitude towards computers and the dental informatics system. These aspects seem to be important to recognize in order to understand the work practices as well as the needs of the dental care staff members in different clinics, but seem left out in DC.

4.4.5 The physical model

The last CD models created were the physical models. Such models are important because they reveal design constraints and show how people organize their environment to support work (Beyer & Holtzblatt, 1998). According to Beyer and Holtzblatt (1998), the physical models should include the places in which work occurs, the physical structure that defines the space, the usage and movement within the space, the tools and artefacts people use and their spatial organization, as well as breakdowns where the physical environment interferes with work. A physical model was created for the front desk, to show the layout of the work stations (see Figure 7). This was perceived as one of the easiest CD models to create, as the instructions in the literature were concrete, as well as the aspects that should go into the model.

![Figure 7. A consolidated physical model in CD, showing the spatial relations of work stations at the front desk as well as constrains the physical environment imposes on work.](image)

In the next section, the consolidation phase of the work models is described in further detail.

4.4.6 Work model consolidation

The consolidation step in CD brings together data from multiple individual cases to look for the overall patterns of work (Beyer & Holtzblatt, 1998). This is done through the affinity diagram, a hierarchical overview showing the scope of work issues captured during interpretation of field data. The affinity diagram shows all of the issues, worries, and key elements of work practices on post-it notes. The affinity diagram should be built bottom up, according to Beyer and Holtzblatt (1998), letting each note find its own structure instead of falling into a predefined set of categories. When notes are sectioned tighter they are given a name to represent that group, a name that should reflect a work issue. At the highest level of the hierarchical structure
are the *green notes* which describe an entire area of concerns within the work domain. Under this level, *pink notes* describe the more specific issues that define that area of concern. At the next level, *blue notes* describe each aspect of the issue. These labels become the means to design from, according to Beyer and Holtzblatt (1998), as the affinity process organizes hundreds of post-it notes into a story in a single day.

When going through the gathered data from the field study, choosing issues, strategies and worries of the front desk were chosen, and post-it notes were created. As Beyer and Holtzblatt (1998) argue, the labels on the notes were designed to give voice to the users of the system, containing user statements such as “I wish patients could check in themselves” or “There is too much clicking back and forth in the system”. While Beyer and Holtzblatt (1998) recommend that the affinity diagram should be build in one single, exhausting session by a team, a small affinity of the front desk issues were created singlehandedly by the author. Hence, the work was spread out over a four day period, since there were a lot of data from the field to go through and building the diagram required a lot of work.

When developing the affinity diagram a coherent understanding of work was gained, just as Beyer and Holtzblatt (1998) argue. The diagram also provides an overview of the different areas of problems, but also helps communicating the users’ different work styles and strategies in a holistic way. According to Beyer and Holtzblatt (1998) this could not be achieved by creating a list of requirements, because such a list would not reveal how the requirements interrelate (see section 2.4.3).

In the next step of analysis, the five different work models are being consolidated in order to generalize the models (see Section 2.4.3). In Beyer and Holtzblatt (1998) there are very detailed descriptions on how to consolidate each of the models, starting with the *flow model*. When consolidating the flow model, patterns of communication and the different work roles are of interest. Beyer and Holtzblatt (1998) emphasize that roles are very consistent across any work domain, because they are driven by the needs of the work. But while the roles do not change, the mapping of roles between people actually might change, because people tend to switch between roles they find congenial or have skills for, according to Beyer and Holtzblatt (1998). The actual consolidation happens when multiple people playing the same role is recognized, which is described by a step-by-step procedure in Beyer and Holtzblatt (1998). While this procedure includes seven different steps and thus seems time consuming, consolidation was made in line with the recommendations in Holtzblatt (2008). While the description on how to consolidate the work models is less detailed and less structured in Holtzblatt (2008), it is also less time consuming, and includes just discussing each models key factors between team members.

The next model that was consolidated was the sequence model. As mentioned before, the CD literature describes the work structure variation between individuals as small, a view on work that heavily influences the method, but maybe is most noticeable when consolidating the sequence model. Beyer and Holtzblatt (1998) argue that during consolidation of the sequence model, the main focus is the *intent* of each action, rather than the strategies to achieve the intended goal. With these recommendations in mind, the sequence model was consolidated to show a generalized course of action (see Table 2).

When consolidating the *artefact model*, focus is on identification of the structure, usage, and intent of each part of the artefact as well as breakdowns (Beyer & Holtzblatt, 1998). Another important aspect of artefacts is how information is
presented, e.g., are there any highlights or underlinings to emphasize certain information?

The consolidated cultural model shows the most common aspects of culture across the user population, i.e., the common values, friction, and policies between clinics (Beyer & Holtzblatt, 1998). As mentioned in Section 4.4.4, the consolidated cultural model leaves out cultural differences between individuals and clinics, an aspect of work which seems important in order to capture the needs of the dental care staff members in different clinics.

The last model to consolidate was the physical model. When consolidating this model, Holtzblatt (2008) argues that common aspects and variations of physical structure between the user populations should be highlighted. The front desk at the different clinics under study had different numbers of work stations depending on the size of the clinic, and of course some architectonic differences. However, the breakdowns and movements in the physical model reveal common patterns and constraints in the work space for all the clinics (see Figure 5).

4.4.7 Summary

While Beyer and Holtzblatt (1998) and Holtzblatt et al. (2005) market CD as an easy-to-use, “off the shelf” method, the method is in fact more complicated and hard to use than the literature emphasizes. This could be because the instructions in the literature on how to create some of the models were considered rather abstract, but also because there are different instructions between the different CD books, which was perceived as confusing. Another aspect is that CD is described in the literature as a step-by-step procedure, but the process is in fact more iterative. During the modelling step, new questions about work practices arise, driving the need for more data to be gathered. The steps between modelling and consolidation of the models were also perceived as unclear, because the instructions in the literature on these two steps sometimes overlap. Hence, a lot of energy went into figuring out what to do, when to do it, and how to perform these steps in the CD process. Furthermore, the method can be very time consuming if it is done according to the instructions in Beyer and Holtzblatt (1998). This was originally the intention, but was impossible to achieve due to the time constraints of the thesis project.

Despite the thorough processing of data in DC, the analysis of the data is rather shallow. This may be a consequence of the lack of theoretical framework in CD, and it has an impact on the methods descriptive power. As mentioned several times in the text, the view on work practice variation as small between individuals, and the strategies to deal with these variations, can compromise the method’s power to capture the complexity of socio-technical systems. Instead, the developers of the CD method are concerned about how to design for large populations of users, a concern that is reflected at every stage in the method. Instead of developing detailed descriptions on different tasks and strategies, the main scope in CD seems to be to instead create a holistic view on work practices and how different tasks, structures, and problems interrelate. The focus on width instead of depth distinguishes CD from the other two methods under study in this thesis. Hence, the CD view on how work practices are interrelated is perceived as one of the major strengths the method offers. Therefore it is important to recognize that one of the models that is essential to provide this holistic view, the flow model, is left out in Rapid CD.

CD is in fact a design tool rather than a method for analysis, and thus should have strong application power. However, the descriptive power and the application are
closely interrelated. As Halverson (2002) argues, the application power mostly translates to the need to inform and guide system design. In order to do this, the world needs to be described and understood at the right level of analysis. Beyer and Holtzblatt (1998) emphasize that the challenge is to design for a population, but to meet the needs of individuals. Therefore it is important to find the common patterns of work. Although the consolidated CD models do not seem to have stronger application power than the DIB or CASADEMA models at first glance, they are created to drive design. It is however important to recognize that Beyer and Holtzblatt (1998) do not intend that these consolidated models should inform designers outside the CD team. Instead, the aim in CD is that the same team goes from the first step of contextual inquiry to the last step of paper prototyping. Consequently, in order for the CD method to show the full potential in application power, all the process steps should be performed so that paper prototypes can be developed.

4.5 Applying DIB in dentistry

The DIB method contains three different steps: data gathering, modelling, and analysis. In this section the focus is on the steps modelling and analysis. The modelling phase in DIB can contain up to four different elements; an activity template, textual descriptions, scenarios, and diagrams. As the textual descriptions and diagrams are optional in DIB, and did not seem necessary in order to capture the information flow breakdown for the video recorded episode, these steps were left out.

4.5.1 Creating the activity template

According to Galliers et al. (2007), the activity template should be the first model generated from the data. The activity template produces a summary representation of important aspects of an activity. When creating this model it is important for the modelling team to keep revisiting and questioning the data according to Galliers et al. (2007), but also to return to the field to gather more data if there is some aspects of the template that cannot be completed with the existing data. However, when looking in such detail on single, isolated activities, an important holistic view of how activities are interconnected in the system can be missed. On the other hand, Galliers et al. (2007) argue that the template has been carefully designed to keep focus on the system view, the information flow and transformations.

An activity template was created to model the generalized course of action when rescheduling an appointment (see Table 5). Although the activity template requires in-depth, domain specific data, the model was actually perceived as one of the easiest models to create. The perceived simplicity can be explained by the concrete instructions in Galliers et al. (2007) and the clear labels for information to go into the template.

<table>
<thead>
<tr>
<th>System goal</th>
<th>Rescheduling appointments for patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>System sub-goals</td>
<td>Handle schedules for dentists, hygienists and dental nurses</td>
</tr>
<tr>
<td>Primary actor(s)</td>
<td>Receptionists</td>
</tr>
<tr>
<td>Secondary actor(s)</td>
<td>Dentists, hygienists, dental nurses</td>
</tr>
<tr>
<td>Information recourses which are accessible to the primary actor, their transitions (and their location)</td>
<td>Information about bookings:</td>
</tr>
<tr>
<td></td>
<td>Computer: schedule, patients’ charts, referrals</td>
</tr>
<tr>
<td></td>
<td>Paper based information: printed copy of the schedule, printed</td>
</tr>
<tr>
<td>Information about bookings:</td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td></td>
</tr>
<tr>
<td>Computer: schedule, patients’ records, referrals</td>
<td></td>
</tr>
<tr>
<td>Paper based information: printed copy of the schedule, calendars</td>
<td></td>
</tr>
<tr>
<td>Knowledge about routines: in head of actors, on paper</td>
<td></td>
</tr>
<tr>
<td>Information about process steps to perform bookings:</td>
<td></td>
</tr>
<tr>
<td>Knowledge of process steps: in head of actors</td>
<td></td>
</tr>
<tr>
<td>Clinicians to clinicians: verbal communication</td>
<td></td>
</tr>
<tr>
<td>System manual: in operatories</td>
<td></td>
</tr>
<tr>
<td>The system support: external recourse (via telephone)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Where activity takes place</th>
</tr>
</thead>
<tbody>
<tr>
<td>In operatories, in front desk</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Preconditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients needs, routines determined by the region, amount of free periods in the schedule</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Triggering event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient calls the clinic, patient is on “short notice list”, according to routines, according to treatment plan</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Generalized course</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Patient need to change time for appointment</td>
</tr>
<tr>
<td>2. Patient-clinic contact</td>
</tr>
<tr>
<td>3. Receptionist log into patient’s record using name or social security number</td>
</tr>
<tr>
<td>4. Receptionist view scheduled appointments</td>
</tr>
<tr>
<td>5. Remove unwanted appointment</td>
</tr>
<tr>
<td>6. Ask patient about suitable time for new appointment</td>
</tr>
<tr>
<td>7. Schedule new appointment</td>
</tr>
<tr>
<td>8. Sign the action</td>
</tr>
<tr>
<td>9. Make a note in the patients record about the episode</td>
</tr>
<tr>
<td>10. Sign the action</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 IF appointment is acute</td>
</tr>
<tr>
<td>2.1.1 Patient contact clinic via telephone</td>
</tr>
<tr>
<td>2.2 IF patient is on “short notice list”</td>
</tr>
<tr>
<td>2.2.1 Clinic contact patient about appointment via telephone or via short message service</td>
</tr>
<tr>
<td>2.3 IF patient do not appear for appointment</td>
</tr>
<tr>
<td>2.3.1 Clinic contact patient via telephone or via mail</td>
</tr>
</tbody>
</table>
### 2.3.2 Clinic sends patient a bill for nonappearance

### 2.4 IF clinician is unavailable

#### 2.4.1 Clinic contact patient and cancels via telephone or via short message service

### 7.1 IF there is no appropriate date and time

#### 7.1.1 Put patient on “short notice list”

ENDIF

### Postconditions

- Patient cancels unwanted appointment
- Clinic cancels unwanted appointment
- Patient gets new appointment
- Patient get required examination or treatment

### Duration

- Varies

### Strategies used

- Receive telephone calls from patients, call patients on “short notice list”, see patients face-to-face in the clinic, send notice by mail, send notice by short message service

### Intrinsic constraints

- Time: varies
- Actor: extent of knowledge varies from novice to expert between actors. Actors also have other duties
- The Dental Informatics system: do not provide an easy overview of bookings for each patient, do not alert on this kind of double booking, do not support all aspects needed for scheduling appointments (children’s different ages and required dental care for each age, routines for scheduling and so on)

### Some potential problems

- There are no free periods for appointments, patients forget about appointment, patients are late for appointments, patients cancel appointments too late, double booking of patients, patient can be scheduled to wrong clinician

### Accident barrier(s)

- Signs and verbal information to patients about the correct way to cancel an appointment, a fee for nonappearance, “who-takes-whom” patients list

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### 4.5.2 A tabular format scenario

When creating the *scenario*, the video recorded double booking incident was used and presented in a tabular format. Galliers et al. (2007) recommend that some of the same categories are used both for the activity template and for the scenario, and a scenario was created in line with that recommendation (see Figure 6). However, DIB scenarios can also be created in a textual form, which can lead to more unstructured data. The decision to present the scenario in a tabular format was made with the analysis step in mind. The thought was that to have data presented in a similar representation, using some of the same categories, it would be easier to compare the generalized course of actions in the activity template to the scenario.

*Table 6: A DIB scenario*

<table>
<thead>
<tr>
<th>System goal</th>
<th>Cancel double booked appointments for patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>System sub-goals</td>
<td>Schedule new appointment for patient</td>
</tr>
<tr>
<td>Primary actor(s)</td>
<td>Receptionist #1</td>
</tr>
<tr>
<td>-----------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Secondary actor(s)</td>
<td>Receptionist #2, hygienist</td>
</tr>
</tbody>
</table>
| Information resources which are accessible to the primary actor, their transitions (and their location) | Knowledge about double booking:  
Patient: communication (via telephone)  
Computer: schedule and patient records  
Recognition of situation: in head of actor  
Knowledge about how to perform steps in the system:  
Knowledge of process steps: in head of actor  
Receptionist #2: verbal communication (in front desk)  
System manual: not used |
| Information resources which are accessible to secondary actors, their transitions (and their location) | Knowledge about double booking:  
Computer: schedule and patient records  
Receptionist #2: verbal communication in front desk  
Hygienist: handwritten information on paper note  
Knowledge about how to perform steps in the system:  
Knowledge of process steps: in head of actor  
System manual: not used |
| Where activity takes place | At front desk, at hygienist’s office |
| Date and time | 11-04-11, midmorning |
| Preconditions | Appointments with hygienists were booked for the patient by a hygienist. One appointment was on the “short notice list” since the patient’s regular hygienist had few visiting hours available. The other appointment was with a hygienist that does not normally treat this patient, but was available. |
| Triggering event | Patient calls the clinic |
| Course of events | 1. Patient describes the problem; she can not attend the two different appointments to hygienists that were scheduled  
2. Receptionist #1 log into the patients records using the patient’s social security number  
3. Confirms the patient’s identity by asking if the name is right  
4. Views the patient’s appointments (one to a dentist and two to different hygienists)  
5. Asks the patient which appointment she wants to cancel, if she wants a new appointment and to which hygienist  
6. Views the patients records to gain more information about why there is two appointments to hygienists  
7. Asks the patient to hold  
8. Asks receptionist #2 about the different appointments with hygienists  
9. Views the schedule to see who booked the appointments  
10. Views the journal to seek information about the two appointments  
11. Decision is made to remove the appointment that least suits the patient  
12. Answers the telephone again and explains the situation to the patient  
13. Cancels both appointments with hygienists |
4.5.3 A checklist analysis of the models

As described in Section 2.5.3, a checklist of questions is used to analyze the DIB models. When doing analysis this way, the generalized course of events described in the activity template should be compared to the adverse event described in the scenario using the checklist questions.

When using the checklist the following aspects emerge:

1. Information is where it should be according to current practice.
   - Information is in patient’s journal in the Dental Informatics system, which has to be opened and viewed in order to notice that there is a double booking of appointments.

2. Information could usefully be anywhere else in the system.
   - An easy overview of information is missed.

3. Information not communicated / transmitted effectively.
   - The incident of double booking is noticed and reported by patient.
   - Information is shared on paper notes between staff to highlight that there is new information in the system.

4. Necessary information missing from the system.
   - Not found in this example.

5. Incorrect information in the system.
   - Not found in this example.

6. Inconsistent information in the system.
   - There is textual information about appointments at two different locations in the system.

7. Action taken on the basis of incomplete, incorrect or inconsistent information.
   - The double booked appointments are cancelled and a new appointment is scheduled.

According to Galliers et al. (2007), the answers to these questions should paint a picture about the nature and location of actual or potential information flow failures. In this case the incident was discovered before actions were taken on the basis of the double booking. But as the patient seems unsure of why she has two appointments to
hygienists in the same week, there is a potential risk that the patient could show up for both appointments, which is unnecessary and costly. However, it seems like the double booking happened due to a lack of overview in the system as well as because there were information about appointments at two different locations in the system.

4.5.4 Summary

Galliers et al. (1997) had the intention to create a practical application of the DC approach. As mentioned before, the DIB method does not provide a full blown DC analysis on the data. However, the method provides structure to perform an analysis influenced by the DC approach. The method was perceived as easy to use due to the clear instructions in the literature and the concrete topics in the activity template, the tabular format scenario, and the checklist analysis. Hence, the DIB method could probably be “picked off the shelf” and used by practitioners without any previous knowledge or experience in doing a DC analysis. Another major strength with the DIB method is that it is relatively rapid. As all the methods in this thesis, DIB requires in-depth domain knowledge, but the actual modelling and analysis of data is less time consuming than the corresponding steps in both CD and CASADEMA.

As the level of structure of each method is of interest in this thesis, it is important to recognize that the method can be more or less structured depending on the choice of use of textual descriptions. While the activity template is an obligatory part of the DIB method, it can be completed by textual descriptions to provide complex information that would not fit into the template. It is also important to recognize that the scenarios can be developed in a tabular format or in textual form, according to Galliers et al. (2007). These choices between templates and textual descriptions also affect the structure of the method, and the structure of the results. Including textual descriptions in DIB can add to the theoretical depth of the method, depending on the content and quality of the text. While the templates might be too constrained to do a full DC analysis of activities and adverse events, leaving out the propagation of information during information flow, the use of textual descriptions have a potential to deepen the analysis and provide a full DC focus. Thus, the descriptive power of the DIB method varies depending on if all of the steps are performed and of the quality of the textual descriptions and analysis.

While the objective in DIB is to identify adverse events, discrepancies between prescribed work practices and current practices, as well as to facilitate double loop learning, DIB is a method for analysis rather than a design tool. As the models and textual data developed in DIB are qualitative and descriptive in nature, the results can be hard to implement into actual design of systems. Thus, it seems like the application power of the method is rather weak, a problem that is well known for these kinds of ethnographical approaches and methods (see Section 2.1). However, Galliers et al. (2007) argue that the results can be used to create lists of requirements. As conducting a requirements analysis demands a mature understanding of the technology according to Schmidt (2000), DIB can be an appropriate choice of method for this aim.

4.6 Applying CASADEMA in dentistry

In order to start the modelling phase of CASADEMA, the video recording had to be revisited in a thorough way in order to do an analysis of what Nilsson (2010) describes as data on the process level and data on the informational level (see Section 2.6.1). Hence, the initial analysis of the video recording followed these steps:
A detailed textual description of the course of events in the video was developed (see Section 4.6.1).

A preliminary sketch to illustrate the course of events was developed, with focus on the distributed nature of cognition and how the actors used technology.

A schematic overview of the work station was created in order to provide an understanding of the spatial constraints and the relationships between artefacts and humans (see Figure 9).

A table describing the different entities in the socio-technical system was created, identifying and describing their usage and the cognitive processes they support, i.e., their mediating functionality as well as the main representational states and the patterns of information propagation (see Table 7).

### 4.6.1 A walkthrough of the video recording

This description of the course of events in the video recording is the first step in the CASADEMA method, and is to be used in later analysis.

The video recording starts when the telephone rings and the receptionist answers the call. The receptionist listens to the patient’s matter and then goes forward to log into the patient’s journal using the patient’s social security number. The receptionist accesses the patient’s record and confirms the patient’s identity by reading her name out loud. The receptionist then views the patient’s scheduled appointments while listening to the patient on the telephone, clicking back and forth between different views in the interface. “You have one appointment to a dentist the 18:th... Yeees, precisely... and you want that appointment?” “And then it was the 20:th at the hygienist? It’s that appointment you can’t make?” “Ehhh... we can start with that. You should be at the hygienist the 19:th, it was the one you couldn’t attend...well, the one that is the 19:th is with L... the other one... that’s right... it’s the 20:th, it’s with H...” The conversation continues and the receptionist asks the patient if she wants a new appointment instead, and which hygienist she wants to see. It seems like the patient’s ordinary hygienist is at maternity leave, which is confirmed by the colleague at the work station next to the receptionist. The receptionist and the patient discuss back and forth on which hygienist the patient should see. They agree to keep seeing the hygienist that the patient already has seen before. The receptionist continues: “But the 19:th of May is a check, you wanted to remove that... Do you want a new appointment instead of that one? Let’s see what they wrote about this...” The receptionist views the notes in the patient’s journal, but then asks the patient to hold for two minutes.

The receptionist’s colleague comes over to look at the patient’s record, and the receptionist explains the situation. “She has an appointment with L, an examination... but look here, she also has an appointment with H...” The other receptionist points at the computer screen: “But what is that? Parodontal causal treatment... I don’t know what that is...” The receptionists discuss back and forth on which hygienist the patient should see, and why there are two different appointments with hygienists so close, and so close after an appointment with a dentist. Meanwhile they try to find information in the journal and the schedule about the appointments. The colleague  

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2 The dialogue was translated from Swedish into English by the author.
guides the receptionist through these steps, both verbally and by pointing at different information on the computer screen. “This has to be a double booking... It was two different texts about this that is what it was... That disturbs me...” says the colleague. After some discussion they agree to cancel one of the appointments.

The receptionist answers the patient again and explains that it seems the appointments are doubled booked. Since the patient can not make it to either of the two appointments with hygienists, both the appointment the 19:th and the 20:th are cancelled. The receptionist asks the patient which hygienists she wants a new appointment with, and asks searching for free periods for one of the hygienists. There are no free periods, so the receptionist starts to search for a free period with the other hygienist. However, there are no free periods for that hygienist either and the receptionist starts searching for free periods further ahead in time, but ensures the patient that she is still on the short notice list and can get an appointment ahead of time. The receptionist finds a free period that suits the patient and schedules a new appointment. After confirming the appointment and thanking the patient for the telephone call the receptionist hangs up and starts documenting the incident in the patient’s record. After signing the action, the receptionist opens the schedule and starts writing a paper note about the incident to one of the hygienists. The receptionist leaves the front desk to deliver the note to the hygienists operator.

Figure 8. The layout of two of the work stations at the front desk.

Figure 9. Schematic layout of a work station.
Next step of the initial analysis concerns information on the informational level, which is further described in the next section and includes modelling of human-artefact mediated transformations.

### 4.6.2 Information flow and human-artefact mediated transformations

In the first CASADEMA model, information captured at the informational level is used to identify *trajectories of information propagation* (Nilsson, 2010). This information is presented in Table 7 below.

Table 7. Summary of information resources available in the video recorded case of rescheduling appointment, and their transformations.

<table>
<thead>
<tr>
<th>Mediating information resource</th>
<th>Information propagation and transformation</th>
<th>Supported cognitive processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telephone</td>
<td>Utilized to gain and communicate information; <em>internal structures</em> (i.e. knowledge) and external information (from the Dental Informatics system) are propagated into auditory information. Information might be transformed by the telephone due to, e.g., disturbances on the line.</td>
<td>Triggers attention, situation awareness, reasoning, communication</td>
</tr>
<tr>
<td>Information display of Dental Informatics system</td>
<td>Utilized to gain situation awareness, documentation, problem-solving, and decision-making; <em>internal structures of humans</em> are propagated into external representations (textual and graphical) in the system available to other users. Information might be transformed to fit into the system due to, e.g., rules of interaction, and information might be added in order to document episodes.</td>
<td>Situation awareness, memory, problem-solving, decision-making</td>
</tr>
<tr>
<td>Receptionist #2</td>
<td>Utilized to gain knowledge on how to use the system and reason about how to solve situation; <em>internal structures</em> propagated into auditory information, gestures, and facial expressions.</td>
<td>Knowledge, reasoning</td>
</tr>
<tr>
<td>Paper note</td>
<td>Utilized to communicate information; <em>internal and external structures</em> are transformed to a textual representation with the main intent to trigger attention of another actor within the socio-technical system (hygienist).</td>
<td>Triggers attention, situation awareness, communication</td>
</tr>
</tbody>
</table>

In the next step, a model to visualize transformations between artefacts and humans were created (see Figure 10). The model uses the developed notation presented in Figure 1 to visualize the changes in representational states.

![Figure 10. Transformations between artefacts and human, which changes the representational states.](image)
As Nilsson (2010) does not provide any clear instructions on how to build the models in CASADEMA, the model was perceived as difficult to create. In order to achieve an understanding on how to model the information trajectories under study in the method, the case studies in Nilsson (2010) has to be studied in detail, and a lot of energy and effort was spent in solving this task. Nilsson directs the reader towards the Figures 7.10–7.14 and 8.6–8.7 for examples of how to model the trajectories of information flow. However, the developed notation appeared to not be utilized to full extent in all of the figures, for example, the mediating artefacts were not highlighted in every model (see, e.g., Figure 7.10; Figure 7.11; Figure 8.6, in Nilsson, 2010). The discrepancy between these models and the developed notation in Nilsson (2010) added to the confusion of how to model the trajectories of information flow.

4.6.3 Analysis by guiding questions

The analysis is guided by the following questions (Nilsson, 2010, pp. 161), and is mainly concerned with the interaction between humans and the Dental Informatics system:

1. What additional property is added (or removed) by changing a representational state?
   - Information is continuously added and removed from the schedule, in order to keep up with the constant changes in the socio-technical system. For example, patients often call the clinic to reschedule appointments. When an event like this happens, a note on the episode is added to the Dental Informatics system, in order to communicate the information to other actors, e.g., clinicians, in the socio-technical system (see Table 7).

2. What role does an information resource provide for the overall process and interacting resources (e.g. humans or artefacts)?
   - The activity of rescheduling patients and the cognitive processes that are involved in the process are distributed between humans and artefacts. As seen in Table 7 the Dental Informatics system contributes to the situation awareness, as it displays information about the scheduled appointments, and also serves as an external memory for the clinic staffs who keep detailed documentation on a wide range of different information regarding patients. When keeping information externally represented, the information load on the staff can be decreased. Furthermore, when the receptionist’s colleague begins helping the receptionist, the Dental Informatics system also serves as a mediating artefact between the staffs, who mutually views information on the display, using both verbal communication as well as pointing gestures towards the display in order to create a common understanding of the situation, as well as engage in problem-solving and decision-making. Another interesting aspect of the Dental Informatics system is that it does not support communication in an effective manner. This becomes apparent in the video recorded episode where the receptionist uses pen and paper to communicate information about the double booking incident to the hygienist. The use of post-it notes in the clinics is mainly to trigger attention that there is new information in the system, information that otherwise is not noticed.

3. In what way is information transferred between humans and technology?
Internal structures of humans are propagated into external representations in the Dental Informatics system available to other users via the use of keyboard and mouse. These external representations are mainly textual and graphical. Internal structures are also transferred via textual representations on paper (see also Table 7).

When answering these guiding questions, there was no time to do an in-depth DC analysis in the way Nilsson (2010) has done. Also, CASADEMA’s focus on internal cognitive structures might not be the right level of description when the aim is to inform system design (see Section 3.3). Instead, the guiding questions served more as a checklist, and the results relied heavily upon the results from the initial analysis. However, when revisiting Table 7 during the analysis stage of the method, new insights were gained, and information was added to the table, i.e., to the problem solving and decision-making function of the Dental Informatics system. This is in line with the CASADEMA method, which puts emphasis on the iterative nature of the process.

4.6.4 Summary

The major concern when applying CASADEMA to dentistry is the ease-of-use of the method, and the amount of time spent. Similar to CD, CASADEMA is a time-consuming method. The method was also perceived as difficult to use, even if the author has previous knowledge of the theoretical framework as well as previous experience in doing DC influenced analysis. It was especially the step between initial analysis and the modelling phase of the method that seemed difficult to bridge. This may be because data on the informational level was perceived as difficult to gain, even though data was collected through video recordings, recordings that were supposed to make it easier to view the information flow and propagation of representation in further detail. An issue when using the video camera to capture human-computer interactions on a detailed level is that it is difficult to obtain high-quality footage of a computer screen. Hence, the author almost felt it was necessary to conduct a cognitive walkthrough of the rescheduling episode in order to be able to create the models of human and technology mediated transformations. However, this is not prescribed in the method, and was therefore not carried out, since the aim in this thesis is not to involve further development of the methods.

As CASADEMA takes a more literal interpretation of DC through the process, using both a DC-notation and an analysis heavily influenced by DC, it seems the method has an ability to describe interactions both at a detailed level as well as the system level. Hence, it seems that CASADEMA has descriptive power to explain contextual aspects of work, as well as more detailed elements of the interface of the computer. However, a concern is that the strong focus on internal cognitive structures is not the right scope when using a method for workplace studies for practical aims in HCI. Hence, CASADEMA would probably be a more suitable method for research aims and cognitive science. Another concern is that socio-cultural aspects of work are mainly left out in CASADEMA, but are an essential part of work practices.

Regarding the method’s application power, the main concern for this project is that the models in CASADEMA would be perceived as rather abstract when describing elements of the systems interface. This is a well-known issue when communicating results from ethnographical studies to designers. For example, Plowman et al. (1995, p. 322) argue that researchers and designers should try to bridge what they call a “gap and misunderstanding between techno-talk and ethno-talk”. In order for designers to
make sense of the CASADEMA models, they need knowledge and understanding of the underlying theoretical framework of DC, in order to understand the different concepts behind the notations. Furthermore, the descriptions of the elements in the systems interface would probably need to be more concrete, in order to be more useful for designers.

4.7 Empirical results

As the research problem in this thesis investigates what level of theoretical depth and methodological structure are appropriate when conducting methods for workplace studies to inform design of complex socio-technical systems, the two criteria descriptive power and application power have been in focus. When applying these two criteria on the empirical results of the methods, some of the strengths and weaknesses of the methods appear.

First, in order to have descriptive power, the methods need a theoretical foundation. A theoretical foundation is a starting point to provide an in-depth analysis and understanding of human-computer interactions. Nardi (1997) addresses this issue concerning the use of ethnographic methods in design and evaluation, and argues that a theoretical perspective is essential in order to provide filter and focus (see Section 2.2). This is an issue in CD, where the theoretical foundation is unclear and weak. As a result of this deficiency it was hard to know exactly what to pay attention to during field work, in order to gather data for the modelling sessions in CD. Another issue regarding this lack of theoretical foundations is that the analysis of the models became rather shallow. When consolidating the work models, several important and interesting aspects of work between individuals, teams, and clinics were left out.

The more structured methods were perceived as easier to use, but can constrain analysis. This is particularly obvious in the DIB method where the templates and checklist analysis provide a high level of structure, but at the same time are too constraining to provide the means for a full DC analysis, leaving out the propagation of representations. However, this is preferred over more unstructured methods, where clear instructions sometimes are missing, as in both CD and CASADEMA. The danger is that the users fail in applying the method, and abandons the project all together, or chooses another method instead.

Halverson (2002) argues that the application power translates to the need to inform and guide system design. In order to do this, the world needs to be described and understood at the right level of analysis. Hence, the descriptive power and the application are closely interrelated. When comparing the three different methods in this thesis, it is apparent that each method provides a different outline of the work setting, describing work processes at different levels of analysis. Susi and Rambusch (2007) introduce the concept of three levels of situatedness, which can be used to illustrate this diversity. At the high-level situatedness, the socio-cultural setting is recognized, e.g., cultural norms and values. The next level of situatedness involves the contextual “here and now” of a setting, according to Susi and Rambusch (2007). At the contextual level focus lies on how cognition is distributed between individuals and their material surroundings, e.g., when people use artefacts, or when they cooperate to solve a task. The next level of situatedness, the low-level, focuses mainly on embodied cognition (Susi & Rambusch, 2007). The main assumption at this level of description is that the body is an important part of cognition through a constant perception-action loop. Hence, the low-level is concerned with the actions that are being perceived and how these perceptions affect our actions. At this level of
situatedness the elements in the interface of the computer would be of further interest. In order for workplace studies to inform system design, methods should ideally describe interactions at all three levels of analysis.

While CD seems mostly concerned with aspects on the socio-cultural level as well as the contextual level, an analysis on the lower, more detailed level of the interaction between human and computer is mostly overlooked. Although Beyer and Holtzblatt (1998) model five different aspects of work, there are not one model that describes a computerized system, or a good way to incorporate electronic information in the work models. Irwin et al. (2008), for example, solved this problem by incorporating a Dental Information system as one of the work roles in the flow model. Nevertheless, this solution is not in line with any of the flow models in the CD literature. The lack of low-level descriptions is in fact an issue in both the DIB and CASADEMA methods as well, where analysis mostly concerns contextual aspects of interactions with the system. But as DIB lean more towards high-level descriptions, putting emphasis on the discrepancy between prescribed work practices and current work practices, CASADEMA puts more emphasis on the low-level situatedness, since the focus on information propagation involves elements of the computer’s interface as well as mental structures of the user. However, the descriptions in CASADEMA of the computer’s interface are rather abstract (see Figure 10), which can be a problem when communicating results to designers. It might be fruitful to provide designers with more detailed and concrete representations of the computer’s interface at the low-level descriptions, for example, screenshots, or models similar to the artefact models in CD.

However, it is important to keep in mind that CD involves several steps and design activities beyond modelling and consolidation. Hence, the models are created and consolidated in order to help a design team focus on different aspects of work, as well as to create consensus between team members, rather than to inform designers outside an existing project. When continuing the CD design process, the view on the system becomes more detailed, and in the last step paper prototypes are being produced, which are models of a system that should have strong application power. As CD includes the researchers conducting workplace studies throughout the design process, Beyer and Holtzblatt (1998) managed to bridge the gap between ethnography and design. However, these results were not obtained in this study, because only the first three steps of the method were conducted empirically.

Table 8. Overview of empirical comparison between CD, DIB, and CASADEMA.

<table>
<thead>
<tr>
<th>Aspects</th>
<th>CD</th>
<th>DIB</th>
<th>CASADEMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of situatedness</td>
<td>High-level and contextual level of situatedness</td>
<td>Contextual level of situatedness</td>
<td>Contextual level and low-level of situatedness</td>
</tr>
<tr>
<td>Level of abstraction</td>
<td>Basic/concrete</td>
<td>Basic/concrete</td>
<td>Abstract/symbolic</td>
</tr>
<tr>
<td>Results from analysis</td>
<td>Emphasis on generalising results across users and organizations</td>
<td>Emphasis on information flow breakdown</td>
<td>Emphasis on the properties of the interactions between humans and artefacts</td>
</tr>
<tr>
<td>Level of difficulty</td>
<td>Medium level of difficulty</td>
<td>Low level of difficulty</td>
<td>High level of difficulty</td>
</tr>
<tr>
<td>Level of structure</td>
<td>Medium level of structure</td>
<td>High level of structure</td>
<td>Low level of structure</td>
</tr>
<tr>
<td>Duration</td>
<td>Time consuming</td>
<td>More rapid</td>
<td>Time consuming</td>
</tr>
</tbody>
</table>
The next section concerns the synthesis of the theoretical work presented in Chapter 3 and the empirical work described in this chapter. The synthesis discusses the different aspects of methods in more general terms and thus offers a meta-perspective on the result from the study.

4.8 Synthesis of the theoretical and empirical work

I keep six honest serving men.
They thought me all I knew:
Their names are What and Why and When

When doing a comparison and analysis of different methods in workplace studies, one of the questions Rogers (2004) addresses is central to the research question in this thesis; how do we know which methods are acceptable, reliable, useful, and generalisable? What constitutes a “good” method? In Section 2.3, two main criterions were singled out as especially important: descriptive power and application power. However, these criteria might not answer all of Rogers’s concerns, but can tell us something about which methods are acceptable and useful when the purpose is to inform system design. The two criteria reveal aspects of the methods regarding the theoretical framework of the methods as well as the structure of the methods. These aspects include, for example, scope and level of abstraction, as well as duration and properties of the process itself, and sometimes overlaps.

**Theoretical depth** – The theoretical depth between methods differs, from, e.g., CD which lacks an explicit theoretical foundation, to, e.g., CASADEMA, which has theoretical depth in its literal interpretation of DC. These differences have a profound impact on the quality of analysis and results in terms of descriptive power. Hence, methods similar to CD, without theoretical depth, might be acceptable for practical use in system design, but should not be regarded as a suitable method for research aims.

**Scope** - The lack of theoretical foundation in CD makes for a method without a clear scope, in contrast to the more theory grounded methods, where the theoretical underpinnings determine the unit-of-analysis. As Nardi (1997) argues, a theoretical perspective is essential to filter and focus.

**Level of situatedness** – Descriptions and level of analysis between methods differ, from high-level situatedness, concerning socio-cultural aspects, e.g., in CD, to contextual level of situatedness. The low-level of situatedness seems to be somewhat overlooked in the methods for workplace studies, but are an important aspect to consider in order to inform system design. In order to be able to investigate the interaction between users and technology in detail, the use of new techniques in workplace studies might be needed, since it is difficult to obtain high quality video footage of computer screens.

**Level of abstraction** – The level of abstraction differ between methods, from basic and concrete, to abstract and symbolic. The level of abstraction is related to the ease-of-use of the methods, but also to the communication of results to system designers. The more basic and concrete descriptions would probably have more power to bridge the gap between what Plowman et al. (1995) call “ethno talk” and “techno talk”.

**Level of structure** - Methods for workplace studies often have an aim to structure the ethnographic process. However, the level of structure between methods differs, from
highly structured methods, e.g., DIB, to methods with a lower level of structure, e.g., CASADEMA. A high level of structure can restrict new ideas and findings, but on the other hand, a low level of structure can put a lot of strain on the investigator, according to Nilsson (2010).

**Type of process** – While the level of structure differs between methods, the type of process is often iterative in nature rather than a step by step process. The iterative process of system design is a key principle in HCI, and regulated by the ISO standard 13407, to maintain focus on the users throughout the design process.

**Level of difficulty** – The level of difficulty between the methods concerns both the level of abstraction and the level of structure the methods provide. The higher the structure of the method, and the more basic and concrete the level of abstraction, the more easy the method is to use.

**Duration** – The time spent on modelling and analysis between methods for workplace studies differ. While some are more time-consuming, e.g., CD and CASADEMA, others are more rapid, e.g., DIB. However, it is important to recognize that most of the methods for workplace studies require in-depth knowledge of the setting, which is time-consuming to gain. Thus, it seems as there are few truly rapid methods for workplace studies.

These aspects might be important to consider when continuing introducing workplace studies in dentistry when the aim is to inform design of Dental Informatics system. Given the complex workflow and work environment in dentistry, the challenge to develop systems that can be seamlessly integrated into the socio-technical system is grand. Hazlehurst et al. (2008) argue that DC is an appropriate approach to take into medical domains, for research aims as well as system design. However, in order to apply DC to more practical work in HCI, more structured methods are needed. These methods should describe the interactions between humans and technology at the high-level, the contextual level, and the low-level of situatedness, which is possible when using DC as a theoretical foundation. On the other hand, while the strong focus in DC on internal cognitive structures is fruitful for research in cognitive science, these kinds of in-depth descriptions might be of less practical use in HCI. Hence, when choosing or developing methods for workplace studies to inform design of Dental Informatics systems, it is beneficial to choose a method with a theoretical foundation in DC, but in order to be of practical use, the method needs to interpret DC in a way that is adjusted to meet the specific needs of system design.
5 Discussion and conclusions

This chapter includes reflections on the case study that was made as a part of the empirical work, as well as for the research process regarding the comparison and analysis of the methods (Section 5.1). The contributions of this thesis and the implications it might have on workplace studies, HCI, Dental Informatics, and other related fields, for example, cognitive science, are also discussed (Section 5.2).

5.1 Reflections

In this section the trustworthiness of the study is further discussed, i.e., an evaluation of the worth of the study (Lincoln & Guba, 1985). In order to establish trustworthiness in qualitative research, at least one, but preferably all, of the following four criteria need to be fulfilled: credibility, transferability, dependability, and confirmability.

According to Lincoln and Guba (1985), there are several ways to establish credibility. In the present thesis the following strategies were applied: prolonged engagement, persistent observation, and triangulation. As mentioned in Section 4.2, prolonged engagement involves investing sufficient time into the study, i.e. enough time to become oriented to the situation. During the case study the researchers visited three different clinics, at five different occasions, during a period of three months, investigating a wide range of work aspects in the setting. As a result of this thorough investigation, an understanding of the complex work practices in dentistry could be obtained. However, it could be argued that more time spent at the clinics would be needed, as dentistry is such a complex and information intense domain. On the other hand, for the purpose of conducting a methods comparison and analysis on a specific part of dentistry, the rescheduling activities at the front desk, the time spent on the field was sufficient.

Persistent observations involve using an adequate amount of observations or interviews, in order to be able to identify the most important aspects under study and focusing on them in detail (Lincoln & Guba, 1985). As several episodes during the case study were video recorded, there was a possibility to go through the data several times, in order to investigate the data at a more detailed level than possible when observations are only documented through field notes. However, one limitation is important to address. When documenting the interaction between human and computer on video, it is notoriously hard to get high quality footage of the computer screen. Hence, it was hard to follow the workflow in the system at the level of detail as I was hoping for. Thus, in order to create the more detailed models, e.g., the sequence model in CD, the affinity diagram in DIB, and the CASADEMA model, I also had to relay on previously taken field notes, as well as knowledge about the system obtained during a system training session arranged for the MedView research group by the VG region. However, in order to reassure that the sequencing in the models were correct, the results were validated towards a receptionist working at the front desk at one of the clinics.

Triangulation involves using multiple data sources in a study, in order to increase the validity of the results (Patton, 2002). Data triangulation involves gathering data from multiple sources, e.g., people in different roles and at different locations (Patton, 2002). During the case study data was collected from receptionists and clinic coordinators at the front desk as well as from clinicians at the operatories, such as dentists, hygienists, and dental nurses at three different dental clinics. By gathering
information from the multiple work roles and multiple clinics, different aspects of interactions with the system emerge. In the case study data was also gathered and interpreted by four different researchers, which leads to investigator triangulation. The research design, using three different methods from different scientific domains, also leads to methodological triangulation and theory triangulation of the results from the case study.

The term transferability refers to the external validity of the results, i.e., that the findings may have applicability also in other contexts (Lincoln & Guba, 1985). To achieve transferability in qualitative research it is important to describe the study and the context in sufficient detail, i.e., provide the reader with thick-descriptions, which has been the intention in this thesis. However, only another person that conducts a similar study can judge if the study is transferable.

When findings are consistent and could be repeated, dependability is achieved (Lincoln & Guba, 1985). However, it is important to recognize that this kind of research in situ can not be replicated, as one can not step into the same river twice. Instead, dependability in qualitative research is achieved by involving external audits to examine the research process, as well as the results, the accuracy of the interpretations and conclusions can be evaluated. As this is a master thesis, external audits have been included to evaluate the study.

The final criterion addressed by Lincoln and Guba (1985) is confirmability, i.e., the findings should be shaped by the respondents, rather than researcher bias, motivation, or interest. There are several ways to achieve confirmability; in the present thesis confirmability has been achieved by continuous reflectivity and by developing an audit trail, i.e., a transparent description of the research steps. This means that the results have to be rooted in the collected data, rather than from the methods used.

Although the trustworthiness of the case study is important, it is equally important that the comparison and analysis of the three different methods for workplace studies is trustworthy. In order to establish trustworthiness for the method’s comparison, the objective was to create a logical relationship between research questions, research procedures, raw data, and results, i.e., establish a chain of evidence (Yin, 2009). More precisely, establishing the chain of evidence involved including thick descriptions, continuous reflectivity, as well as the models created, in the present thesis. These techniques are also important in order to achieve transferability, dependability, and conformability in a study, according to Lincoln and Guba (1985). Furthermore, the main strength of the present thesis is that both a theoretical and an empirical comparison and analysis of the three methods were carried out, which triangulates the results.

Another important aspect regarding trustworthiness and quality of the results is the previous experience of the researchers. As previously mentioned, all the team members involved in the case study have a background in cognitive science and HCI, as well as precious experience in doing ethnographically influenced field work. Furthermore, several of the team members had previous experience in modelling. However, this was not the case for the author of the thesis, who sometime struggled to develop the required models of the methods. This inexperience can be both an advantage and a disadvantage in the study. However, the main advantage in being inexperienced was that the ease-of-use of the methods became noticeable. For example, the tabular format in DIB made the model easy to design, an aspect of the method that was much appreciated by the author.
For this thesis, time has also been an important aspect. As both CD and CASADEMA proved to be more complicated and time-consuming than anticipated at first, time ran out to do all the steps of consolidation in CD, or a full-blown analysis of the internal cognitive processes under study in CASADEMA. Even though consolidation in CD can be done in a more rapid manner, according to Holtzblatt (2008), and even though the strong cognitive focus in CASADEMA might not be of practical use in HCI, the ambition has always been to do justice to the methodological process of each method. However, to do both a theoretical and an empirical comparison and analysis of three different methods have been an ambitious project to take on considering the time constraints of the thesis project, and would probably also reveal constraints that others might experience when using methods for workplace studies in different projects, since time is always an issue.

5.2 Contributions and implications

The contributions of the present thesis are several, and go beyond the intended contributions presented in Section 1.2. The contributions are:

- An increased knowledge about the theoretical and methodological differences in workplace studies
- Valuable information to researchers and practitioners when choosing methods
- Valuable information to developers of new methods for workplace studies
- An increased understanding of technology and social action in dentistry
- New insight to the challenges which lie ahead when continuing to introduce workplace studies in Dental Informatics

First, the comparison and analysis of methods of workplace studies in HCI fills a much needed gap, since it seems like no method comparisons have been conducted in the domain before. The field has continuously expanded, and as Rogers (2004) argues, no one really knows its purpose anymore, or what criteria should be used to assess its contribution and value to knowledge and practice in HCI. The present thesis is a starting point to begin exploring the many new (and not so new) methods in workplace studies. As mentioned before, these methods might add to the theoretical and methodological differences in the field, and thus need to be analyzed further in order to create an in-depth understanding of the use of workplace studies in HCI.

The second contribution of this thesis involves a more practical need in HCI, as the results can be used to inform researchers and practitioners when choosing methods for different aims. For this purpose results concerning the structure of the methods would be of further interest, since the structure affects the ease-of-use of the methods, as well as the amount of time spent on applying the method. Hence, the author’s first hand experience in applying the methods have been valuable in order to reflect on the process steps of each method.

The third contribution of this thesis is that its results can guide researchers when developing new methods for workplace studies. As there still seem to be a gap between ethnography and design, it appears to be a need for new methods with both descriptive power and application power, in order for workplace studies to be of more practical use in system design. However, one of the limitations of the study that is important to keep in mind, is that only three methods have been compared and analyzed, in order to be able to do both a theoretical and an empirical assessment of each method. Furthermore, both the DIB and the CASADEMA method have other
purposes than to inform system design. Hence, these methods are not to be considered to be design tools, but rather tools for analyzing complex socio-technical systems. The results of the study would probably be different if methods that have more explicit design purposes were chosen. For example, Distributed Cognition for Teamwork (DCoT) was excluded from the study because of the method’s focus on small teams (see Section 2.3). However, the DCoT method draws on ideas from CD, but re-orients them towards the principles that are central to DC, in order to support reasoning about existing system design, but also for possible future designs (Blandford & Furniss, 2006). This sounds as a fruitful approach to system design, as the notion of how CD can be used as a design tool can be seen as a possible approach to redirecting DC towards more practical design purposes. However, it is worth noting that Blandford and Furniss (2006) do not follow all the steps of CD, arriving at paper prototypes, in order to inform system designers. In my opinion, the ethnographers’ involvement throughout the design process is the major strength in CD, and the most important lesson learnt when assessing the CD method.

The final contributions are to the field of Dental Informatics. One of the initial thoughts was that the CD models produced in this thesis would validate the work done by Irwin et al. (2008). However, it seems as there are several cultural and organizational differences between the Swedish public dental service and the private clinics in the U.S. under study in Irwin et al. (2008). On the other hand, there are also similarities between the models, e.g., in work roles and work tasks. The main contribution to Dental Informatics is instead knowledge of how the applied methods can contribute to a new understanding of technology and social action in dentistry, as well as a better understanding of the challenges that lie ahead when taking workplace studies into this relatively unexplored and complex domain, and how to inform design of these systems. As only a limited amount of work has been done in Dental Informatics from a HCI-perspective, it is important to continue to explore the domain. Hence, in order to be able to develop systems that support the complex workflow and work environment in dentistry, and thus enhance patient care and safety, design teams have to explore dentistry “in the wild”. Alternatively, the results from this study could probably be used also as a guide to design of complex socio-technical systems outside of dentistry. Workplace studies emerged as a response to new challenges in technology, and need to keep evolving to meet the new requirements in HCI, as technology constantly getting more advanced, and the number of complex socio-technical systems increase.
References


