University of Oslo
Department of Informatics

Walking away from the PDA

A contextual study of medical students' use of mobile terminals and services in relation to their clinical practice

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Cand Scient Thesis

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Preface

THIS master thesis is written as a part of the degree Candidatus Scientiarum at the Systems Development Group at the Department of Informatics, Faculty of Mathematics and Natural Sciences, University of Oslo. This thesis is a collaboration between the undersigned, and the work constitutes 20 credits (two semesters). The basis of our study has been the Knowmobile project which is a Nordunet2 project managed by Intermedia at the University of Oslo.

During our work we have cooperated with researchers and other master students related to the Knowmobile project. And, we have gained much knowledge through this work and from each other through many constructive discussions. The work-process throughout this thesis have given us a deeper professional understanding and we have certified our skills to plan, accomplish and terminate a larger project.

We want to thank all the people that have given us different point of views and feedback and criticized and supported us throughout the project. First of all we want to give an extra warm and special thank to our teaching supervisor, Jo Herstad, for excellent professional and social support. We would like to thank the Knowmobile researchers Knut Lundby, Judith Gregory and Ole Smørdal for their inspiration and guidance, and the Knowmobile master students David Hsu, Kim Finkenhagen, Øystein Haga and Kari Blekastad Ellingsen for sharing field results and ideas. We also give thanks to the medical students and physicians that sacrificed their valuable time to let us carry through field studies and interviews at Rikshospitalet, Sentralsykehuset i Vestfold, Nedre Eiker Legesenter and Gulskogen Legesenter.

At the Third Nordic Workshop on Computer Supported Collaborative Learning and Mobile Learning (CSCLML) May 2001 in Gothenburg, Sweden, we got a lot of feedback on our two articles which were to be submitted to the IRIS24 conference. We wish to thank all the participants at the workshop for reviewing our articles and for sharing ideas.

During our participation in the 24th Information Systems Research Seminar in Scandinavia (IRIS24) in Ulvik, Hardanger, Norway 2001 we experienced a great social and professional time. Thanks to Saxifraga working group and all our friends from Högskolan i Trollhättan, Uddevalla and the Viktoria Institute, Gothenburg.

We would like to give thanks to Judith Gregory, Kim Rune Borgersen and Lars Duvaas for helping us with linguistic matters and their contribution of proof-reading of this thesis.

Finally: *Parken, you're my guidance and my light...* We would like to thank all our fellow students and friends at Parken study room. You gave us a lot of fun and a great social time, but most important; inspiration. Thank you for your support throughout the studies. **Parken forever!**

Hans E. Gallis
Jarle Petter Kasbo

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Abstract

This thesis presents our study of medical students in their clinical practice and their use of mobile terminals, serving as information resources, in relation to the Knowmobile project. The main objective is to shed light upon *conditions for the possibility* for use of mobile terminals, serving as an information resource, in contexts related to the clinical practice. By focusing on this objective, we hope to give a contribution to the area of mobile informatics.

The empirical work consists of interviews of medical students and contextual inquiries in the clinical contexts, hospital and general practitioner's office, and the context of travelling by train. Our empirical work has been supplied by other reports written by master students, researchers and the users in the Knowmobile project.

As a tool for reaching our goal, we developed a prototype of an e-book based on the findings from the interviews. The main intents of the prototype were to provide an additional service to the medical students, and that the use of this prototype could illuminate use of mobile terminals as an information resource in general. We carried through the contextual inquiries with the prototype and note taking by means of the mobile terminal in focus.

Our discussion is based on literature studies and the findings from the contextual inquiries. The literature studies have ranged from core technical articles and reports about mobile technology, through mobile IT use and information infrastructures, to science of artifacts. We believe that this wide scope of literature has given us a good insight in order to accomplish the goal of our thesis.

The title of this thesis reflects our most distinct discovery: We observed a very limited use of the mobile terminal in the medical students' clinical contexts. We observed that they prefered to use other resources instead, and often left the mobile terminal at home or in the cloak room at the practice location. When moving away from the clinical contexts and the clinical tasks, the use increased.

Through a cross-case analysis of our empirical data and discussion, we state that several aspects affect the use, or more correctly: the non-use of the mobile terminal. We state that the use is dependent upon the characteristics and resources of the mobile terminal as well as the other information resources available in the

context. In addition, we believe that because the use of the mobile terminal was not perceived as a part of the community of practice, the medical students did not find the mobile terminal useful in their clinical practice.

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List of Acronyms

CSCW	Computer Supported Co-operative Work
DTD	Document Type Definition
GSM	Global System for Mobile communications
GPRS	General Packet Radio Service
GPS	Global Positioning System
HCI	Human-Computer Interaction
HTML	HyperText Markup Language
ICT	Information and Communication Technology
IT	Information Technology
JIT	Just-in-time
PDA	Personal Digital Assistant
SGML	Standard Generalized Markup Language
SMS	Short Message Service
UMTS	Universal Mobile Telecommunications System
WAP	Wireless Application Protocol
WLAN	Wireless Local Area Network
XML	eXtensible Markup Language
XSL	XML Stylesheet Language


Cat food

Chapter 1

Introduction

IMAGINE *that you are a medical student in your clinical practice at a hospital. Because you are a part of a project focusing on collecting information through mobile terminals, you are carrying a PDA in your white coat. In addition to the PDA, you bring a medical handbook, a notepad, a piece of paper containing all the names of the patients, a paper note with today's schedule, a stethoscope, a personal pager and pens. These are all items which other physicians are carrying around as well.*

You are about to carry through a visit of a patient in room 2314 located 20 meters down the hall from the meeting room. Before going to the patient you update yourself by reading the patient's Curve[1]*. Your patient is in a stable condition and you are just having a visit to check the patient. When reading the Curve of the patient, you get a bit insecure because of an issue concerning the diagnosis of the patient. The meeting room contains a range of medical handbooks and medical reference books, in addition to a desktop computer with access to medical databases, all patients' lab results, an application handling X-ray pictures etc. To check out the diagnosis of the current patient, you turn to a reference book, and are able to find the answer rather quickly. You also check her X-rays on the computer to acknowledge the information in the book. There are many details in the reference book, and in order to not forget anything, you write down some keywords on the piece of paper which contains the names of all the patients. You do not even consider using the PDA for this purpose. You fold the paper, put it into your chest pocket, and start wandering down the hall.*

The visit is almost over. Then the patient ask a question about the treatment and the medicines she is getting. She complains about some skin eruption, and wonders if maybe the medicine is causing this. You don't know the answer to this question, and the handbook in your pocket does not give an answer to this question. Neither

[1] A Curve is a folder of paper describing the patient's condition, diagnosis and planned treatment. The Curve is only containing information of the current stay at the hospital.

does the electronic version of the handbook installed on your PDA. You therefore write down the problem on the paper note, because you have to add this to her Curve, and you pick up a small piece of paper - your "remember list"- and make a note saying that you have to inquire about this when you are back in the meeting room.

Back in the meeting room you first inquire about the medicine the patient is getting in a handbook, and compare the precautions of this medicine with the information in the patient's Curve. You discover that it may be the medicine causing the skin eruption. As a student you can not change a patient's medication on your own, so you will have to get assistance from a physician. But, first you want to check if you are able to determine what alternative medicine to be prescribed. For this task you look up the problem in both a handbook and the database. Then you call for a physician to help you out. Together you solve the problem and a new medicine is prescribed. Actually, the same medicine that you found suitable. To close the task you update the Curve, utilizing your personal notes, and walk back to the patient to inform her about the new medication.

1.1 Background and motivation

> *Everyone is talking about technology, when what's important is what people **do** with technology.*
>
> — Martin Cooper (Cooper 2001)

People use technology all the time, technology help us in our everyday lives, and technology annoy us when it does not work right. But what is actually technology? The Webster's dictionary defines technology as:

1. A technical method of achieving a practical purpose
2. The totality of the means employed to provide objects necessary for human sustenance and comfort

The traditional conception of technology, which originated with Aristotle, is that technology is a human development or arrangement of tools, machines, materials, and methods to serve the attainment of human purposes (Ciborra 2000).

In modernistic organization theory, technology is understood as a tool to obtain something; a desired outcome, a goal or a result which is usually realized as a product or service (Hatch 1997). From this perspective, technology is often defined as (1) physical objects or artifacts, including tools and equipment that is used in the production of them, (2) activities and processes that make up the production

methods, and (3) knowledge that are used to shape and employ equipment, tools and methods to produce a definite outcome (ibid.).

From these definitions we can mention some examples of technology which are not that obvious. Glasses can help weak-sighted people to read books, and shoes help people walk. Glasses and shoes are therefore technology, not just something people wear. In everyday speech, we use the word "technology" to refer to things that are new, where the technology dominates over usability and usefulness (Norman 1998). But what about glasses and shoes? They are all technologies which follow advanced scientific and engineering practice in their design and manufacture. Technology are made to ease tasks people are carrying out. Glasses and shoes are unobtrusive and almost invisible technology. We do not have to pay attention to the glasses when we read and we do not have to pay attention to our shoes when we walk. The only time we get annoyed by this technology is when the glasses gets dirty and the shoelaces is untied. Glasses and shoes have become so commonplace that we take them for granted. We assume the technological features are reliable and robust, and so, on the whole, we ignore them (ibid.). On the other hand, it is much more difficult to find what is not technology. Everything that is made from humans can be defined as technology. Even our methods can be seen as technology. In that way, a whole organization, such as a hospital can be viewed as technology. A hospital contains many devices, but also standardized methods and structures. The organization of the hospital is itself technology, which have been formed for centuries. This indicates that the mobile terminal should be seen in relation to all the other technologies at the hospital or in the environment. We have to take the existing technology, including devices, methods and organization, into consideration when looking at new technology and practices.

From talking to thinking

From talking about technology, which everyone do according to Cooper (2001), it is time to focus on how people are able to utilize technology. Today, the development mobile high-technology, such as mobile phones and PDA's[2] are running fast. New mobile devices are introduced to the market frequently, and they are getting more and more advanced and powerful, with more and more applications and services available.

Mobile devices and services should provide help as well as comfort in our everyday lives:

> *The fundamental idea of systems development is to use technology to make the world a better place for us. Systems development is part of the project for progress.*
>
> — (Dahlbom & Mathiassen 1993, page 135)

[2] PDA is an acronym for Personal Digital Assistant

Does this technology succeeded? So far, wireless services, other than voice services and SMS services for the mass market, have been a huge disappointment failing to live up to the hype that heralded their arrival. Current portable computers and PDA's fail to truly become part of our daily lives, in the sense that we need to stop what we are doing and focus on the device or service instead of the task in order to use them (Mann 1996*b*, Norman 1998, Weiser 1993, Mark 1999). This is not only a problem regarding mobile devices and services, but stationary computers as well. Because these mobile devices are carried with you wherever you are and thereby used in different settings they become even more obtrusive.

During our studies at Institutt for Informatikk (Department for Computer Science at the University of Oslo), we have got to know to the use and development of applications and services for stationary computers. But, mobile computer solutions are different from stationary computer solutions. This statement are supported in literature of Computer Supported Collaborative Work (CSCW) (Dix & Beale 1996), and literature of new possibilities and challenges of mobile information technology (Rodden, Chervest, Davies & Dix 1998, Bellotti & Bly 1996, Kristoffersen & Ljungberg 1998). The most obvious difference is that use of a stationary computer or terminal, the user is situated in front of a desk, while the use of a mobile computer is not location bound. Koht-Tøfte & Olsen (1999) presents five contexts of use of mobile terminals. These are:

Professional use. The context of use is the users work space, and the use has a professional character.

Personal use refers to use at home and the processing of private data.

Leisure cover the contexts of leisure. The use in these contexts differ from the home and work contexts.

Local travels. Use during travel to and from work, or shorter travels which is not thorough planned.

Global travels. Use at more planned and prepared travels, which may last for a long period of time.

We think that these contexts are sufficient to cover most of the contexts of use of mobile terminals. The intent with this list is not to identify as many contexts as possible, but to indicate that a mobile terminal is utilized in a combination of several contexts, which not is the case of a traditional stationary computer (Koht-Tøfte & Olsen 1999).

1.2 The aim of the thesis

Let us turn back the time about 12 000 years, to the Stone Age; the Stone Age man, called Fred, his Stone Age friend, called Barney, and a flint stone:

> *Fred did not have access to many tools, but he had the flint stone and a need for tools to make things easier. The flint stone, situated on the ground, did not have much use for Fred, other than to be thrown and piled. But, Fred discovered possibilities in the stone. He found that he could shape the stone by hitting it against another stone. The stone then became sharp, and the man discovered that he could utilize the stone in new ways. He could now shape other materials with his stone, and new possibilities opened up. One day Fred's friend, Barney comes by. He catches the sight of this strangely shaped stone, picks it up and throws it more than 50 meters. He is proud.*

This example tells a story about a human inscribing meanings into an object. By shaping the stone the man turns the object into an artifact[3] with characteristics and resources meaningful to him. These resources are still not meaningful for his friend. The use of an artifact, as this example shows, is dependent upon whether the resources are useful or not. The story also illustrates the conditions for the use of an artifact.

The aim of our thesis is to gain the understanding of: **use of mobile information services and technology, and provide a contribution to the area of mobile informatics.**

The aim presented are extensive, and it inspired several questions: What are the conditions for mobile IT use? Is it so that mobile services are useful in all contexts? What are the characteristics of such a context? Are manufacturers and developers of mobile technology and services creating an artificial need for their products, or is it an actual need? If a actual need - what services and devices are needed?

We will try to discover factors concerning use of mobile technology and services through our research. An important aspect is to search for possibilities to make the mobile terminal with its services fit the context of use without re-organizing the medical practice. The issue is then not to search for ways to utilize this technology better.

The focus is on mobile services, or more specific: information resources, but we also have to take the mobile device itself into consideration when discussing the services. To reach that goal, we have made a prototype of an e-book, carried through interviews and contextual inquiries. The basis for this thesis are experiences and results from 9 interviews and two contextual inquiries.

We have studied medical students in their practical term, the 10th semester in their medical education, where the students are carrying through six weeks of practical training at a hospital (3 weeks) and at a general practitioner's (GP) office (3 weeks). We have accomplished our studies/research in relation to the Knowmobile project.

[3] An artifact is according to Merriam-Webster (n.d.) something created by humans usually for a practical purpose. More about artifacts in Chapter 5.1.

The results of the contextual inquiries and interviews were gathered, categorized and analyzed in order to discover how they could make a contribution to the field of mobile informatics. Our empirical work has been supplied by reports written by master students, researchers and the users in the Knowmobile project.

1.3 Problem area

The Knowmobile project managed by InterMedia, University of Oslo was established during autumn 1999 and spring 2000. The full proposal name of the Knowmobile project is **Knowledge access in distributed training. Mobile opportunities for medical students**. We are carrying through our research as a part of the Knowmobile project, and therefore it was natural to use their problem area as a basis for our problem area. Thus, we had to limit our scope due to the extent of this thesis. Knowmobile is focusing on how the medical students, in a variety of local contexts, use the net to access and apply relevant knowledge and information for their practical training. It also focuses on how they apply the Internet to keep and build collaborative support structures with their fellow students and their teacher around this knowledge acquisition while at assignment on their own (Lundby 2001). Our problem area in relation to the Knowmobile project is the clinical practice contexts, and how they can access and apply relevant information resources by the use of a mobile terminal.

During our work with identifying our problem area we did some literature studies, which lead us into the area of mobile informatics. The case of mobile informatics is to explore the possibilities of new and innovative concepts of how IT could be used in mobile work and leisure activities, thus not only the technical aspect (Kristoffersen & Ljungberg 1999*b*). Mobile informatics implies a focus on the activity within which people are engaged (ibid.). A model of mobile IT use given by Kristoffersen & Ljungberg (1999*c*) describes the situations of use of mobile IT. The model is pointing out that the use is dependent upon the environment in which the mobile IT use takes place, the application[4], and the modality. (See 5 for further descriptions on mobile informatics and the model of mobile IT use). These theories acknowledged that the Knowmobile project were within the area of mobile informatics, and that we would work within the same area, but they did not help us focusing.

To help ourselves focusing better, we arranged interviews with one physician, three students who already had accomplished their practical training, and three who were going to start their clinical practice[5]. We had then developed a preliminary research question, which was “How can mobile technology and mobile services support the

[4] Kristoffersen & Ljungberg (1999*c*) defines application as the technology, data and the program.

[5] Even though they had not accomplished their practical term, the students have had already carried through several short periods of practical training.

need for information in the medical students' clinical practice?". The focus for these interviews were then, to discover what information resources the medical students utilized in their practical training, in what situations they were utilized, and how they were utilized. We also focused on the procedure of making notes in the practical training (See Chapter 3.2.1 for further description of these interviews). The results of these interviews gave us the idea of developing a prototype which could meet one of the requirements the students mentioned. The main intents of the prototype were to provide an additional service to the medical students, and that the use of this prototype could illuminate use of mobile terminals as an information resource in general.

Through further literature studies we found interesting issues concerning conditions of use. Brown & Duguid (1994) emphasize the characteristics and resources of the artifact as important issues concerning information systems design. At the same time Brown & Duguid (1996) and Braa & Sandahl (2000) point out that transformation of paper-based documents into an electronic version may lead to new functionality, which could be a factor that turns the document into another genre (Brown & Duguid 1994).

Our prototype, which is an e-book of *Metodebok for Turnusleger*, and the activity of making notes on a PDA were in focus (which do not require a network connection), and we would investigate the conditions for use of mobile technology and mobile services with these services as a basis for discussion.

This leads us to the problems addressed presented in the next section.

1.4 Problems addressed

Our main research question:

> **What are the conditions for the possibility for using the mobile terminal as an information resource in the medical students' clinical practice?**

A *condition* is in Webster's dictionary defined as "a premise upon which the fulfillment of an agreement depends; an environmental requirement; to put into a proper state for work or use". We want to find the premises for how the mobile terminal can be useful, by looking at the artifact and its environment, in the context of use.

By the term *use* we refer to how the users employ and adapt the mobile technology to the situations they experience. Rolland (1999) suggest this definition of use: "Use are the relation between a human and the artifact, where the human is a part of the context (work) and the artifact is an IT device." This definition supports our view.

A *mobile terminal* is technology that is small and light enough to be carried everywhere. The term is covering phrases as PDA, handheld computer and Pocket PC. We use terminal as an expression to any computer device. In this way we separate terminal from device. A device, by our definition, is any object or artifact containing information or enabling information to be stored. Thus, a device could be a medical book, journal or a notebook.

Information resource refers to the role of the mobile terminal as an artifact containing information, or enables information to be stored. An information resource is the artifact the medical student can use to access information. Our main focus of information resources are **our prototype** and **the mobile terminal, serving as a notepad**. We will not distinguish between a paper-based notepad and a piece of paper in this thesis. Both are seen as an information resource, and will be referred to as a notepad through this thesis.

Medical students' practical training is the 10th semester of the education of medicine by the University of Oslo. The phrase refers to six weeks where the medical students are placed in different hospitals and general practitioner's offices (GP offices) in the South Eastern part of Norway. In our case this means the medical students who are a part of the Knowmobile project. The practical training implicates two clinical contexts, but we are focusing on traveling by train to and from the clinical contexts as well. The train context was chosen because we wanted to discover different conditions for use by looking at a completely different context.

1.4.1 Specific research questions

To approach an answer to the main research question, we identified several questions which could throw light on and together give an answer to the main research question. These minor question can be divided into two categories. This categorization illustrates our perspectives of approach to answer the main research question as well.

The artifact: What artifacts are the students utilizing as information resources? How does the characteristics of the artifacts (terminals and devices) affect the use of it? And what are the consequences? What are the differences between the mobile terminal, serving as an e-book and a notepad, and the respective paper-based artifacts?

Contextual aspects: In which contexts are the mobile terminal utilized? In what contexts are the use of the mobile terminal and its services supported? What type of mobility is required in the clinical practice, and how does the mobile terminal and services support this mobility? In what way do the community of practice affect the use of the mobile terminal and services? How is the use influenced by the presence of other devices? In what extent do the services of the mobile terminal

support the student's current tasks? How does the mobile terminal, serving as an information resource, support just-in-time interactions?

These perspectives do not exclude one another, but are intertwined in relations. The artifacts are *in* a context, which consists of humans, social relations, work practices, other devices etc. The perspectives are to be seen in relation to each other. Together, we think, that these perspectives can shed light onto our main research problem.

1.5 Actuality

In this thesis we are roaming a field within informatics which deals with mobile technology, mobile IT use, mobility, information access, e-books, and the relationship between an artifact and the use of them. We will base the degree of actuality by looking at these areas.

The trends today indicate that people are becoming more and more mobile. Statistics from various sources support this claim:

- From December 1998 to July 2001 the amount of GSM subscribers worldwide has increased from 138.4 million to 564.6 million. The technology forecast indicates that there could be 1.4 billion subscribers within 2005 (GSM Association 2001).
- In Norway there were per. December 31th 2000 3.1 million mobile phone subscriptions (Statistisk Sentralbyrå 2001)
- September 1th, 2001 there were 14461 domestic flight departures in USA (Bureau of Transportation Statistics 2001).
- During 1999 Norwegians carried through more than 23 million travels with minimum one overnight stop(). This is corresponding seven travels per. person (Statistisk Sentralbyrå 2000).

Dahlbom & Ljungberg (1999) states that people become more mobile in work. Cooperations leads to increased use of IT that bridges distance, such as e-mail, but also leads to mobility: people travel to meet physically. Another factor is the emergence of service work as the main occupation in the Western society. Service work is often performed where the customer is, which differs from time to time. Therefore, many workers are mobile (Dahlbom & Ljungberg 1999). These arguments strongly indicates that there are a need for mobile technology, and that there is a tendency of use of mobile IT.

On one hand is the need of being mobile, but another aspect of mobile IT use, is what this leads to. When being mobile, the user is away from his regular context

and information resources. This raises a need for accessing needed information in other ways or through other medias. Technology such as wireless network access is an example of an approach to enable information access while being mobile. The Knowmobile project, is an example of a project exploring these possibilities. The mobile IT use makes just-in-time and just-in-place information access topical. As a curiosity we mention the new work context of of the 7500 employees of Telenor[6]. The motto of the new context is: "clean desk". The idea is to access all needed information resources and to store all documents electronically[7].

The e-book is a relative new phenomenon. e-books have not been a extensive commercially success, yet. But, big and influential companies emphasize applications for reading e-books on terminals, such as Adobe and Microsoft e.g. More and more terminals are supporting e-books, and dedicated e-book readers are developed[8]. A quick search for e-book publishers on the Internet, gives us hundreds of hits and thousands of e-book titles.

1.6 Research approach

The area of a medical student's practical training was not known to us when we started with our study. We therefore carried through interviews using a qualitative approach. Open and unstructured interviews with students and a doctor gave us insight in the area, and we got acquainted to work practices, tasks and needs regarding our problem area.

We have developed a prototype of an information resource to be used in the Knowmobile project and as a mobile service of study. And, scenarios of use has been developed based on the first interviews.

The gathering of empirical material was done by contextual inquiries, which involve questioning the students during the inquiries. In addition we have conducted a contextual evaluation of the mobile terminals which are used by the medical students in Knowmobile. This evaluation gave us valuable insight to the use of these mobile terminals.

1.7 Main discoveries and results

The medical students we observed was not very familiar with the use of mobile terminals, and had problems of taking advantage of the 'new' technology. Use of

[6]Telenor is a Norwegian telecommunications group with extensive and fast growing business operations in a number of countries in Europe and Southeast Asia (www.telenor.com).

[7]Found in the article "Telenor-ansatte først inn på Fornebu" of Nilas Johnsen on www.aftenposten.no November 23rd, 2001

[8]ebooks.org presents 24 software applications for reading e-books, and 34 handheld devices enabled for e-books, thereby six dedicated e-book readers.(www.ebooks.org)

the mobile terminal was dependent upon the context in which it was used. The use in the clinical contexts was very different from the use on the train. On the train, the students used it mostly for accessing the Internet, but they also used the mobile terminal as an information resource. In the clinical context the PDA was mostly left behind, because the students did not see the utility value of the mobile terminal. The reasons for this are quite diverse, but some of the most important results are listed below:

- The mobile terminal was seen as an obstacle instead of a companion due to its characteristics mentioned by the students.
- The mobile terminal was not preferred as an information resource, because important resources of the paper-based artifacts for the students in their clinical contexts were removed.
- The mobile terminal, serving as an information resource, was not a shared object in the clinical contexts, and hence it did not become a social valuable artifact in the community of practice.
- Because there was a misfit between the mobile terminal, serving as an information resource, and the task chains, the use of it became limited.
- The mobile terminal was not preferred as an information resource in the clinical contexts because it did not support just-in-time interactions.

1.8 Outline of the thesis

The rest of the thesis is organized in the following way:

Chapter 2 explains the Knowmobile project more thoroughly. The chapter presents the consortium, research objectives, aim, user group and the places where the clinical practice is conducted.

Chapter 3 describes our research approach, and how we have applied the different methods in our work.

Chapter 4 introduces our prototype; an e-book version of a medical handbook which can be read on the mobile terminal. We presents the background, aim, and technical solution.

Chapter 5 presents our theoretical approach. Through the theoretical approach we try to build a framework which can explain and shed light upon our empirical findings.

Chapter 6 presents our empirical findings. First we present results from the three different contexts which have been our focus; hospital, general practitioner office, and travelling by train. Then we presents context independen findings.

Chapter 7 consists of analysis and discussions of our empirical findings, and we argue for our statements by using the theory presented in chapter 5. The chapter is divided into two main parts; *characteristics of the artifact* and *contextual aspects*. Those two parts shed light on our main and secondary research questions.

Chapter 8 points to the essence of our analysis and discussion in the previous chapter, and possible further work based on our empirical findings and discussion is presented.

Appendix A shows the specifications of the mobile terminals used in the Knowmobile project and our thesis (HP 548 and HP 720).

Appendix B is the interview guide (in Norwegian) we used for our semi-structured interviews with medical students prior to the development of the prototype and our field study.

Appendix C presents the data collection procedure which describes the focus in our contextual inquiries.

Chapter 2

The Knowmobile project

THE *work described in this thesis is part of the Knowmobile Project, managed by InterMedia, University of Oslo and was established during autumn 1999 and spring 2000. This Chapter gives a description of the project.*

2.1 Overview and research objective

The Knowmobile project[1] is a Nordunet 2[2] project and its full proposal name of the Knowmobile project is "Knowledge access in distributed training. Mobile opportunities for medical students" (Lundby 2001). The term "Knowledge access in distributed training" refers to life long learning in a variety of health professions. By *knowledge* in this context, is meant information and material made meaningful for the learner in relation to the given problem or task. The project is a research and development project exploring just-in-time access and functionality with Internet based educational resources. The consortium of the project consists of:

- InterMedia, University of Oslo.
- Faculty of Medicine, University of Oslo.
- Department of Informatics, University of Oslo.
- Telenor R&D.

[1]The full proposal could be found on the following web-page: *www.intermedia.uio.no/prosjekter/knowmobile/soknad/soknad.html*.

[2]Nordunet2 is a research program financed by the Nordic Council of Ministers and by the Nordic Governments. The overriding aim of this program is to help secure the position of Nordic countries at the forefront of Internet development. Its focus is on network utilization and network-based applications. See *http://www.nordunet2.org* for more information.

- Hewlett-Packard Norge.
- Ericsson Norway.
- Umeå University.
- MedCAL (computer assisted learning in medicine odontology and veterinary medicine)

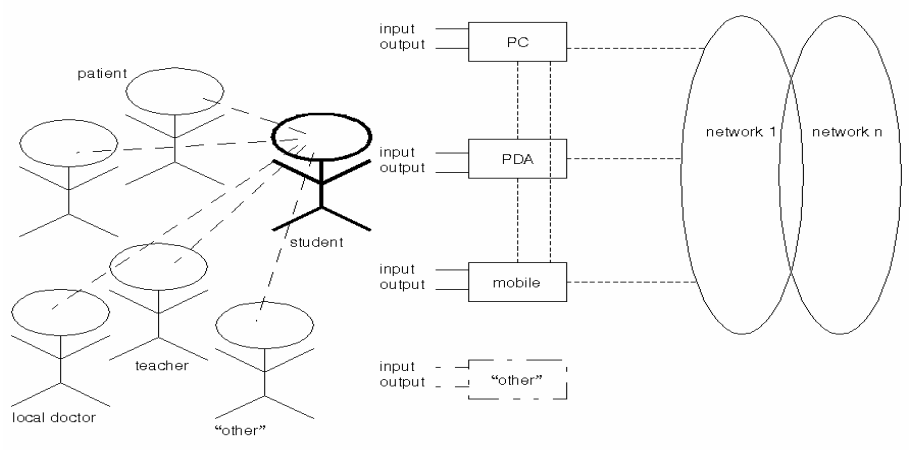


Figure 2.1: Users and their access to information

2.1.1 Aim

The aim of the Knowmobile project is to develop and evaluate net-based solutions for knowledge access in distributed training of medical students, which will lead up to life long learning. The project concentrates on mobile communication solutions of primary health care services. Focus is on the student's needs for just-in-time knowledge in training situations as future mobile health workers, and on the learning processes in such distributed, net-supported training.

2.1.2 Research objective

The overall research objective, the general question which the consortium wants to answer, is: "How could just-in-time knowledge access to net-based educational resources be performed and utilized in practical problem-solving by learners with mobile terminal equipment in a distributed work-like training situation; and what are the technological and sociological conditions as well as the learning outcome of this?". There are two main research tracks that is defined. These are (1) a

pioneer group track that focus on the existing technology and (2) a experimental track where new and emerging technologies are tested together with a context from the students situation. The second track gives more opportunity to choose what technology and what to focus on in the project, but the context will still be the medical students and their study- and practice situation.

2.1.3 Research dimensions

The R&D of Knowmobile concentrate on the three dimensions of

- knowledge access in the distributed learning context of general medical practice
- application development and communication solutions in this local context
- the possible pleasurable learning from the just-in-time knowledge access

2.2 Distributed medical education

Figure 2.2: PDAs used in the Knowmobile project

During their tenth semester the students will be distributed to eight hospitals in Southern and Eastern parts of Norway, and to offices of general practitioners, linking up to the hospital in their area. The students are grouped in three units utilizing a different range of technology and equipment (see Figure 2.2). Figure 2.3

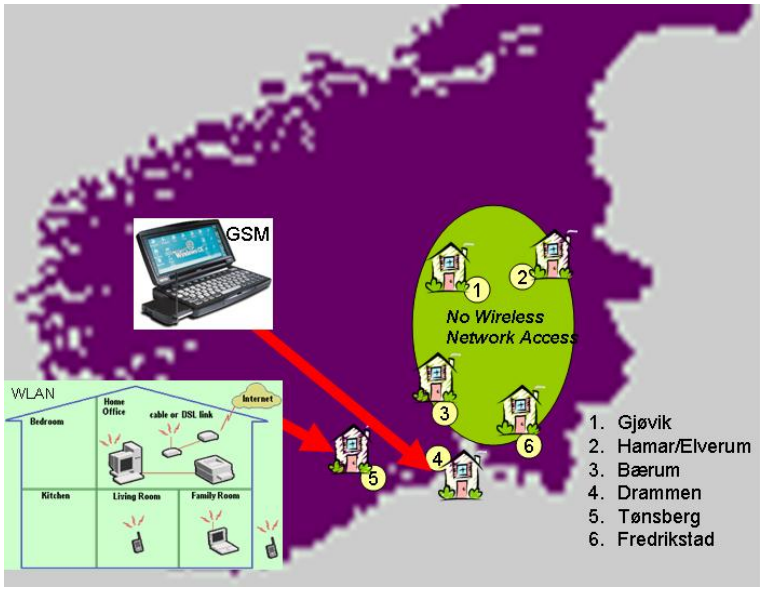


Figure 2.3: A map of the Southern and Eastern part of Norway showing the locations and what kind of network access the students have in these places (the different locations are not placed at their real coordinates).

is a graphical overview over the students' locations and their network connection. Table 2.1 are showing available equipment and services for the students in the different groups. 'Location' shows where the student is placed (with a number referring to figure 2.3), 'Equipment' gives what device the student have and the degree of connection to the Net, and 'Services Available' describes the services the student can utilize with his equipment. These services are currently made available by master students related to Knowmobile. Our focus have been on the general practitioner offices in Drammen and a hospital in Tønsberg.

2.2.1 Research objects

The research objects in our research are the medical students participating in the Knowmobile project. The group is homogeneous in the way that they are all under education. That is, they are in their 20's and 30's, they live the social and educational life of a student and they are doing something they have a strong interest in. The medical students in the research group applied for participation in the Knowmobile project. But, the amount of experience in use of technology would probably differ among the research objects. Some of them are surely more or less used to, curious and interested in technology and especially computers.

Even if the students are in their practice period, some of them have more clinical

Location	Equipment	Services Available
Tønsberg area (5)	- HP548 - WLAN	- Online Knowmobile portal - Metodebok for turnusleger - Jabber - AvantGo
Drammen area (4)	- HP710 - GSM Card	- Online Knowmobile portal - Metodebok for Turnusleger - Jabber - AvantGo
Distributed groups - Gjøvik (1) - Hamar/Elverum (2) - Bærum (3) - Fredrikstad (6)	- HP548 - Offline - Docking station	- Offline Knowmobile portal - Metodebok for Turnusleger - AvantGo

Table 2.1: Three different settings i Knowmobile

practice from earlier than others. This make the research group divided because of former experience. The user's former experience with computers and medical experience are probably the most important factors in our user group. The students carry out their practice in different hospitals, and in different wards at the hospital, and at different practitioner offices. There are probably also some variation in structure and organization from place to place, and how the training is carried through.

Chapter 3

Method

DURING *this study, we were forced to make up a point of view concerning collecting true information, and how to gain true knowledge about our problem area. In this chapter we will first introduce fundamental philosophical views of which methods can be derived, and then, theories of research approaches. These views and approaches are theories we considered when choosing our approach and methods for our study, which are described in section 3.2.*

3.1 Views and approaches

> *"the empirical-analytical method is the only valid approach to improve human knowledge. What cannot be investigated using this approach, cannot be investigated at all scientifically. Such research must be banned from the domain of science as "unresearchable".*
>
> — (Bleicher 1982, page 14)

3.1.1 Positivism and anti-positivism

Positivism is "a view that directly reflects the methods of natural science and a belief in their generality for all spheres of inquiry" (Burrell & Morgan 1979). Positivists believes that all true knowledge is based on the observation or experience of real phenomena in an objective real world. This research aims to give rise to objective facts that cannot be disputed. And, the facts produced are seen to have no social values encoded in them and are timeless (ibid.). These claims assume that there is an external and objective reality, and that knowledge is only of significance if it is based on observations of this external reality.

On the other hand, there is anti-positivism. An anti-positivist position is one that cannot accept the clear distinction between fact and values, and rather sees them as intertwined (Burrell & Morgan 1979). Anti-positivism claims that all knowledge, including scientific knowledge, is socially constructed and is therefore conditioned by the values of the society (Cornford & Smithson 1996). The reality is not objectively determined. For an anti-positivist it is important to understand and explain, and not to do research by measuring different properties. The role of the researcher is subjective, open and committed, and in contrast to positivism it is the totality that is interesting (ibid.).

3.1.2 Quantitative and qualitative perspectives

Positivism and anti-positivism are two views which give rise to different approaches on how to seek knowledge. *Quantitative* research relies on developing metrics that can be used to describe phenomena under study. Such data can subsequently be analyzed using the techniques of statistical analysis. Science has strongly influenced the widespread adoption of such approaches in the social sciences in general, and information systems in particular (Cornford & Smithson 1996). Qualitative methods enables the researcher to describe phenomena in a more differentiated way. These methods seek other means of capturing and analyzing data than the quantitative methods (Cornford & Smithson 1996). Miles & Huberman (1994) describe qualitative research as usually based on words rather than numbers. Words, in means of stories or incidents, have a concrete and meaningful flavor that often proves far more convincing to a reader than pages of summarized numbers (ibid.) This implies that the researcher has to spend substantial time in the field collecting unstructured and 'real time' observations, and then work to make some sense of them. Observations may be in the form of interviews, transcripts of conversations or field notes made at the time (Cornford & Smithson 1996). The results must then be processed, structured and analyzed in some way. Then, in the qualitative research the researcher's role and actions are somehow more central and intrusive than in quantitative surveys with quantitative analysis, and is naturally strongly associated with an interpretivist and relativist position. The qualitative researcher is seeking out the individual's experience and awarding it its own value, and thus, he must accept a more subjective view of the reality (ibid.).

3.2 Our approach

A Norwegian proverb says: "A good start is halfway accomplished[1]. The proverb emphasizes to always start with the problem when accomplishing a research project (Andersen & Schwencke 2001). A problem in this sense is something as simple

[1] Informal translation done by the authors

as an area or subject the researcher wants to gain new and more knowledge about (ibid.)

There are however several different ways to gain information about a subject. Patel & Davidson (1995) list three ways of doing scientific research:

1. *Explorative.* This comprises the investigating methods. The researcher is using several different techniques to obtain information about a certain problem area. An explorative approach is often utilized when the knowledge about the problem area is limited.

2. *Descriptive.* This approach are characterized by a detailed and thorough examination of a few aspects of a phenomenon. Usually one technique is utilized for obtaining information. Descriptive approach assume a certain amount of knowledge about the field of research.

3. *Testing of hypothesis.* In order to be able to utilize this approach, the researcher needs to have comprehensive knowledge about the area of concern. This approach comprises deduction and testing of assumptions or hypothesises based on theory.

Before we started the work with our master thesis, we did not have much knowledge about the area of research. We have therefore used several techniques and methods to gain knowledge and to obtain information. In this way we categorize our approach as explorative.

Our problem area lies within the area of informatics and mobile informatics. We are looking at medical students' use of mobile terminals in their practical training, their accomplishment of tasks in relation to patients, other students, physicians and the context. The study of the practical training as a study in social science, as well as in informatics. The term 'informatics' is as well referring to the utilization of IT and IT use. We base our statement upon Galliers & Land (1987) when we claim that our approach should be based on anti-positivism. Galliers & Land (1987) gives two main arguments for why positivism and empirical-analytical methods not are proper for our study. First they state that there are only a limited number of factors that can be studied under laboratory conditions, and it is difficult to reproduce a 'real-world' environment in these circumstances. For example, the use of mobile terminals in a hospital context can only be properly studied in the real world hospital environment. Second, the need to apply values to variables, as in natural science and positivism, often leads to the elimination of factors that are difficult to evaluate, even though they may have relevance.

> *Our research methods must take account of the nature of the subject matter and the complexity of the real world.*

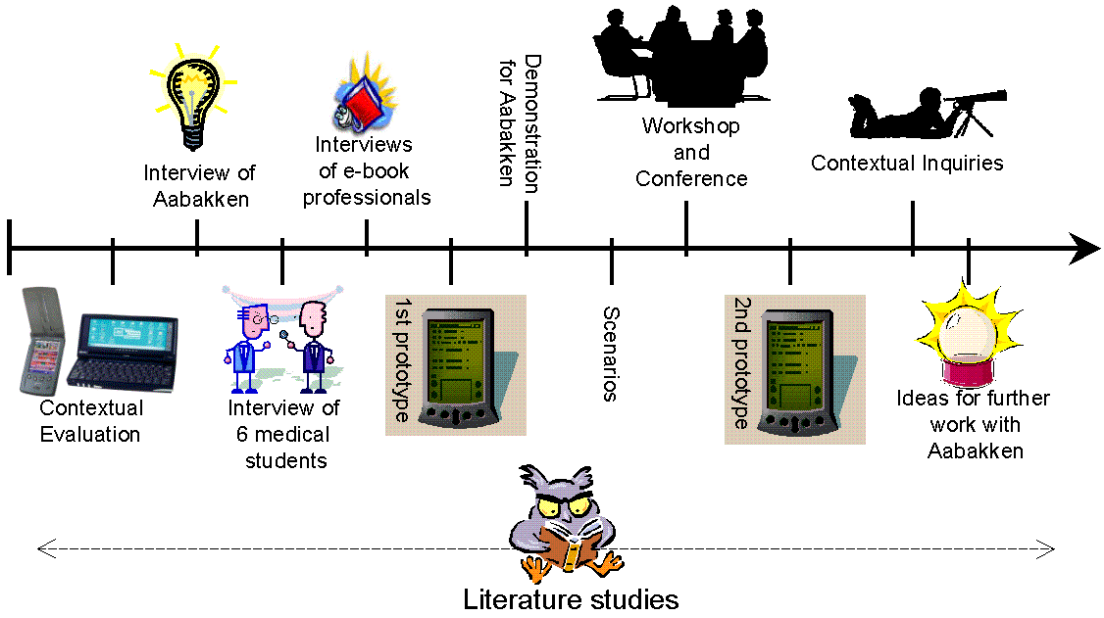


Figure 3.1: Time line of our approach.

— Galliers & Land (1987, page 901)

Figure 3.1 is an overview of our approach and the work with this thesis. The applied methods displayed in the figure will be further discussed in the following subsections, as well as our motivation for choosing these methods and how we carried them through. 'Workshop and Conference' indicates our participation on the *Third Nordic Workshop on Computer Supported Collaborative Learning and Mobile Learning (CSCLML)* in Gothenburg, May 2001, and on *Information Systems Research Seminar in Scandinavia (Iris24)* in Ulvik, August 2000. We submitted two articles to both CSCLML and Iris24 which deals with the multidevice paradigm in Knowmobile (Gallis, Kasbo & Herstad 2001), and a descriptive case of a possible approach for designing information services in a multidevice environment (Kasbo, Gallis & Herstad 2001). Before we began to interview the medical students, we started out with a contextual evaluation of the mobile terminals. The evaluation was conducted together with another master student, and we tried to use both the terminals in a variety of study situations. This was done in order to get an idea of how the PDAs worked in different use situations.

3.2.1 Interviews

Cornford & Smithson (1996) states that interviews offer researchers the chance to explore topics in depth and to gain appreciation of the context within which

the interviewee is addressing the topic. This is the argument for choosing this approach in an early phase. Also, interviews is suitable because they allow interaction between the researcher and the interviewee, and because the researcher can adjust the line of questions depending on the response given by the interviewee. In this way interviews can deal with much more complex topics than questionnaires and deal with topics where different people have different perspectives (Cornford & Smithson 1996).

Interviews can be in a structured or in an unstructured form. In structured interviews the researcher utilize a interview guide and stick to these pre-prepared questions. Structured interviews are suitable when interviewing a large amount of persons and to be assured that all are asked the same questions (Cornford & Smithson 1996). By conducting an unstructured interview the researcher is more free to set the topics and issues to be touched, and to ask follow-up questions to gain a better understanding. In relation to the medical students, we found it most suitable to conduct an interview which was a combination of these two forms; a semi-structural interview (ibid.). By conducting a semi-structural interview we could touch the important topics and issues in all interviews, and have the possibility to go in depth on issues that were interesting. The interviews of Aabakken and e-book experts were unstructured, and rather conversations than interviews.

Interviews of medical students

Interviews were chosen to increase our knowledge and understanding of of the clinical training, and to help us focus on what to study. The medical practice is rather diverse and complex, and we wanted to gather information about the contexts of use, the student's thoughts on mobile technology, their use of information resources during the training, and on making notes in their clinical practice.

The interview draft for these interviews is enclosed in Appendix B (written in norwegian). This draft were not followed rigorously, but were meant to keep the conversation within the topics we were interested in, and to act as a guide (Cornford & Smithson 1996).

We carried through interviews of six medical students at *Rikshopitalet*[2], three that already had finished their practical term, and three which were about to start their practical training, but who all had some experience from former part time jobs. The reason for interviewing these two groups of students was to discover both the experiences and the expectations from the interviewee. Naturally, the questions were asked in a different manner, adapted to the interviewee.

Interviews as a background for the prototype

In relation to a project assignment in a seminar conducted at the University of Oslo we got in contact with Dr. med. Lars Aabakken at Rikshospitalet in Oslo. We made

[2] *Rikshospitalet i Oslo* is a university hospital located in the same area as the faculty of medicine, University in Oslo

an appointment for an unstructured interview in order to explore possible topics for this assignment. This interview gave us ideas, not only for the assignment, but also for this thesis, which is further described in chapter 4.

To explore the area of e-books and e-book technology, and to gain knowledge within the area, we carried through two unstructured interviews, with Dag Asbjørnsen at *Ebøker i Norge*[3] and Rune Remøy at *eBok.no*[4]. Asbjørnsen and Remøy are both characterized as authorities within the domain. Our outcome of these interviews were an approved understanding of the phenomenon of e-books, prospects for the e-book, e-book technology and ongoing research related to the e-book.

3.2.2 Scenarios

There are several definitions and descriptions of what a scenario is. In the context of systems development and user-interaction, Carroll (1995) describes it as a *a narrative description of what people do and experience as they try to make use of systems and applications*. Scenarios can be used for representing, analyzing and planning how users' activities and experiences should be affected by a computer system.

The Webster's dictionary defines a scenario as "an outline or synopsis of a play". But, there are also many other descriptions of what a scenario is:

- A scenario is an idealized but detailed description of a specific instance of human-computer interaction (Young & Barnard 1987).
- A scenario is a description of an activity, in narrative form (Nardi 1992).
- Scenario is an encapsulated description of an individual user interacting with a specific set of computer facilities to achieve a specific outcome under specified circumstances over a certain interval of time (Nielsen 1995).
- A scenario is a narrative that describes someone trying to do something in some environment (Karat 1995).

How the scenario is defined depends on the intent and the use of the scenario. Scenarios figure in methodologies ranging from tightly focused means to multiperson, multiyear projects (Kyng 1995).

Kristoffersen, Herstad, Ljungberg, Løbersli, Sandbakken & Thoresen (1998) suggest a scenario-based approach to design of mobile services after a brief empirical

[3] *Ebøker i Norge* is part of a larger explanation project which deals with structural changes in norwegian book industry. For more information see (in norwegian) *http://www1.his.no/ebok/index.htm*

[4] Former *eBok.no*, which at the time of writing has changed name to *CyberBook*. For more information visit: *http://www.cyberbook.no/*

investigation. Since the use of mobile services will be conducted in quite heterogenous contexts, scenarios help us finding a relevant space of problems. The scenario also help designers to early focus on the user (Nielsen 1995, Carroll 1995).

Thus, scenarios are often open-ended and fragmentary; they help developers and users pose new questions, question new answers, and to open up possibilities. Scenarios help developers and their users envision the outcomes of design (an integrated description of what the system will do and how it will do it), and thereby better manage and control these outcomes (Carroll 1995).

Between the development of our two versions of the prototype (see Chapter 4), we wrote two different scenarios. These scenarios were written in order to open up for new possibilities and ideas regarding e-books and the medical students' use of information resources. In combination with our own contextual evaluation of the mobile terminals, this helped us focus on possible and different use contexts. The scenarios produced is presented in (Gallis et al. 2001, Kasbo et al. 2001).

The scenario produced in the work with this thesis is intended to explore the field and to help us visualize how the service provided by the prototype would be used. The scenario is also made in order to examine potential possibilities and as a tool for communication between system developers and users (Carroll 1995). In our case this regarded Dr. med. Lars Aabakken.

3.2.3 Prototype

Prototyping is an activity and a method within evolutionary systems development which is utilized when there is uncertainty concerning what technology to use and what the customer's requirements are (Mathiassen, Munk-Madsen, Nielsen & Stage 1998, Sommerville 2000). Sommerville (2000) describes a prototype as *an initial version of a software system which is used to demonstrate concepts, try out design options and, generally, to find out more about the problem and problem solutions.*

Prototyping implies producing early versions of future applications, services and solutions, and in that way create a basis for discussions among groups involved in the development process (Budde, Kautz, Kuhlenkamp & Züllinghoven 1992). Another benefit of prototyping is that software development staff may find incomplete and/or inconsistent requirements as the prototype is developed (Sommerville 2000). A working, although limited, system is available quickly to demonstrate the feasibility and usefulness of the application to the management (ibid.). The prototype thus gives the users an early feeling about the future system, and misunderstandings can be solved at an early point in the process.

In Budde et al. (1992), three different prototypes are mentioned. The first is *prototype proper*, which is a preliminary working system that is developed in parallel to

the information system model. It is designed to demonstrate certain aspects of the user interface or part of the functionality.

The second type is *breadboard*. This is a prototype that helps clarify construction-related questions facing the developer team. This kind of prototype does not involve any users and is therefore a restricted form of prototyping.

A *pilot system* is the third kind of prototype Budde et al. (1992) mention. Pilot systems are implied in the application area as the core of the future system, and their increments should be geared only to user priorities.

Budde et al. (1992) also distinguish between three techniques of prototyping, which have dissimilar goals:

- *Exploratory prototyping* is an approach often used when the problem at hand is unclear. Different prototypes proper are frequently subjects for discussion.
- *Experimental prototyping* has focus on the technical implementation of a development goal. It is important that the technical problems that may arise are discussed with the users.
- *Evolutionary prototyping* is seen as a continuous process for adapting a system to rapidly changing organizational constraints.

The terms *horizontal* and *vertical* prototypes are mentioned in Hjelm (2000) and Budde et al. (1992). In horizontal prototyping different layers of the application is developed, and the level of functionality is reduced (Hjelm 2000). According to Budde et al. (1992) horizontal prototyping is in the literature referred to as developing user interface.

In vertical prototypes the number of features of an application are reduced and the full functionality of those chosen is implemented (Hjelm 2000). This is an appropriate technique when the functionality of the system still is uncertain (Budde et al. 1992).

In this thesis we chose to utilize prototyping because prototyping is suitable for demonstrating concepts, to explore the problem and possible solutions. The working prototype should be quickly available and employed in the practical training, and demonstrate the feasibility and usefulness of the application to researchers in the Knowmobile project and to ourselves.

We wanted to test a service specialized for the medical student's practical training in order to discover several aspects within use of hand-held terminals and mobile information services as a supplement to the information resources available today. Thus, usability engineering which Nielsen (1994) defines, and design of user interfaces are not focused in this prototype.

Based on the theory of prototyping presented above, our prototype is a pilot system and we have followed a kind of exploratory prototyping. Our prototype is neither a horizontal or vertical prototype in a strict sense. We chose a trade-off between those two to provide a complete (all content implemented) service with sufficient functionality.

The development of the prototype went through two phases. One where we explored the area of cross publishing, tools and techniques, and one where we focused on the product to be delivered and employed. We refer to chapter 4 for a thoroughly description of our prototype and the process of development.

3.2.4 Contextual inquiry

Contextual Inquiry (CI) is based on ethnography and sociological research tradition where the researcher/observer goes into the research object's own environment (Beyer & Holtzblatt 1998). The observers observe the potential users of the developed product for a period of time, typically some hours. The observer stays in the background for most of the time, but also inquires about events that are not obvious but may be significant regarding the focus of the research (Väänänen-Vainio-Mattila & Ruuska 1998). CI is an explicit step for understanding who the customer really are and how they work day to day (Beyer & Holtzblatt 1999). A contextual interviewer observes users as they work and asks about the users' actions step by step to understand their motivations and strategy.

In addition to notes from the observations and inquiries, work products as data sheets, notes and other artifacts from the environment can be collected. These artifacts are collected for later reference about the user's specific tasks and work practices (Väänänen-Vainio-Mattila & Ruuska 1998).

Väänänen-Vainio-Mattila & Ruuska (1998) reports that CI is successful in use of developing mobile communication units at Nokia. Our CI has not been concerning development of a service, but research on how information resources are used, and particularly how our prototype and the pre-installed notepad, the PDA and mobile services are utilized. Our analysis is more extensive than what would be necessary in a system development process. But anyway, we think it is appropriate as a qualitative approach.

Accomplishment of the contextual inquiries We carried through CI at Sentralsykehuset i Vestfold (SiV), Nedre Eiker Legesenter (NEL) and at Gulskogen Legesenter (Gulskogen). Prior to the CI, we developed a data collection procedure describing the focus of CI, and sent this to SiV, NEL and Gulskogen. The data collection procedure enclosed (see Appendix C), describes the procedure at SiV.

The focus in the contextual inquiries is described in the data collection procedure, and the focus was the same as in all inquiries. Naturally, we made some adoptions

when inquiring the traveling context, because the environment of the student was quite different from the clinical contexts.

During the contextual inquiries we asked questions concerning work, tasks and other issues of interest. These questions were based on the situation we observed, and they were asked either during the activity, or later, when we found it proper. It was important to us not to disturb the student in accomplishing a task.

Subsequent to our contextual inquiries, we wrote reports on our empirical findings, and these reports were distributed to researchers and master students in Knowmobile[5].

3.2.5 Cross-case analysis

Cross-case analysis is a method for categorizing and analyzing data (Patton 1990). All data and material collected are analyzed by a group consisting of system developers and the researchers responsible for the data collection.

In cross-case analysis the observations of the different research objects are categorized in order to analyze perspectives and issues concerning the problem area and the area of use[6]. The observations are grouped in subjects or themes (Patton 1990).

We chose to use a cross-case analysis in order to achieve a general understanding of the use of information resources and which factors affecting the use of information resources and the mobile terminal serving as an information resource. Our goal was not to identify individual differences between medical students and their use. We have through the cross-case analysis compiled our observations and the collected data through interviews, and in this way made a basis for further analysis and discussion.

The results of the cross-case analysis were presented for the research group in the Knowmobile project November 27th, 2001.

[5]The reports presenting our findings from our contextual inquiries can be found at: www.ifi.uio.no/~jarlek/knowmobile/documents.php3

[6]Here we refer to the problem area and the area of use as the terms 'problemområde' and 'anvendelsesområde' which are defined in Mathiassen et al. (1998) page 10-11

Chapter 4

Prototype

THIS *chapter presents the prototype of an e-book we developed and which was used by the medical students during the Knowmobile project. We made two versions of the prototype, and they are both described here.*

We have developed the prototype described in two phases, which resulted in two slightly different versions. The first prototype[1] focused on exploring the area of cross-publishing (See Section 4.3.1). The second prototype was intended to be a service to be implemented in the Knowmobile project, a more complete service which was usable in the medical students' clinical practice (See Section 4.4). The second prototype is emphasized, but we give a brief description of the first as well, because the second are developed based on the first.

4.1 The background for the prototype

The initiative of our prototype was inspired by Dr.med Lars Aabakken at Rikshospitalet, Oslo. We contacted Aabakken during a seminar at Institute for Informatics, University of Oslo, to get some ideas for an assignment related to the seminar. As long as we already were involved in the Knowmobile project, we were interested in issues concerning medical students in their practical training. Aabakken had experienced some issues that could be problematic for the students in their training; lack of access to the needed information in training *when* and *where* they needed it. Aabakken said that the medical students are frequently in need of information related to issues concerning tasks to fulfill or issues they meet. To solve this problem, students fill their pockets with medical handbooks, extracts from medical literature and other information resources, and they carry these artifacts during the whole day of training. Aabakken mentioned that carrying these artifacts, in addition to other

[1]The first version was developed in collaboration with Marit Andreassen and Anders Breivik in relation to the INF-Mobi seminar, Spring 2001

medical equipment, such as a stethoscope, note books, personal pager and pens, are heavy and quite annoying to have in their pockets. When we carried through interviews with six medical students, they confirmed that these issues existed.

We agreed to make a prototype based on *Metodebok for turnusleger* by Lars Aabakken and associates (Aabakken, Lyseggen & Røttingen 1998) (see Figure 4.1), and we received a MS Word document with the content and presentation of this handbook.

Figure 4.1: The original paper-based version of *Metodebok for Turnusleger.*

Intention of the prototype

The intention of the first version was based on the idea to provide a service for the medical students in their practical training by making one of the medical handbooks accessible on handheld devices, desktops and laptops so that students could access information from multiple devices; either stationary or portable (cross-publishing). In this way, the information could be accessible *anywhere* and *anytime*. This version was never intended to be released in the Knowmobile project, only developed in order to explore the possibilities of cross-publishing, to be able to determine the best platform for accessing the electronic version of the handbook, and to broaden our view concerning possibilities for mobile services in the medical students' clinical practice.

The intention of the final version had several aspects:

- To provide a service for the medical students in their practical training by making one of the medical handbooks accessible on handheld devices.
- To study through contextual inquiries how such a service is utilized in the clinical training, both as a single service and among other information resources.

- Through this study shed light on the use of mobile services and information resources in the clinical training in general.
- To discover characteristics of contexts and situations appropriate for use of a mobile information resource,
- and thereby obtain ideas of other new useful services.
- To discover conditions of use of such a service in the clinical training.

The intention was not to evaluate the prototype itself. Other master students in the Knowmobile project have been focusing on usability engineering and usability tests related to the mobile terminals and its services, which includes our prototype. Usefulness (Lindgaard 1994) is a term suggested incorporated into the definition of usability, which concerns with meeting users' need by covering specific tasks. We refer our intent of the prototype to usefulness.

4.2 About the book

Metodebok for Turnusleger is a handbook describing routines and procedures within several medical areas. The book is frequently utilized by physicians and students in their practical work and training, and others which have need for this kind information. The handbook is mainly a reference book and is useful to bring during the day of work. Even though physicians also are users of the book, our target group for the service is the medical students in their practical term.

Metodebok for Turnusleger starts with a table of contents, to be followed by forewords, before medical issues are described through 20 chapters. Keywords are listed in an alphabetical register (index) in the end of the book.

The handbook is structured based on medical areas; Heart/blood-vessel and Stomach/intestine e.g. Each chapter can be divided into three areas: Journal, Symptoms, and Procedures. These areas have no technical differences, only by content. Each area is divided in different themes. A generic structure of the chapters is shown in figure 4.2.

4.3 Technical Solutions

4.3.1 Cross Publishing

As mentioned in Section 4.1, the initial version is a solution for cross publishing on several devices and in several formats[2].

[2]For further reading of this first prototype, we refer to the project report *XML-based cross publishing* (in Norwegian) which can be downloaded from: http://www.stud.ifi.uio.no/~ jarlek/mobi/prosjektrapport.pdf

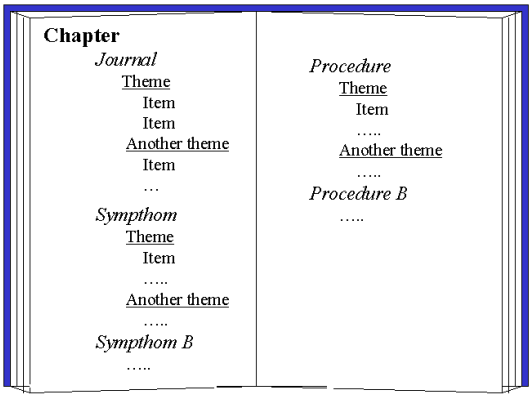


Figure 4.2: The generic structure in *Metodebok for Turnusleger*

To do this, we decided to focus on an extract from *Metodebok for turnusleger*, and we identified the chapter of *Stomach/Intestine* to be suitable for our exploration. This chapter was chosen on the basis that it is well structured, and has less figures, images and tables than the other chapters in the handbook. The structure in this current chapter is shown in figure 4.3.

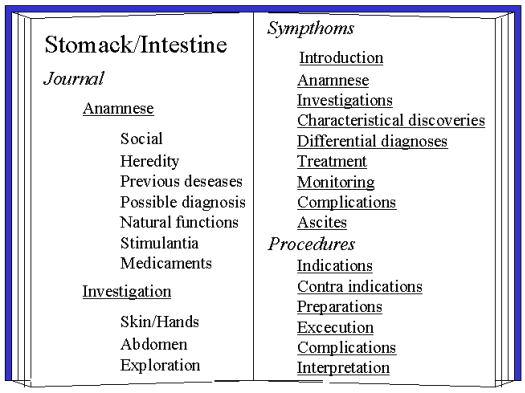


Figure 4.3: The structure of the chapter *Stomach/Intestine*

In collaboration with Aabakken we identified on which terminals the chapter should be available. These terminals were chosen based on what most hospitals and general practitioners offices provide, and on what students have access to personally. The terminals chosen differ in technical characteristics, such as screen size, storage capacity and input procedures, and do differ in ability to handle file formats and complexity concerning layout. We had to have these issues in mind when designing and developing this first prototype. Table 4.1 shows the terminals chosen, what kind of file format we assigned to the terminal, and what applications needed to

utilize the prototype.

Terminal	File format	Application	Net Access
Desktop & Laptop	HTML	Web browser	Online/Off-line
PDA	AvantGo[3] e-book	Web browser e-book reader	Off-line Off-line
Mobile phone	WML	WAP browser	Online

Table 4.1: The terminals and file formats focused on in the first prototype.

A possible solution by XML-based cross publishing

An application, especially a browser-based application like an information service, consists of three parts: *The semantic layer*, which holds the content, *the syntax layer*, which concerns the structure of the information and creates the user's sequence of interaction with the information (the grammar of the language for interaction with the site), and *the lexical layer*, where the semantic and syntactic information is further refined to concrete data types that have to be provided for interaction (audio, video, spatial, and so on) (Hjelm 2000).

Related to the XML environment, the semantic layer correspond to the XML file, which holds the content, the syntax layer correspond to the DTD, and the lexical layer to the XSL file.

XML is a way of making sure that all data follows the same rules. We declare what elements we are using in the document type description (DTD), and what types of data the elements will contain. Now that the content is declared and structured valid to XML, and we can start think about how to present this information into different types of terminals.

We used XSL (XML Style Language) for the presentation on all the devices. The XML and DTD for the current chapter could be constant, only the XSL had to be modified for the various devices, so that the presentation were customized to the screen size, memory and processing capacity. In terms of resizing, reformatting and reformulating, we reformatted for Web and PDAs (e-book and AvantGo), while reformulating for WAP because of the limitations of the terminal.

Implementation

We worked out a model of a XML processor which illustrates our approach (figure 4.4). The circles in this model illustrates different file-formats which is used or generated during the process. To present the information on different types of terminals the three files XML, DTD and XSL are combined. Each terminal will have an according XSL-file which determine how the information should be presented.

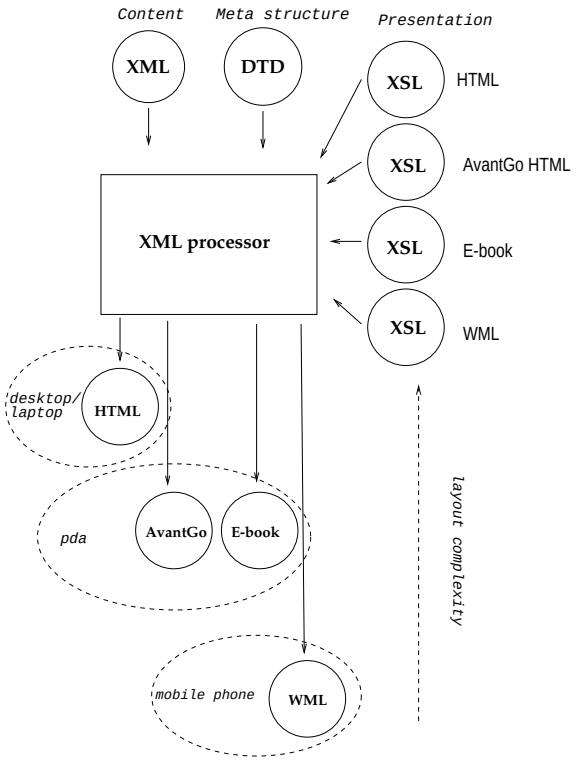


Figure 4.4: A graphical presentation of our approach

There are several processors existing which validates XML, XSL and DTD files and generates the desired output. Developing our own processor related to this prototype was beyond our scope. Therefore we utilized an XML editor from Wattle Software (XMLWriter)[4].

The output from XMLWriter are an HTML file. In order to generate an e-book[5] file from HTML, we utilized Microsoft's ReaderWorks. WML was not supported by XMLWriter, and some changes in the HTML file heading by hand was required.

We received a Ms (Microsoft) Word document of *Metodebok for turnusleger* from Aabakken, and used the XMLWriter to produce the XML, XSL and DTD files and validate them according to Figure 4.4. Then XMLWriter transformed the XML files to three different HTML files. One for desktops and laptops, one for PDAs and one for WAP. Then we used Ms ReaderWorks to generate the e-book file, and made those small changes to get a valid WML file for WAP. Figure 4.5 shows samples of the result on a desktop computer, a PDA and on a mobile phone.

[4] http://xmlwriter.net/

[5] The data file format for e-books depends on what kind of tool that is utilized for developing the e-book, and what kind of e-book reader that is used.

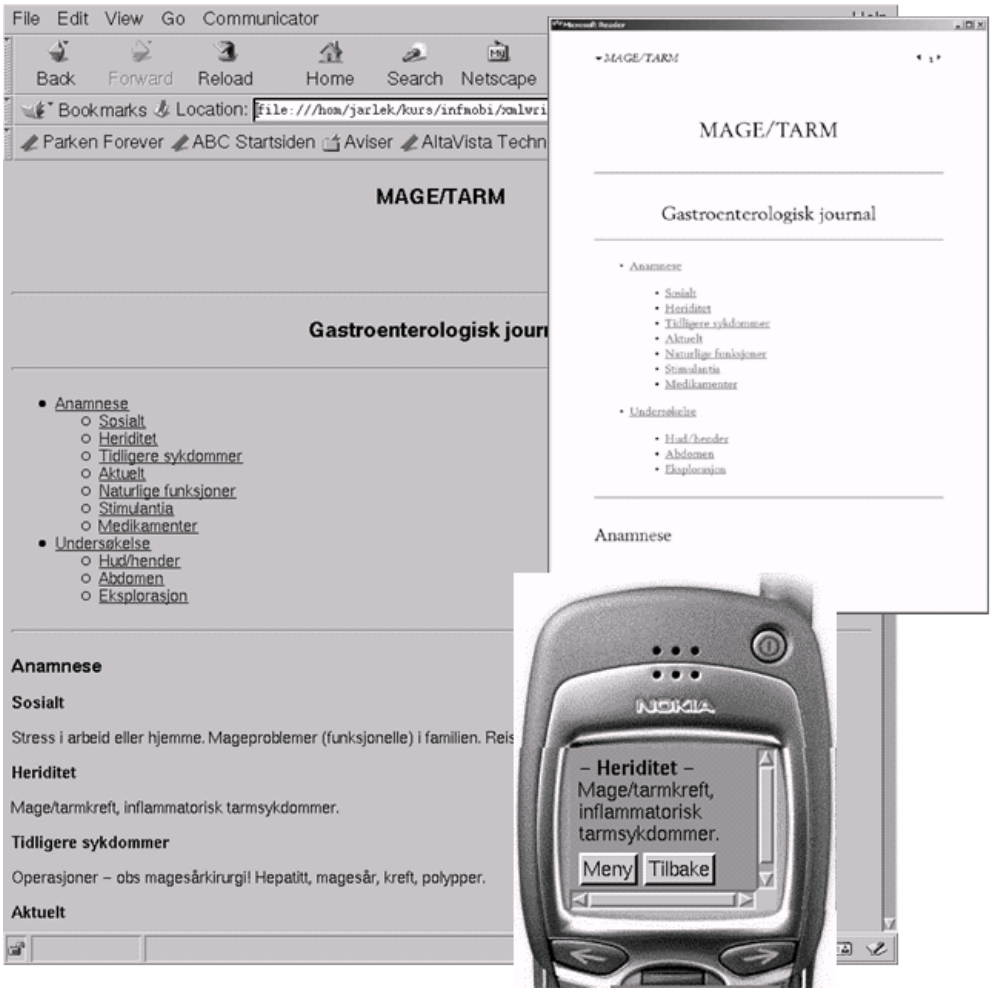


Figure 4.5: Samples of the prototype on desktop, PDA and on mobile phone

4.3.2 Demonstration

When we had generated the output files, we installed them on their respective terminals. The prototype was tested on the terminals in order to discover display errors and errors concerning linkage between cards in the WAP version.

When the testing was satisfactory accomplished, we had a presentation of the prototype for Aabakken. The presentation was conducted by showing him all versions of *Metodebok for turnusleger* on different terminals. After a short demonstration, he tried the different versions out.

Based on this presentation and the following discussion with Aabakken, we concluded that the most suitable solution - if we only should develop one further - had

to be either the e-book or the AvantGo version. The conclusion is based on the following arguments:

- The HTML version for desktops and laptops are already available on the web pages of Legeforeningen, and offer functionality in navigation in the document. The lack of the desktop's terminal mobility and the fact that laptops rarely are available for the medical students in their training, makes this version less suitable for our purpose.
- The WML version for WAP was not good enough because of the limited screen size, the processing capacity and because of low bandwidth. Connecting to a WAP site took approx. 90 second, and this time aspect makes the WAP version disqualified in order to be "just-in time".
- The AvantGo version, which is implemented on a PDA is more suitable because of the characteristics of the PDA compared to a WAP enabled phone, especially the screen. But, AvantGo does not provide division into pages and it does not support tables. The readability was also inferior the e-book version. Using AvantGo, the document can be accessed off-line.
- The e-book divides the document into pages, and enables navigation through the e-book reader application. The readability is superior to the AvantGo version, but tables are not supported. Using an e-book does not require any network connection.

Based on these arguments, we found the e-book version most suitable for our intent for the final prototype.

4.3.3 e-book

According to Hillesund (2001) an e-book refers to digital objects specially made to be read with reading applications operating on either a handheld device or a personal computer. Lekvam (2001) specifies the definition by adding that an e-book is the digital version of what is generally defined as a book. Based on this addition the term e-book is narrowed. Documents which are not originally books, are not e-books when transformed to an electronic version.

E-books have also been defined due to the physical appliance which is the bearer of the content, both dedicated e-book readers and multi-purpose devices. Lekvam (2001) stick to a definition which embrace both the content and the physical appliance: "an e-book is a digital text-file which contains the digital version of a book, and which can be read on a mobile screen[6]". This is the definition we will refer to throughout the rest of the thesis.

[6]Translated from norwegian

Based on these definitions, our prototype, which is a medical handbook installed on a mobile terminal and read with a reading application, is truly an e-book.

Figure 4.6 is showing the e-book architecture. The “artifact” is the physical appliance which holds the book. The “application” is the program installed on the PDA which enables the e-book to be read. The “content” is the e-book itself with all its content. The application and the content are together constituting the presentation of the e-book.

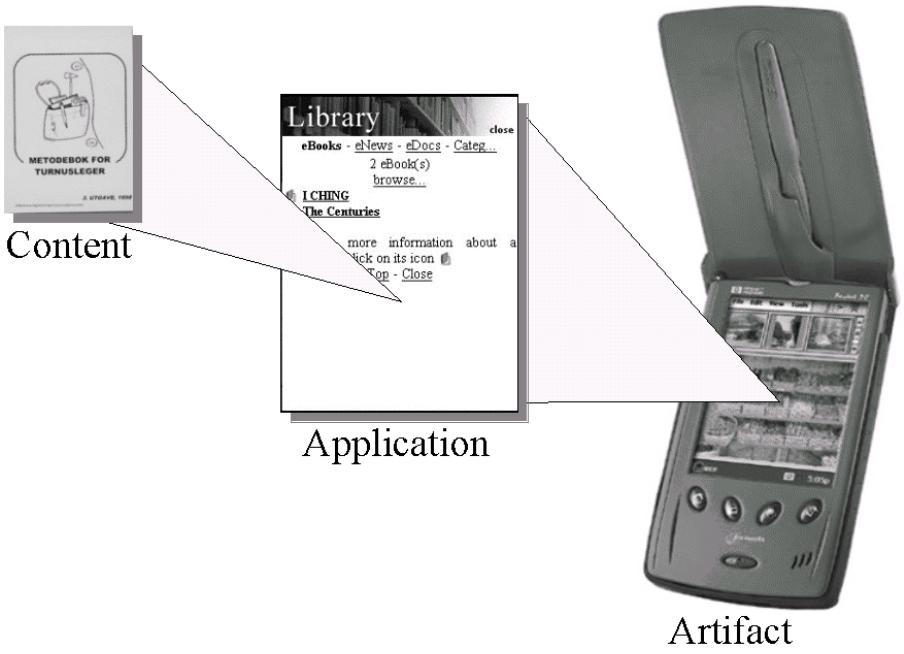


Figure 4.6: The e-book architecture

4.3.4 Final Prototype

The second, final prototype is an e-book version of *Metodebok for turnusleger* where the content is identical to the paper-based book. To ease the searching for chapters, paragraphs and words we added functionality to the e-book version. In addition to our intents of the study, an intention of this service was to provide an alternative to the paper-based book in the practical training (See 4.1). Because carrying the handbook in the coat can be inconvenient, and the students hopefully would bring the PDA in any case, this service could ease the load of their coats.

When we developed this prototype, we had short interactions and just-in-time access to the e-book in mind. We thought the PDA would be a good tool for this kind of ’fast’ use, especially in the hospital and the GP office.

We chose not to utilize XML for this prototype, partly because of lack of skills and partly because of lack of time and tools for automatically tagging to XML. To manually transform the entire book into XML is a rather complex and time consuming activity. We had experience in doing this from our first prototype and realized that we were not able to do this in the final version.

To build the e-book we used Ms Word and the Word-document as a basis. First we extracted chapter titles and paragraphs in the chapters and made a chapter page for each chapter. Then we manually made links between the titles to the respective chapter or paragraph (see Figure 4.7 C). We linked all indexed words to their respective words in the text (see Figure 4.7 D which shows the link to the section of words that starts with the letter of the link). The table of contents in the paper-based version consists of both chapter titles and paragraph titles and these were also linked. We kept this table of contents, but made another which contained only the chapter titles which we called *Overview* (see Figure 4.7 B). These chapter titles were linked directly to the chapter pages and there were a link to the alphabetical index. On each chapter page there were links to the previous chapter, to the next chapter and to the overview, as well as to each paragraph in the current chapter (see Figure 4.7 C). Each paragraph title was a link back to the chapter page of the chapter that contained this paragraph.

Figure 4.7 A shows the first page of the e-book, and Figure 4.7 E is a picture showing the menu in the reader application (mentioned below).

We planned to utilize Microsoft's Reader Works to generate the e-book file from the HTML file made by Ms Word, then synchronize this file with the PDA and read the file with Ms Reader which was pre-installed on the PDA.

During the development we generated the e-book file just as a test, synchronized and read the e-book on the PDA, and everything seemed OK. But, when we were about to finish and carried through the last test synchronization, Ms Reader was not able to read the file. A lot of error handling were done, but at last we had to give up and use another e-book reader; Mobipocket. Ms Reader and Mobipocket differ slightly in functionality and appearance, but this is not significant for the accomplishment of our study. So we continued using the Mobipocket generator and reader, and finished the prototype successfully.

A problem we encountered was that neither Ms Reader or Mobipocket supports tables, and *Metodebok for turnusleger* contains several tables. So, we had to transform all the tables to pictures and include them manually. The result of this was rather small tables which could be hard to read.

A user manual for MobiPocket and the e-book version of *Metodebok for turnusleger* was written and added to the e-book library on the terminals.

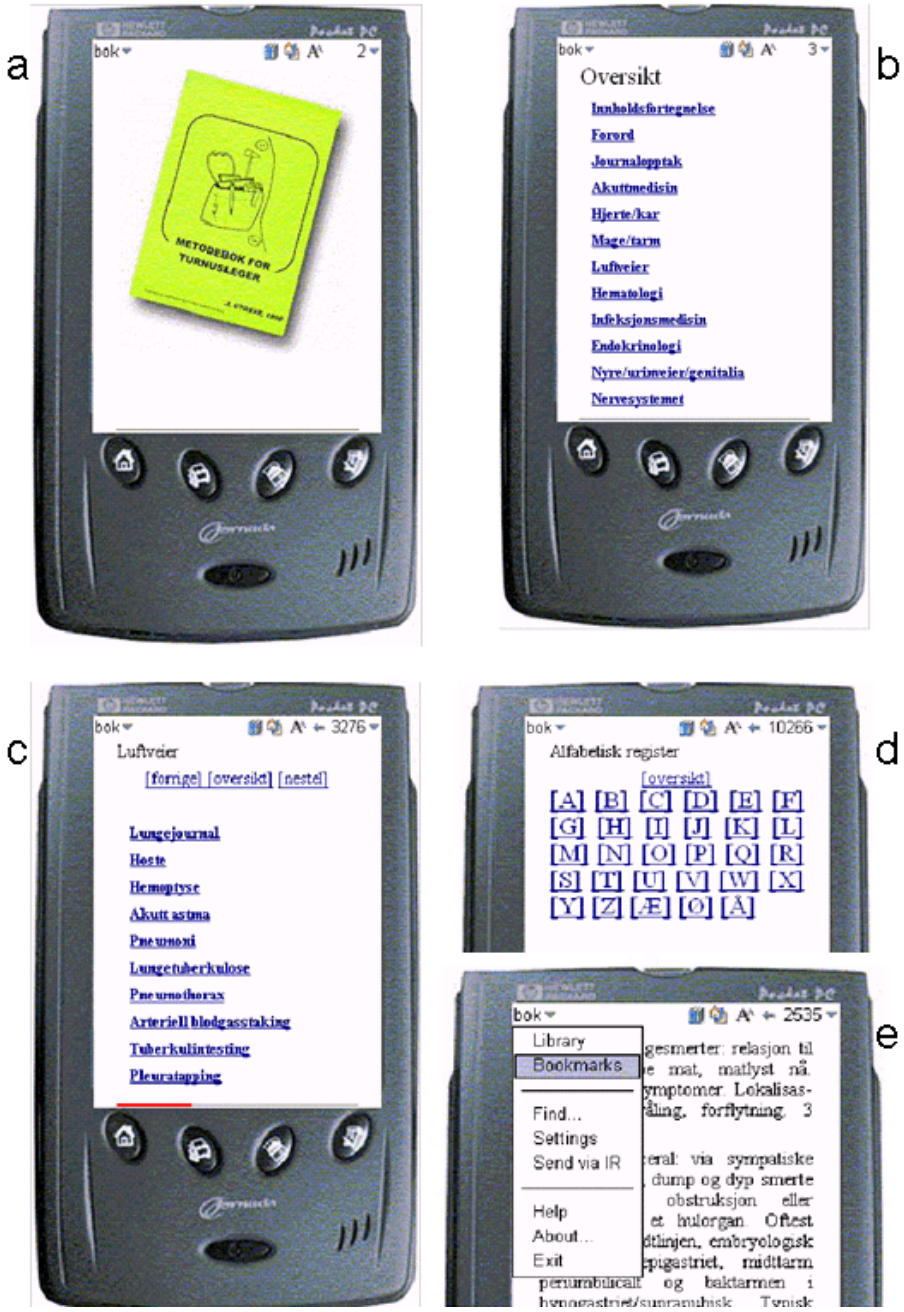


Figure 4.7: Extracts of the content of the e-book *Metodebok for turnusleger*

4.4 Final remarks

During the process of development, we used a Ms Word document to generate the files for both the first and final version of the prototype. This document was

easy to change, and there could easily have occurred accidental changes to the document, for instance when creating links. The information we handled is rather critical because it is used in relation to treatments of patients and to make diagnosis. A change in the content could have had given inconvinient results. Our process of generating an e-book is a subject of criticism because we did not make any precautions for not changing the content, and the content was not verified after the process.

Chapter 5

Theoretical approach

THIS *chapter presents the theory, which together with our empirical observations, make up the foundation for the analysis and discussion. The goal of this chapter is to build a theoretical framework which can explain our empirical findings. Parts of the theory was also used as a starting point for our field studies, and thus it helped us to find out what to focus on.*

5.1 Artifacts

Artifacts are:

> *Any object made by man, esp. with a view to subsequent use.*
>
> — Definition 1 of 'artifact' in Webster's Encyclopedic Unabridged Dictionary

In Chapter 4 we presented our prototype; an e-book, which can be used on the PDA. A PDA, paper-based handbook and notepad are all made by humans and they have a certain meaning to us. They are artifacts.

In the article "*En vetenskap om artefakter*", Dahlbom (1993) refers to Herbert Simons' definition of an artifact[1]. Simon says that an artifact can be recognized as the interface between the inner part (substance and structure) of the artifact and its environment. We see substance and structure of the artifact as the same as what Brown & Duguid (1994) call *the canonical artifact*. The canonical artifact is the artifact in its simplest physical form. Dahlbom (1993) states further that artifacts do not only have functionality, but also quality. An artifact's functionality is not equivalent with its use value.

[1] Herbert Simons' book called "The Sciences of the Artificial" (1969) is the source to the definition.

5.1.1 Borderline issues

The concept of an artifact with interfaces (Dahlbom 1993) is almost identical to Brown & Duguid's (1994) concept of an artifact's *border resources*. Brown & Duguid (1994) distinguish between the canonical artifact and its resources. An artifact's resources are the possibilities humans have to utilize the artifact. What kind of resources that are essential to people depends on the person's relation to the artifact and the context in which it is used. Brown & Duguid (1994) gives an example with a machine: For most people the noise of the machine is something they want to avoid as much as possible. But, for a mechanic the noise could be essential when searching for errors. The noise is therefore a resource for the mechanic. An artifact's resources could *peripheral* for some users, but the very same resources could be *central* for others (Brown & Duguid 1994). As the example above show, the noise was a central resource for the mechanic. A peripheral resource for a person can also be swept to the central and vice versa. According to Brown & Duguid (1994) this occurs when attention, perspective, or practice changes. When driving a car the noise of the engine is a peripheral resource. But, when the engine starts to sound strange, the noise is suddenly a central resource of the engine.

Resources can be of both physical and social type. A socially established resource can be as important as the artifact's physical characters. If a designer's starting point is an artifact, there are many important considerations involved. Brown & Duguid (1994) say that designers have to draw the lines of what is important or not when developing a new product. This border is the part where the center and the peripheral resources meets. Resources inside the border is called *border resources* (ibid.). The difference between a peripheral resource and a border resource is to which extent the resource are socially shared or not. A peripheral resource are more individual. Figure 5.1 illustrates an artifact's peripheral and border resources, and Brown & Duguid (1994) explains this in the following way:

> *The border comprises those aspects of an artifact and its periphery that are available to each person involved in a particular interaction with that artifact. Border resources are those resources that are socially shared.*
>
> — (Brown & Duguid 1994, page 8)

5.1.2 The power of paper

Braa & Sandahl (2000) state that there is no clear interpretation of what should be seen as a central part of the artifact, and what is in the periphery. Paper is used in many different settings and in many different tasks. Paper also builds up the artifact we call a book. Paper is made by humans and in this way it is an artifact in itself. The medical students use information resources to educate themselves, or to

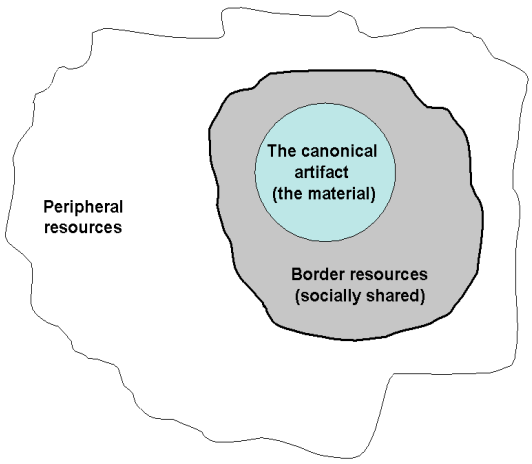


Figure 5.1: The canonical artifact is surrounded by border resources, resources that are socially shared. In the periphery we find the resources that are not socially shared, but more tied to individuals. The figure is based upon a similar from Haugset (2001, page 20).

just update themselves. Paper has thus a central function in the students learning process to become doctors.

Braa & Sandahl (2000) points to the fact that paper is “tangible, flexible, and light”. This has implications for the ease with which it can be physically transported, manipulated and laid out in space (Braa & Sandahl 2000). Paper can for example be applied in discussions with colleagues, which Luff & Heath (1998) call *micro mobility*. A person can bring a document to another room or department and show and discuss the document with others. Micro mobility can be seen as a paper’s resource which make collaboration possible. Micro mobility is the way in which an artifact can be manipulated and used for different purposes inside a geographical area (Luff & Heath 1998). Mollerup (2001) points to paper and books as collapsibles. One of their strong border resource is that both paper and a book has the ability of repeated transformation between expanded and compacted (ibid.). When compacted they are portable, and when expanded they give a good overview. One example of this would be the city map, which often can be folded many times and thus become very small. But, when unfolded they are extensive and can give you an good overview.

Because of the paper’s strong characteristics, a transformation from paper to digital format is not easy. There are several studies in the literature that show this. One example is from Braa & Sandahl (2000), where a news agency tried to transfer a paper-based construction of the TV-guide to a digital format (SGML). A short explanation for the misfit is that the designers did not think the artifact was more important than the content (Braa & Sandahl 2000, Sandahl 1999). In this way

they emphasized the content and forgot the artifact as an border resource in itself. Brown & Duguid (1994) would state that the *genre* was not preserved. A whole new genre was created during the transformation from paper to digital. Genres are socially constructed interpretive conventions that bridge the addresser and the recipient. (ibid.).

5.1.3 Genres and border conventions

People communicate through different artifacts. We can choose whether we want to communicate through a phone, a handwritten note, e-mail, SMS, memo, or formal letter (Brown & Duguid 1996). Those different genres will have quite different significance for the recipient. In choosing one or another genre, the same words (or the content) will give a quite different meaning for the recipient. Those differences arise, among other things, because of the border resources. Changing the border can also change the genre (Brown & Duguid 1994). Getting the border right, both designers and users, is essential to good communication. Genres is, according to Brown & Duguid (1996), an important concept in software design for three reasons:

1. genres engage socially shared knowledge
2. understanding genres is crucially important to deal with the demands of the information age
3. new technology requires new genres

Brown & Duguid (1994) use texts to show that something as simple as a paper-note with information is interpreted differently depending on the context. When such a simple artifact can be interpreted different, they assume that the same regard other artifacts as well. All kinds of artifacts should give the user hints on how to interpret it right. That is, to show the user the artifact's genre. Graphical designers, for instance, use different materials, colors, shapes, volumes, light, and so on, to appeal to different users' interests and conventions. The different borders set up different expectations. Books, for example, are sold with very different covers, and the user or reader can usually judge some things about just the cover of the book. In this way the artifact itself defines in which way it want to be interpreted. Or more specific, which genre it is. Brown & Duguid (1994) call this the artifact's *portable context*. A product designer works on the border to address and engage a particular market segment.

Under what conditions do the border develop into a resource? Brown & Duguid (1994) state that the border develops under two conditions: A material part and a social part, or *continuity* and *community* are essential to this development. The

process needs recognizable continuity on one hand, and on the other hand it requires a community whose members share, recognize, and over time reformulate conventions collectively. To be turned into a border resource, the artifact's resources have to be constant across time and space. This is, according to Brown & Duguid (1994), the essence of the term continuity. If book covers were optional and changed sporadically, they would be unable to play their interpretative role. Its genre would not be the same if those border resources were removed. This implies that when only central features or functionality are considered, the changes in technological form or media will be unproblematic (ibid.).

5.2 Community of practice

The usefulness of the border relies heavily on the continuity, and continuity, in its turn, relies on the relative stability of artifacts and the communities that use them (Brown & Duguid 1994). Different *communities* use artifacts differently. Brown & Duguid (1994) states that it is important that the artifact, its border, genres, and its uses are understood by its actual users. What designers need to know, is then the social extent of an artifact's use and conventions (ibid.). This involves identifying what Wenger (1998) calls *the community of practice*.

> *The community of practice is that level of the social world at which practice is common, coordinated and reproduced, at which significance is created, and consequently, in which the border is socially recognized and generic conventions are developed and shared.*
>
> — (Brown & Duguid 1994, page 20)

A community of practice is characterized by three factor according to Wenger (1998): mutual engagement, joint enterprise, and a shared repertoire. Communities of practice exists everywhere (Wenger 1998), and in relation to communities artifacts play analytically distinct roles (Brown & Duguid 1994). They can mediate relations within a community and mediate relations and coordinate activities among communities. Brown & Duguid (1994) states that:

> *Artifacts that cross the boundaries among communities need to be understood both internally, that is, in terms of the role they play within a community, and externally, in terms of the way they mediate (and occasionally mask) relations among communities.*
>
> — (Brown & Duguid 1994, page 20)

Members of a community of practice have common interests, shared practices and common ways of understanding artifacts, work routines and languages (Wenger

1998). They discuss, they share experience, and they learn from each other during the tasks they carry out together. Their work is, in one way or another, often linked to others work. In this way they have a common understanding of their work and work situation.

5.2.1 Task chains

In his article about integration of computing work and routine work, Gasser (1986) states that work is often a sequential part of a chain of tasks. A task might be dependent upon others tasks, or it might be dependent upon another task. In this way the task chains intersect and must thus be co-ordinated for the production of work.

> *In any particular instance, the precise structure of the task chain is unpredictable, because it depends upon the contingencies of the work process, including intersecting task chains.*
>
> — (Gasser 1986, page 28)

A complex, co-ordinated structure of intersecting task chains is called *production lattices*. Each production lattices has some elements of its basic structure that are stable and routine based. This gives the organizational work and production its stability (Gasser 1986).

Work is a contingent process and is dependent upon the consistent alignment of resources and commitments in the workplace (Gasser 1986). Those resources may be misaligned with the demands for work in three ways. They may be oversupplied, undersupplied, or qualitative misaligned (ibid.). Gasser (1986) says that "misalignment is assessed with the relation to both (1) the resource requirements of the task, and (2) the conventions under which key participants expect that task to be performed." When resources are oversupplied, there is a *slack* in the resource supply. And resource *slip* is the undersupply or qualitative misalignment of resources needed or expected for carrying out a task. According to Gasser (1986) slip may occur:

> *... in any resource dimensions in the work situation, such as when there is too little time, technology, budget, attention, etc., or when the quality of resources is inappropriate, such as when data representations do not precisely reflect shop conditions.*
>
> — (Gasser 1986, page 30)

When slip or slack occurs, Gasser (1986) state that there is a misfit between the resources needed to support the work and the intended work.

When slip occurs people tend to choose among three strategies for accommodation to the error (Gasser 1986):

- *Fitting*, which is the activity of changing computing or the structure of work to accommodate for computing misfit.
- *Augmenting work*, which is to undertake additional work to make up for misfit.
- *Working around*. which is to use computing in ways for which it was not designed, or avoiding its use and rely on alternative means for accomplishing work.

5.3 Mobile IT and mobility

Brown & Duguid (1994) states that a document has two main qualities, immutability and mobility, which is important to what is recognized as a document. Mobility allows documents to communicate easily across space and in a variety of circumstances, and immutability allows them to survive both space and time unchanged (ibid.). Paper, documents, books, notepads are immutable and mobile artifacts. But, they are dependent upon the humans mobile nature to move around. In the following we will explain what mobility and mobile mean in the area of IT.

5.3.1 Mobile informatics

> *Rather than going on about "developing information systems" we are defining our discipline in terms of "using information technology", and when that use is focusing more and more on mobile IT support, we find ourselves doing "mobile informatics".*
>
> — (Dahlbom & Ljungberg 1999, page finnbibliotek)

The field of mobile informatics is a relatively new field within the area of informatics. The research agenda was introduced by Kristoffersen et al. (1998) in order to deal with the aspects of mobile computing concerning linkage of technical requirements in mobile computing with the particular needs of the users in the broader context of mobile work. The case of Mobile Informatics is to explore the possibilities of new and innovative concepts of *how* IT could be used in mobile work and and leisure activities, thus not only the technical aspects (Kristoffersen

& Ljungberg 1999*b*). Mobile informatics implies a focus on the activity within which people are engaged (ibid.).

Kristoffersen & Ljungberg (1999*b*) states that Mobile Informatics is an attempt to establish an applied research field concerned with new applications for mobile settings. The objective is to explore, design and evaluate innovative ways of *using* IT in these settings (Kristoffersen & Ljungberg 1999*b*), and to explore services and concepts of mobile IT use (Dahlbom & Ljungberg 1999).

5.3.2 Mobile IT use

The model of mobile IT use presented in Kristoffersen & Ljungberg (1999*c*) gives an explanation of what the term implies. The focus of the model is the situation in which a mobile person use IT (Kristoffersen & Ljungberg 1999*c*). This model is also reflecting the ways in which using IT in mobile settings differs from using IT in stationary settings (ibid.). The model of mobile IT use is shown in Figure 5.2. Mobile IT use always takes place in an environment (Kristoffersen &

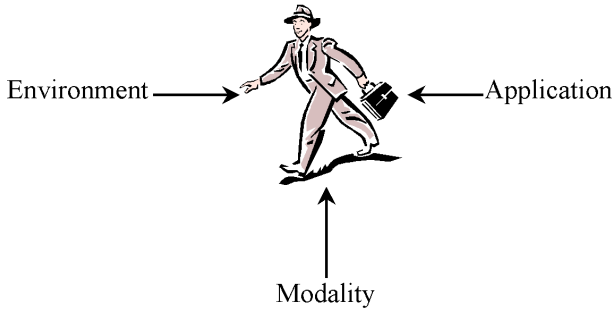


Figure 5.2: Model of mobile IT use.
(Source: Kristoffersen & Ljungberg (1999b), page 279)

Ljungberg 1999*c*). The environment is either a physical environment consisting of the observable, physical surrounding of the use situation, or social environment. The physical environment is for a train commuter the chairs, tables etc. of the railroad car, The social environment or surroundings are factors such as formal structures and rules, and informal structures (ibid.).

Medical students, as for everybody else, seldom execute all their tasks at one specific place. They use different devices depending on place, time and context. Modality is the fundamental pattern of motion of an activity (Kristoffersen & Ljungberg 1998). The three archetypes of modality are: wandering, traveling and visiting (see Figure 5.3). (Kristoffersen & Ljungberg 1998, Dahlbom & Ljungberg 1999). *Wandering* is an activity characterized by extensive local mobility as for example when walking around in a building (e.g. short trips to the water

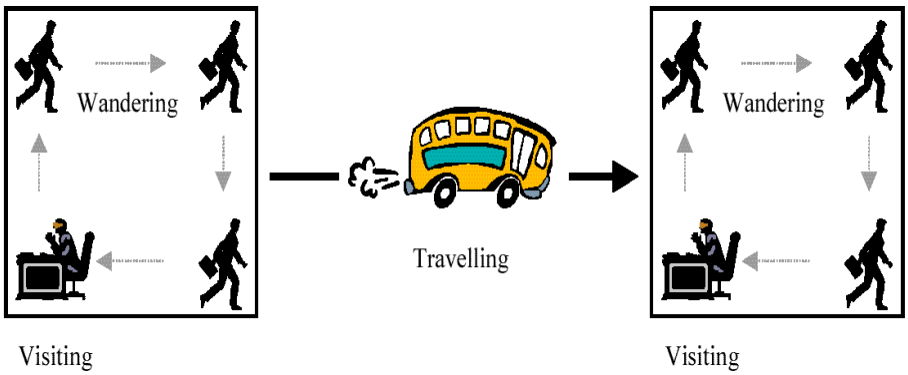


Figure 5.3: Types of modalities: traveling, visiting and wandering

dispenser or copier, visits to other offices, etc.) *Traveling* is moving from one place to another in a vehicle, while *visiting* is an activity that occurs when a person stays at a place for a coherent but temporal period of time. An example of visiting is a consultant, who spends a few days in a client's organization and thus use IT there.

The technological part of mobile IT use is by Kristoffersen & Ljungberg (1999*c*) called application. The three components of the application are technology, data and program. *Technology* is the carrying platform, or medium of the application. Technologies involved in mobile IT use may be stationary (desktop), movable (laptop) or portable (PDA). *Data* is the second part of the application, and is e.g. databases or the "to do items" stored in a PDA. The *program* processes data, and can be e.g. a scheduler, e-book-reader etc. (Kristoffersen & Ljungberg 1999*c*).

5.3.3 Aspects of mobility

Mobility in CSCW

Mobility affects the initial ability to communicate, the reliability and performance of communication, and the characteristics of the individual devices used for communication (Dejan Milojicic & Wheeler 1999). Bellotti & Bly (1996) found that people more often than expected went out of their office to talk with others and use different equipment. In a work setting, people moved around in pursuit of resources and and other people. Bellotti & Bly (1996) term this *local mobility*. Local mobility is defined as "walking between rooms or buildings at a local site" (Bellotti & Bly 1996).

> *We are all nomads, but we lack the systems to support to assist us in various forms of mobility.*

— (Kleinrock 1996)

In a medical work setting, medical students, physicians and patients have to share information and resources. The physician may want to show the medical student a note or a medical record, and the medical record is often moved around at a hospital. This can be seen as *micro mobility* and is defined as "the way in which an artifact can be mobilized and manipulated for various purposes around a relatively circumscribed, or "at hand", domain (Luff & Heath 1998). The paper based medical record has portability as one of its main successes. It is passed between the hands of different professionals, it is carried around the practice and located in different parts of the office and clinic. Luff & Heath (1998) did also find, in their research, individuals who move around different physical locations who require access to information and colleagues. They called this kind of mobility *remote mobility*. Remote mobility have a lot in common with long distance mobility and the combination of the modalities walking and visiting, but remote mobility focus on smaller areas and distances. Luff & Heath (1998) exemplify remote mobility with a situation from a construction site where a foreman has to monitor the work of the gangs based in different locations around the construction site.

If a person is able to work from different locations, can it be called mobility? Hjelm (2000) means that the answer is no because an application that chains you to a desk for more than one minute cannot be classified as mobile. Mobility means that the person can walk out of the building while maintaining contact with the network and continuing to use the applications he was using inside the building (Hjelm 2000). Hjelm (2000) argues that mobile devices have to be handheld and small enough to fit in a person's pocket. The user should be able to operate the mobile device with just one hand. This disqualifies keyboard and pen-based handheld computers from being called a mobile terminal.

Mobility in telecommunication

The Telecommunications Information Networking Architecture Consortium (TINA-C) [2] has defined, as one of its objectives, the support for mobility (Kristiansen 1997, Hegeman & Abarca 1997). TINA-C defines four types of supporting mobility that is essential within the area of telecommunications systems: terminal, personal or user, application and session mobility (ibid.). We will only focus upon terminal and personal or user mobility.

Terminal mobility is defined as allowing a terminal to change location while maintaining all the services. In our case, the definition will also be used for PDA's which

[2] TINA-C is an international collaboration aiming at defining and validating an open architecture for telecommunications systems for the broadband, multi-media, and information era. See www.tinac.org for more information.

do not maintain their services when changing location. A person can of course also move from one place to another which is called *personal mobility* or *user mobility*.

Today there exist many different wireless technologies that support mobile hosts and mobility. These technologies are different from each other regarding the frequency of the signals and therefore also the reach and range of these signals. This is essential to the availability of services and *continuous mobility* enables continuous availability of services while the user moves (Thanh 1997). This type of mobility is offered in cellular networks, such as GSM, GPRS, UMTS and satellite, and is making use of the mechanisms of session mobility (ibid.). *Discrete mobility* enables the availability of services within certain areas and for certain access points, as for example at home and in the office, but not while moving from one area to another (ibid.). Thanh (1997) mentions *portability* as an example of discrete mobility, where a person are just allowed to move a terminal from one plug to another. Discrete and continuous mobility is described further in figure 5.4 and 5.5.

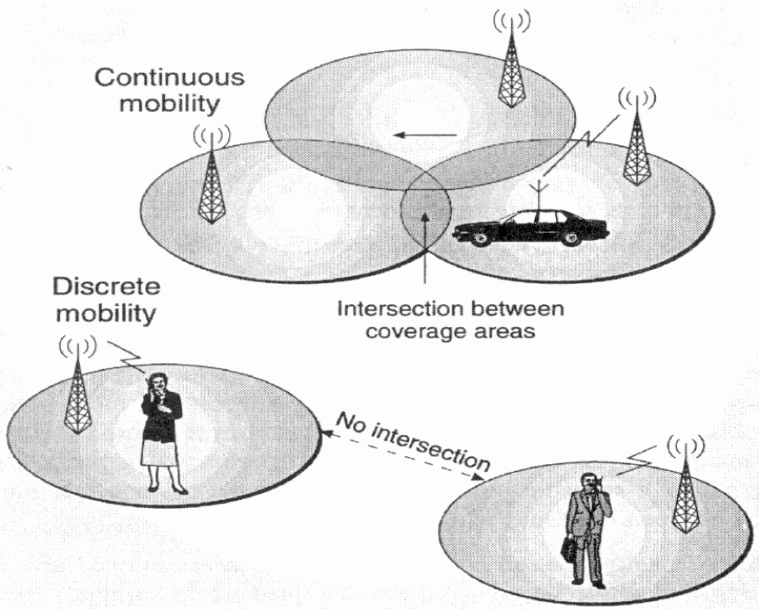


Figure 5.4: Mobility can be classified according to the availability of the service. An example of a wireless network technology which supports continuous mobility, is the GSM network. WLAN is an example of a wireless network technology which supports discrete mobility. The figure is based upon (Thanh 1997, page 22).

5.3.4 Mobile computing

Interaction with computers in the early days started with mainframes where each machine was shared by many users. Then came the personal computer, and the

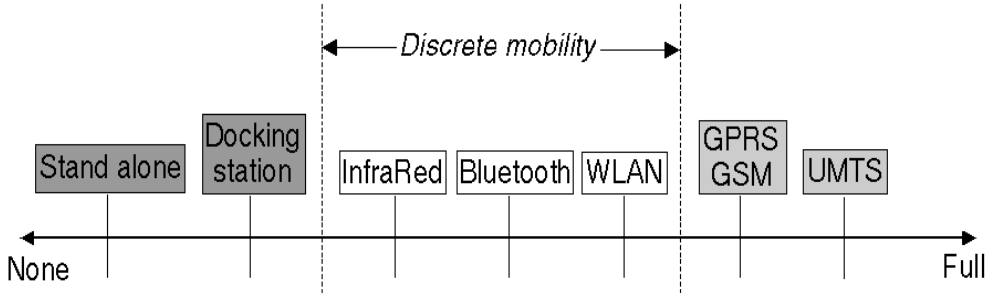


Figure 5.5: The figure is showing to what extent different wireless network technologies support continuous mobility. An off-line mobile terminal is seen as a *stand alone*. GSM and UMTS supports an available network over larger areas, but a full continuous network connection is only reached when the a network service is available everywhere a person is located in the world.

personal computer era where each person had his or her own machine. The next era, according to Weiser (1993), is called *ubiquitous computing*. This is shown in figure 5.6.

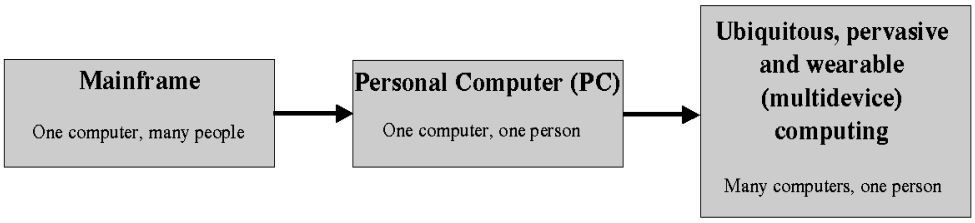


Figure 5.6: Historic development between people and their interaction with computer devices

In ubiquitous computing one person interacts with many computers and these devices, or actually, the technology recedes into the background of our lives. Weiser (1993) envisioned computers embedded in walls, in tabletops, and in everyday objects. In ubiquitous computing a person might interact with hundreds of computers at a time. These computers are invisibly embedded in the environment and they communicate wireless with each other (Weiser 1993). Ubiquitous computing is the opposite of virtual reality where you put the people inside a computer-generated world. Computer devices in a ubiquitous computing world are outside a persons real world, unconsciously to the person. Ubiquitous computing is a complex integration of human factors, computer science, engineering and social sciences (ibid.).

> *By invisible, I mean that the tool does not intrude on your consciousness; you focus on the task, not the tool. Eyeglasses are a good*

> *tool—you look at the world, not the eyeglasses. The blind man tapping the cane feels the street, not the cane. Of course, tools are not invisible in themselves, but as part of a context of use.*
>
> — (Weiser 1994, page 7)

Wearable computing refers to devices that is always with you, is comfortable and easy to keep and use, and is as unobtrusive as clothing (Mann 1996*b*).

> *In the future, perhaps we'll become cyborgian—our clothing will significantly enhance our capabilities without requiring any conscious thought or effort.*
>
> — (Mann 1996*a*)

The wearables should be possible to use hands-free. In addition to user-inputs, the wearable should have sensors for the physical environment and their inputs or signals. Such sensors might for example include wireless communication, positioning systems such as GPS (Global Positioning System), cameras or microphones.

There are some significant differences between wearable computing and ubiquitous computing. One difference is where the computer devices are located. In wearable computing the devices are located on the person, or more precise, in the persons clothing. In ubiquitous computing the devices are located in the persons environment. In the purest form, the wearable user would do all detection and sensing on his body, requiring no environmental infrastructure at all. This implies that the processing is mainly executed on the person in wearable computing and in the environment in ubiquitous computing. There is especially one thing that those two

Feature	**Ubiquitous**	**Wearable**
Privacy		X
Personalization		X
Localized information	X	
Localized control	X	
Resource management	X	
Devices localized on person		X
Devices localized in environment	X	
Multidevice	X	X

Table 5.1: Comparing wearable computing against ubiquitous computing. The table are based upon a similar from a Mark Weiser.

computing paradigms have in common: interaction with many different computer devices.

Pervasive computing is seen as a shorthand for the strongly emerging trend toward a numerous, casually accessible and often invisible computing devices. Pervasive computing is frequently mobile or embedded in the environment and it's connected to an increasingly ubiquitous network structure. The aim is easier computing and more available services and devices everywhere it's needed. Mark (1999) states that the computer forms (workstation, personal computer, personal digital assistant, game player) through which we now relate to computation will occupy only a small niche in this new computational world. Related to ubiquitous computing and wearable computing, pervasive computing can be seen as a mix of those two. Pervasive computing can be seen as a solution to the problems of both ubiquitous and wearable computing shown in figure 5.1. We are interacting with a lot of devices, both direct and indirect, and pervasive computing refers to devices that are everywhere; in the environment around us, in our clothing and in our hands.

5.3.5 Technical characteristics

When talking of access to information anytime and anywhere there have to be a network to support the mobile services. A wireless network is the underlying basis for the support of mobile computing. The wireless network (e.g. GSM, WLAN and Bluetooth) are part of the mobile technology that enables the use of wireless, mobile services. The wireless network is stationary in itself, at least inside a defined area. The GSM base stations are for example stationary, but they enable a wireless connection for the mobile terminals. A handheld computer without the support of wireless networks can still be seen as a mobile terminal. That is, it contains applications and services that could be accessed everywhere (as long as there is enough battery power).

The physical architecture, or the characteristics, of a mobile environment consists of (1) a wireless medium (for example WLAN, GSM, UMTS, satellite or radio), (2) mobile hosts and (3) fixed hosts (Pitoura & Bhargava 1994). The Wireless medium and the mobile hosts have characteristics that particularly are different from the wired medium and stationary hosts. These characteristics is shown in Table 5.2.

Characteristics of:	
The wireless medium	**Mobile hosts**
-low bandwidth -frequent disconnections -high bandwidth variability -predictable disconnections -broadcast is physically supported in a cell -high error rates	-small size -small screen -limited battery life -limited memory and storage

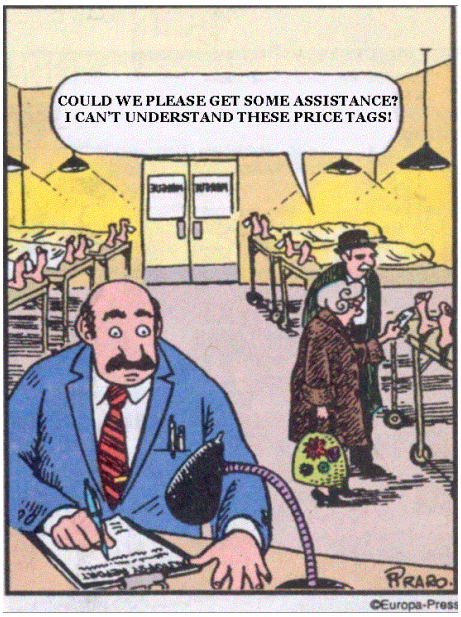
Table 5.2: Characteristics of the wireless medium and mobile hosts

5.4 Context

> *Undoubtedly, to designers contemplating the unpredictability of the uses and settings of what they design, grappling with context can appear about as attractive as wrestling with a whale: The task looks overwhelming, and the opponent offers few obvious handholds. Context independence, by contrast, appears much less demanding.*
>
> — (Brown & Duguid 1994, page 6)

Context is important in the theory of mobility as well as in design. We find ourselves in different contexts because we can move to different places. Artifacts are also located and used in quite different contexts.

In our daily life, when we talk to others, we are able to use implicit situational information, or *context*, to increase our conversational bandwidth. Dey (2001) states that this ability to convey ideas does not transfer well to humans interacting with computers and an understanding of context will enable application designers to choose what context to use in their application. By being mobile we find ourselves in mutable and unfamiliar environments frequently (Kristoffersen & Ljungberg 2000).



Stationary or fixed-location computers are used for a variety of tasks and are set within a rich social and organizational context (Rodden et al. 1998). Mobility, applied to IT-systems and terminals, triggers use in different contexts. The nature of mobility, for example the change of location, entails use in different contexts

and the context sensitive nature of mobile devices sets them within a multi-faceted contextual matrix (Rodden et al. 1998). On the other hand the nature of a stationary computer as a whole is fixed and acontextual (ibid.). Applied to mobility, the context is essential to design and human computer interaction.

Context is used with a number of different meanings as illustrated by the following definitions from Schmidt (1999):

> *Context* n 1: discourse that surrounds a language unit and helps to determine its interpretation [syn: linguistic context, context of use] 2: the set of facts or circumstances that surround a situation or event; "the historical context" (Source: WordNet®1.6)

> *Context*: That which surrounds, and gives meaning to, something else. (Source: The Free On-Line Dictionary of computing)

As these definitions show, there are more to a context than location, but context is anyway dependent upon the location. Most of the research within context and IT-systems have been applied to context-aware computing (see subsection **??** for more details) which focuses on an application's ability to sense the context. This can be done by ubiquitous sensors in the environment which give input to the application. In addition to context-aware computing there are many definitions that define context by example and by synonyms. These types of definitions are difficult to apply and use consistent. Dey (2001) has developed a more concrete definition:

> *Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves.*

This definition says that if a piece of information can be used to characterize the situation of a participant in an interaction, then that information is context. An example can illustrate this definition: A person is using an application on a PDA inside a building and there are other people and computers there as well. The obvious entities in this example are the user, the application, the PDA, other people and the room itself. Let us first look at the weather as an entity. Since this application is used inside a building, the weather does not affect the use. The weather is therefore not context. But what about the presence of other computers? If the other computers in the room hold the same application, the user may decide to use one of them instead of the PDA because of for example a bigger screen size. The other computers in the room can be used to characterize the user's situation, therefore it is seen as context in this example.

Context is a diverse term which can be defined according to many different factors and aspects. The following descriptions show this:

- Rodden et al. (1998) suggests that the context can be described by three types of entities within the environment: *people*, *devices* and *objects*.
- Schmidt, Beigl & Gellersen (1999) defines context in the term of *human factors* and *physical environment*, where human factors are divided into the sub terms *user*, *social environment* and *tasks*. The physical environment is divided into the sub terms *location*, *infrastructure* and *conditions*.
- Agre (2001) states that context has to be reckoned in both architectural and institutional terms. It is important to distinct between the places where the activity is carried out. It matters whether a place is a restaurant or a theater, since the activities that occur in those places have a different categorical structure (e.g. 'house rules' and social aspects) (Agre 2001).

Chapter 6

Empirical Issues

In this chapter we describe empirical issues of our thesis. The empirical findings is structured according to the three contexts we have observed; hospital, general practitioners office, and travelling. Then we present more general findings. The findings are mainly based upon our contextual inquiries and interviews presented in chapter 3.

6.1 Introduction

In chapter 2 we presented six different places where the mobile terminals were put into use. Two of the groups had the possibility to access a network, WLAN or GSM. Those two groups were located in Tønsberg and Drammen respectively and they have been our main focus of the empirical gathering. In addition to our own data collection we have also utilized empirical findings from the super-users and Kari Blekastad Ellingsen, Kim Finkenhagen, Øystein Haga, Morten Andreas Enger Jensen and David Hsu[1], thus in diverse extent.

The super-users are medical students with experience in IT use, who were not in their practical term. Their job in the Knowmobile project is to provide support and assistance to the users of the mobile terminals in Knowmobile. Each is responsible for two-three students. Halfway through the practice period they wrote a report based on their feedback from all the users. Kari Blekastad Ellingsen conducted a usability test of some of the applications and services on the mobile terminal, including our prototype. Kim Finkenhagen, Øystein Haga and Morten Andreas Enger Jensen also carried through contextual inquiries in Knowmobile, but with a different focus. Still, we have read their contextual inquiries and used some of their empirical findings to acknowledge and deepen our own empirical issues. Together

[1]Kari Blekastad Ellingsen, Kim Finkenhagen, Øystein Haga, Morten Andreas Enger Jensen and David Hsu are master students in informatics and connected to the Knowmobile project

with David we evaluated the use of the mobile terminals which were to be used in the Knowmobile project.

The empirical findings are presented and structured based on the contexts we studied. The contexts are *hospital*, *general practitioners (GP) office*, and while the medical student is *traveling* by train. These findings are basically founded in the contextual inquiries and the unstructured interviews we conducted when carrying through the contextual inquiries. The last section presents findings which are independent of the contexts we are studying. These findings are collected from our interviews during the contextual inquiries, the reports of the super-users and the usability report of Kari Blekastad Ellingsen.

6.2 Hospital context

Figure 6.1: Sentralsykehuset i Vestfold (SiV)

> *The practical training at the hospital is mainly consisting of observations, journal recordings, conducting consultations and surgery assistance.*
>
> — Medical student at SiV

SiV is located approximately 100 km from the University in Oslo, but the students conducting their practice period here use an apartment approximately 150 meters away from the hospital. Between the hospital and their apartment there is an education centre, which is located approximately 20 meters from the hospital. The apartment and the education center was equipped with a WLAN, but the hospital was not. Therefore the mobile terminal had to be used off-line inside the hospital. This is due to the strict rules concerning hospitals in Norway where they are afraid of interference with the signals from other medical equipment in the hospital. We met three of the medical students connected to Knowmobile doing their practical

Time	Task	Description
07:20	Morning meeting	All the doctors at a department gather to discuss new patients, and every day there is a lecture over a medical theme This meeting is conducted once a day
09:00	Pre-visit	The staff - chief physician, two house physicians, a nurse and the medical students - at one post have a meeting where they discuss each patient at the post. This meeting is conducted twice a day (09:00 and 15:00 - between shifts)
10:00	Visit	The staff conduct a round, visiting each patient at the ward
12:00	Lunch	No description needed
14:00	Presentation meeting	The hospital laboratory had a presentation of their department trying to recruit new staff.
15:00	Lecture on how to cast Colle's fracture	Lecture in two parts: theoretical and practical training.

Table 6.1: An example of a students program at SiV

training. This was their second week at the hospital, and a typical program of their day is shown in Table 6.1.

The students participating in the Knowmobile at SiV were equipped with Hewlett Packard Jornada 548 (see Appendix A.2 for technical specifications and a picture of the terminal).

We found no use of the mobile terminal at SiV and the use found by the other master students were also very limited. "No use" is a finding in itself, but in the following we present the context and findings that are relevant for our analysis and discussion. In fact, two of the students were a little embarrassed when we one day came early in the morning. One of them told us: "*I don't think you need to observe me a whole day. I don't even bring the terminal with me in the hospital.*"

6.2.1 Story of John

> *Tuesday morning at the hospital. The morning meeting is just finished, where he and the other physicians have discussed new patients coming to the ward (Post H). On a piece of paper he has noted some keywords of medical issues raised in the morning meeting which he wants to update himself on. First he checks the medical handbook which he has in one of his pockets. He knows which chapter that concerns this issue and quickly finds the right page. The information is*

not specific enough, so he walks to the meeting room at Post H. There he accesses two other medical handbooks and a medical database on the Internet via the desktop computer. In one of the articles from the database he finds a quite concrete answer to his problem. It is 15 minutes to the pre-visit meeting and he starts looking in the Curves of some of the patients that are going to be discussed. One of the medical issues is quite unknown to him. This time he picks up the PDA from his pocket to look up in the electronic version of the medical handbook. But, he changes his mind. The PDA has a small screen and some of the content are not properly displayed (such as tables), so he chooses to utilize the paper-based version of the book instead.

In the evening he is on duty at the hospital and a new patient arrives. He walks down to the reception area where he meets the patient and starts questioning him about symptoms in order to prepare the treatment. He becomes a bit unsure of the treatment, and utilize the PDA, which he has in his pocket. He searches in the e-book and finds the right treatment. When the day is over he walks home. There he tries to put in the wireless network card, but the PDA "crashes". When he finally manage to turn it off and on again he can not find the e-book application or his mp3-files. The next morning John leaves his PDA in the apartment.

6.2.2 Description of the context

The context of SiV is rather complex following the definitions presented in Chapter 5.4. The student finds himself in a range of different places and thereby in different surroundings and situations in the hospital. In our contextual inquiry we identified several contexts in which the student are during the day; meeting room, halls, education center, canteen and patient rooms.

There is a meeting room at each ward which works as a "base" for the staff. In the meeting room there are a computer, medical handbooks, medical literature, booklets, two desks, Journals, curves, chairs and tables. This office is used as a meeting room for meetings regarding patients at the ward, as a place where the staff gather information, where they are writing Journals and where they are making phone calls.

The rooms with the patients are located in a hall which is about 50 meters long and has approximately 14 rooms.

At the education center, which is a separate building close to the hospital, the medical students have their own office. This office is mainly used for solving PBL-assignments[2] and for changing between civil and work clothes (white coat

[2]PBL is an acronym for Problem Based Learning

equipped with different devices of use). There are also class rooms in the education center which is used for internal education.

Because of the fear for interference between signals for mobile phones and medical equipment, all people inside the hospital are instructed to turn off their phones. This means that the medical students neither are allowed to utilize mobile phones or mobile terminals with a network connection. Therefore, WLANs are not installed at the hospital, only at the educational center and in their apartment. The WLAN cards had to be taken out of the mobile terminal if they wanted to bring the PDA with them in the hospital. One of the students told us that he had taken out his card in order to bring the terminal inside the hospital. Later, when he was putting the card into the PDA back home in the apartment, the whole terminal "crashed". After this incident he had to wait for a couple of weeks before he got help with fixing the terminal.

In the hospital the use of mobile terminals as information resources, as notepads, and in general was very limited among other physicians and nurses. We observed only one house physician having a Palm, but he did not utilize it for medical purposes. The staff at the hospital used the information resources described in section 6.2.4

6.2.3 User mobility

At the hospital the student did a lot of wandering; to and from different wards, but also within the ward (mainly between the meeting room and the patient rooms). The student often ended up in the meeting room to access and gather information. The meeting rooms served as a center for all the physicians and nurses at the ward. People came, searched for information, asked questions and went out again. The meeting room contained everything the medical student needed of information resources despite its small size. The room could actually be quite crowded sometimes.

During the meetings the staff gathered around the table and most of the information resources were to be found inside a range of a meter. Folders, such as Journals and curves, were passed between the participants. If someone wanted to have a look at some information (statistics, pictures or other data) they just asked for it and then it was passed to the right person. In this way, they shared the information.

All patients are situated in rooms at the ward, and in order to conduct a consultation (during the visit), the staff had to walk up to the patients bringing all the needed equipment and information. The trolley with Curves is brought at the round of visit (See Figure 6.2). In addition the medical students, as well as the physicians and nurses brought their personal information resources and devices in the pockets of their coats (see Figure 6.3).

Figure 6.2: A nurse with the trolley of Curves

Figure 6.3: To the left: A student with his coat filled up. To the right: An overloaded pocket.

In this way they actually wore many devices such as pager, different medical handbooks, pieces of paper, notebook, copies of pages from the Journals and curves, pen, personal organizer and stethoscope. The paper-based version of *Metodebok for turnusleger* was actually printed in a format that fitted the side pockets on the coat (see the book on the left side in Figure 6.4).

Figure 6.4: Content of a student's coat.

The medical students (as well as the physicians and the nurses) do not have their own office at the ward. If they have an office it is often located another place in the hospital, and during the day they are mostly away from their office.

6.2.4 Information resources used

In the meeting room there were a range of information resources available for the medical students:

- *Felleskatalogen*: Listing all medicines available for the doctors and patients in pharmacies in Norway.
- *Norsk legemiddelhåndbok for helsepersonell*: The content is partly about medications and treatments, but it also provide descriptions of procedures.
- *Metodebok for turnusleger*: Describing procedures, symptoms and diagnosis. Several students and physicians bring this book with them during the day.
- *Journals*: of the patients at the ward. A Journal is a folder that contains the whole hospital history of a patient.

- *Curve*: is a folder containing information about the patient's present stay at the hospital. In that way the curve contains just updated and the most recent information about the patient.

The students also used a *telephone* to call for different laboratory results and the staff's pagers. Stationary telephones were placed all over the hospital. A stationary computer with a printer was also located in the meeting room. The following services were to be found on the stationary computer:

- *PIMS*: (Patient information management system) is an application holding all the patient Journals and notes written by the staff concerning these Journals.
- *SECTRA*: is an application handling X-ray pictures and X-ray analysis of all patients.
- *LABSVAR*: is an Intranet service giving laboratory sample results. It also contains old results.
- On the *Intranet*: there were also papers about methods connected to each ward, i.e. procedures for how each ward should perform when treating the patients.

6.2.5 Use of information resources

During the activities in the practical training the student makes notes, most often on a piece of paper or in a paper-based notebook. The notebook was used for personal notes, such as medical themes or keywords the student want to find out more about later.

> *Some of the medical fields I'm practicing here, I learned five or six semesters ago at the university. At the hospital we also practice in a specialized area of medicine so I have to know the right details. No wonder I have to update my knowledge now and then.*
>
> — Medical student explains why information resources are essential at the hospital

When the student made notes about a patient he used an A4 piece of paper which he "arranged" by himself, or he received a printed piece of paper with the patients' names where he could write down keywords in a separate column beside the patient's name. The student also brought a notepad along in one of his coat's pockets

(see Figure 6.4). The notepad was mostly used for taking short notes about medical themes he had to check up on later.

At the hospital there are many ways for the student to access information. He can ask physicians, nurses or fellow students; use a stationary computer with Internet, databases and more specialized applications for the medical practice; access medical books or brochures; or find the needed information in Journals or Curves. Except the staff, these information resources are always available in the meeting rooms.

> *Here I have everything I need!*
>
> — Medical student when sitting in the meeting room at "Post H"

Metodebok for turnusleger is often utilized in consultations when the student is unsure of the current topic or theme. This book is used in addition to the handbook *Skadestuehåndboken* when the student is in charge of the consultation. The students mostly used the *Metodebok for turnusleger* to update themselves bedore consultations, or after a session in order to repeat themes, but never in front of a patient.

> *Books (paper-based) are available all over the hospital. And, the pages, and especially text, tables and figures, are bigger. It also shows me two pages at a time. This gives me a better overview.*
>
> — Medical student explaining why he used the paper-based instead of the electronic version

Except for the handbooks they carried in their pockets, other paper-based handbooks and information resources were easily accessible around the hospital. Quite often the students also had to use other books as well to accomplish their task. One student explained why he did not bother to utilize the e-book in this way:

> *I often have to use other books as well when searching for information. Why should I then use the PDA and after that start searching in other books and information resources. It feels quite awkward to do so.*
>
> — Medical student explaining why he did not use the e-book

During the practical training the students several times recorded a journal[3]. Recording a journal consists of a conversation with a patient, where the student writes

[3]This journal differ from the journal described earlier, which is a folder containing the whole hospital history of the patient. The recorded journal is a state report of the condition of the patient when arriving at the hospital.

down social status, case history and other issues concerning the patients condition on a standardized piece of paper (called a pre-journal which is shown in Figure 6.5). The student uses a template for interviewing, which is printed on page 14 & 15 in *Metodebok for turnusleger*, when writing the pre-journal.

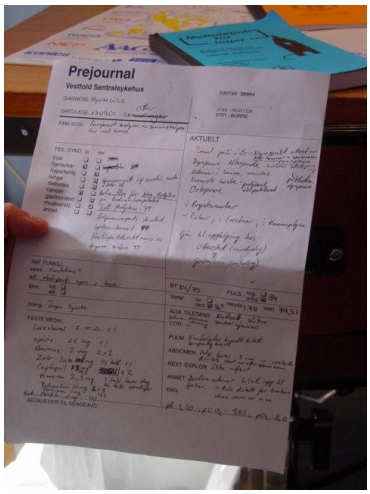


Figure 6.5: Pre-journal

When the pre-journal is completed, the student completes the journal by supplementing the pre-journal with other sources such as the cardex, and then walks to a dictation room where he reads the journal into a microphone.

The medical students use, or at least participate in using, many different information resources to solve their tasks. The following observation during the pre-visit examplifies this: When discussing one of the patients at Post H, the chief physician had the patient's Curve in front of him on the table in order to "remind" the staff of the current patient. The chief physician read loud from the Curve and started discussing with the other physicians, nurses and medical students about further treatment for this patient. When discussing, the chief physician looked up an issue in the handbook called *Norsk legemiddelhåndbok for helsepersonell*, and based his further arguments on what he found. One of the house physicians walked over to the stationary computer to check an X-ray picture of the current patient. He turned the screen towards the table so the others could have a look as well (see Figure 6.6). Then they mutually studied the picture, and continued the discussion. The Curve told the staff that a specimen had been taken, but the results were not recorded. One of the medical students used "LABSVAR" to check if the results were inserted in the database, which was not done in this case. The other medical student, the one who sat closest to the telephone, then made a call to the laboratory to inquire about the results. The results were ready and he got the answer immediately. After this the staff closed the discussion and agreed on a treatment.

Figure 6.6: Mutual study of x-ray pictures. The size of the screen is 21 inches and one of the two house physicians was operating the computer. The screen can be turned against the table so everyone at the meeting can see the picture.

We did not observe any use of the mobile terminal at the hospital, but informal interviews, the reports from the superusers, Kari Blekastad Ellingsen's usability tests and the other contextual inquiries carried out by the master students, showed some use of the mobile terminal. The use was anyway very limited, and we will discuss this in a more general way in chapter 6.5.

6.2.6 Time

Between the activities the students often had time to search for and update themselves on medical issues. They usually had to wait with accessing the right information until the consultations, meetings and other information-demanding activities were finished. During the different activities they asked questions and took notes in their notebook or on a pre-arranged A4 paper. Later, when they had time, they checked up on the issues they did not know well enough. This mostly occured during their breaks in advance of another activity or at home.

6.3 The GP office

We conducted two contextual inquiries at two different general practitioner (GP) offices , one at *Gulskogen legesenter* (Gulskogen) and one at *Nedre Eiker legesenter* (NEL). The context of the two offices are identical, but the way in which the students carried out the practice varied. We have chosen to present the two offices together, but we will point out possible differences when that is required. The students we have observed through our contextual inquiry were equipped with a Hewlett Packard Jornada 720 with a GSM card (see Appendix A.2 for technical specifications and a picture of the terminal).

6.3.1 Story of Elisabeth

It is Thursday morning when Elisabeth puts away her jacket and bag in the wardrobe. She brings her mobile terminal in her shoulder bag, which she brings to the office. Elisabeth is borrowing the office of an absent physician this day, and she conducts the consultations on her own. An elderly woman has just been called in. She questions the patient while she writes extracts from the answers directly into the patient's journal on the desktop computer. At one point she feels a little unsure of the treatment. She quickly checks with one of the medical handbooks lying right beside the PC before she continues with asking questions. She wishes she could have more eye contact with the patient and sit face-to-face with her, but the PC needs her fully visual attention. She wonders if she should try to use the PDA and write short notes on that while she questions the patient. That could give her more eye contact, and she could at least sit face-to-face with the patient. She skips this because she is afraid of the patient's reaction to this small computer.

6.3.2 Description of the context

At the GP office the student is situated in an office where she conducts the consultations. She does not have her own office, but is borrowing an office from an absent physician or participate in the advising physicians consultations. This means that she is using several different offices to have consultations during the time of practical training. The student is having her own consultations, but can utilize the tutor when she is incertain of an issue. The tutor has his own office so the student can either walk up to his office to get help, or make a phone call. All offices are about the same size and are equipped with identical utilities and information resources. An overview of the office is shown in Figure 6.7.

When conducting consultations, the patients are called to the office by the student. The patient and the student are sitting face to face during the examination.

At Gulskogen the student wore casual clothes. That is, he did not wear a white coat like the students at the hospital. Thus, he had no pockets big enough to carry the terminal. The student left the terminal in his jacket in the wardrobe. The white coat was used by the student at NEL, but she puts the terminal in her shoulder bag instead. The reason for this was that:

> *The terminal is too heavy to carry in my pockets.*
>
> — Student at NEL

Figure 6.7: An overview of the office at NEL.

The medical students at the GP offices had everything they needed, equipment and information resources, in the office. The only thing they wore was the stethoscope.

The GP offices do not have the same restrictions regarding the use of mobile phones and other wireless equipment, just like the hospitals. It is therefore possible to use the mobile terminal with the GSM connection inside the whole GP office.

As we observed in the hospital, the use of mobile terminals as information resources, as notepads, and in general was very limited among other physicians and nurses even in this context.

6.3.3 User mobility

At the GP office the student was, more or less, always located in an office the whole day, except when having lunch. The student just had to walk to the door and call the next patient in from the waiting room. The patient then came to the office.

The patient sat down beside the desk on which the desktop computer was on top, and the student started to questioning the patient.

During the examination the student noted interesting issues directly into the PC. Three of the patients at NEL this day leaned forward to see what was written on the PC. When writing notes on the PC, there arised an interval of time where the patient sat waiting, because the attention of the student was directed to the computer screen (see Figure **??**). There were some occasionally walking inside the office between the desk and the examination bench located two meters from the desk.

6.3.4 Information resources used

At Gulskogen, the student occasionally wrote down keywords on a notepad during the consultation in order to type in the findings at the end of the day.

Figure 6.8: The medical student paying attention to the computer screen while he writes in the patient's Journal

The GP offices were using computers with *WinMed* installed. WinMed is an application handling electronic journals, medications (listing medicines as a result on a query), prescriptions, requisitions (which can be electronically sent) and the physicians time schedule including the patients consultation reservations. The student have attended a course in advance of the practical training to learn WinMed, and the use of it appeared unproblematic.

The offices were also equipped with printers (for printing prescriptions, references, drug and specialist requests, and letters), telephone, special medical equipment as well as many paper-based information resources: medical brochures, literature and handbooks. Some of these information resources are shown in Figure 6.9. The

Figure 6.9: Extraction of literature and equipment available in the office.

medical handbooks were:

- *Felleskatalogen*: (see section 6.2.4 for a description)
- *Norsk legemiddelhåndbok for helsepersonell*: (see section 6.2.4 for a description)
- *Legevakthåndboken* is a reference book containing descriptions of symptoms, treatment and differential diagnosis.

It was stated by students that *Metodebok for Turnusleger* are intended for students and physicians practicing in the hospital. We observed the absence of this book in the offices, and that the students did not bring it.

6.3.5 Use of information resources

WinMed was the most utilized tool at the GP offices. Both as an information resource and as a notepad. During the consultations at NEL WinMed was used several times during a consultation. Only once did the student look up an issue in one of the handbooks on the desk, on what the patient responded:

> *Are you not supposed to know this by heart?*
>
> — Patient at NEL. The statement was intended sarcastically.

The patients did not perceive WinMed as an information resource. Once the student wrote a note on a piece of paper. She wrote down the blood pressure result of a patient, as a memo while she was examining the patient further. When she had typed the result into WinMed, she threw the paper note. An electronic database called *Norsk Elektronisk Legehåndbok* [4] was also to be found on the stationary computer.

Twice during the day the student at NEL called for her advisor inquiring for help. The advisor entered her office, and they discussed the problematic issues.

The student at Gulskogen conducted some consultations alone, and was a passive observer to other consultations. The student did not take any notes when being an observer, but after the consultation the advisor and the student discussed the patient and the procedure. When having the consultations on his own, the student accessed information prior to the consultation in order to see the patient's case history via WinMed, and then he discussed the problems with his advisor. In this way, the student was well prepared for the consultations, by using his advisor as an information resource.

[4] *Norsk Elektronisk Legehåndbok* is a web-based medical information database for health staff

6.3.6 Time

Approximate time available for each consultation was 15 minutes. Then another patient was waiting for his or her consultation. In this way they did not have time to utilize the mobile terminal or to read more thoroughly about a medical theme.

6.4 Traveling by train

The medical students at SiV lived just 150 meters away from the hospital, but the students at the general practitioner offices, Gulskogen and NEL, commuted by train to and from the office every day.

6.4.1 Story of Christine

It is five minutes to the train arrives on the platform, and Christine is killing time using her PDA. She has just read the review of the movie she is going to watch at the cinema tonight on the Internet, and now she is writing and sending SMS-messages to the friends she is going to the cinema with. Christine is on her way home from the practical training at a general practitioner office. The train arrives. On the train she access an online newspaper with a specially designed web-page for terminals with small screens. Then she checks her hotmail account for e-mails. This takes a long time, and when she has just started to answer a message the network connection is lost. She looks around her and discovers that the train is inside a tunnel. She knows that there are five or six more tunnels on this 50 minutes trip, so there is no use of connecting to the wireless network again. Christine has not brought any other books or newspapers today, but luckily the PDA has a wide range of services which she can use off-line as well. So she decide to play some card games on the PDA. After a while she gets bored with card games and start updating herself on some medical themes in the e-book version of a medical handbook. She wrote down some medical themes during the day on a piece of paper which she goes through. The e-book installed on the terminal does not give answers to all her inquiries, so she makes a note on the terminal which contains the unsolved inquiries. She will search for the remaining answers in books she has at home.

6.4.2 Description of the context

The students take a local train which takes approximately 50 minutes from the train station in the Drammen area to Oslo. During the journey between Oslo and

Drammen the train is passing through nine tunnels.

The context of traveling by train includes “waiting for the train” and “sitting on the train” (see Figure 6.10). At Mjølndalen (NEL), Gulskogen and Oslo train stations

Figure 6.10: Left: Waiting for the train. Right: On the train

there are waiting-rooms and platforms with benches for the travelers. The Gulskogen and Mjølndalen platforms are not covered with roofs. On the train there are usually seats available. The local trains have three seats on each side of the corridor. If there is three persons sitting on the same row, the area of space is quite small. Reading a paper-based newspaper can therefore be quite difficult. On the train the students are located at the very same seat the whole trip, when there are seats available.

6.4.3 Information resources available

The information resources available on the train were the resources the students had brought with them. Our research objects brought regularly the mobile terminal, their mobile phone and some novels.

6.4.4 Use of information and Information Resources

The students mainly used the mobile terminal for accessing online or AvantGo-versions of different newspapers, reading about themes in the e-book, playing games, listen to music, sending SMS messages or just surfing the Internet. They also used it now and then to send and receive e-mails, and for writing notes.

> *I use the terminal a lot on the train. Then I use it mostly to read in the e-book version of Metodebok for turnusleger, send SMS and read newspapers on the Internet. I have also done some writing related to assignments on the terminal. These documents are transferred to my desktop computer at home. But, it's annoying with all the disconnections on the distance Drammen - Oslo.*
>
> — A medical student commuting between Oslo and Drammen

6.4.5 Time

The time available for use of the mobile terminal and its services on the train depends on the student's priorities of what activities they prefer. The journey from the Drammen area to Oslo takes approximately 50 minutes, and is the disposal time for use.

There were two issues concerning time when using the terminal. First, to set up a wireless network connection, and second, to download web-sites and e-mails to the terminal. The setup of a new network connection were usually a very slow process, taking everything from one to several minutes. The frequent breakdowns lead to more use of off-line services and applications in preference of online services and applications.

> *I just have to wait for a while.*
>
> — A student setting up a wireless GSM connection.

Regular web-sites, adapted to a stationary computer with a fast network connection, such as online newspapers and web-mail pages, took a long time to download.

> *I think it's too slow.*
>
> — A student surfing the Internet with the mobile terminal on a GSM connection.

6.5 Leaving the PDA behind

In general, there were very limited use of the mobile terminal and its services in the GP office and hospital context. The mobile terminal was often left behind. In the traveling context, we observed and found remarkably more use. In this section we will present findings which is not related to any specific context studied, but rather general findings related to the use of the mobile terminal and the mobile services. In this section we utilize the reports from the super-users and the usability test report of Kari Blekastad Ellingsen, in addition to our own findings.

6.5.1 Technical limitations and consequences

> *I choose to use the PC instead of the PDA. I have access to a PC at home, in the hospital and at the GP office. The PCs have larger screens, bigger keyboards, and they have a more stable connection to the network.*
>
> — A student explaining why he does not bring the PDA with him

While talking about the mobile terminals, the students were displeased with the technical aspects of the terminal:

Small screen A student said that in the hospital or at the GP office they often had a stationary computer close by. They preferred using the stationary computer when they had the opportunity. As one student said: "Why should I write on the PDA when it goes faster on the PC. The screen is bigger and the keyboard is bigger. And, by the way, I always have to synchronize the notes to my PC to edit them anyway. And that takes years!" The students preferred to write down small keywords in their notebook and then write more about the issues when they had access to a stationary computer.

> *I can't see the purpose of reading a newspaper on the mobile terminal. I like the paper-based version better. Everything get too small on the PDA.*
>
> — A student talking about the screen size of the PDA

Unstable network connection and low bandwidth This is described in section 6.4. In the education center at the hospital the students could use the terminal online. But, the terminal 'crashed' due to what the students believed was the network card's fault.

Size and weight A student stated that the terminal was not lighter than the paper-based book, only slimmer. Some students also expressed that the terminal (especially the HP 720) was too big and heavy to carry in their pockets.

Pen based input on the HP548 The pen based input on the HP548 was awkward and time consuming. The students said that they needed more exercise to utilize the pen based input well.

> *Awkward typing!*
>
> — A student commenting the pen based input on a HP548

A student using the HP720 (with keyboard) thought it was bothersome to use the small keyboard.

Storage capacity The memory capacity of both HP548 and HP720 is 32 MB. When using the terminal as a mp3-player, the PDA could only store three songs. When we mentioned the possibility for voice recording on the PDA, the students at SiV wanted to explore the possibilities for recording the pre-journal on the PDA (pre-journal recording is described in Section A.2). They soon found that the storing capacity was a major problem in this case. To get a clear perception of what was being said they had to use the highest bit rate for recording (at least if they should not hold it against their mouth). One minute of recording with this bitrate uses approximately 2,5 MB, and the necessary recording time for one pre-journal is likely to be ten minutes. Ten minutes will then create a file of 25 MB, and compared to the total capacity of the terminal (32MB) this is far too much.

Battery capacity Some of the students experienced that the mobile terminal did not work because of no power left. They, who experienced this, said that this happened several times and the terminal could only be used for a very short period without being charged.

In addition, problems concerning loss of information or applications, crashes and problems with synchronization, were mentioned. Several students mentioned that the e-book reader disappeared from the terminal, or had not been installed (which we know it was). Others had problems with the hyperlinks in the e-book. Sometimes it happened that they did not work, and then the whole e-book was useless.

> *I have to reset the PDA several times a week!*
>
> — Medical student in Drammen

Because the students were afraid of what they called 'blackouts' (battery went out or the terminal just 'crashed'), they had to synchronize quite often, "just to be sure of not losing any 'unsaved' data" as they mentioned it. They thought this synchronization part was far too slow, and because some of them did it often, they got fed up with it.

> *Do there exist better and easier ways to synchronize?*
>
> — Medical student

Several students expressed that they rather utilized a desktop computer in preference of the PDA. The keyboard is larger, the screen is bigger, the network connection is faster and they feel more comfortable using the desktop computer. One student said: "I use the PDA only when I really have to and if it is crucial, otherwise I prefer to locate a PC."

6.5.2 Support and training

First of all, the users wanted more support. This concerned all the users, but some had bigger problems and less motivation for using the terminal than others.

> *I really wonder what I'm supposed to use this for?*
>
> — Medical student

> *Does anyone have any good suggestions for what kind of needs this PDA could cover well? How can I use it effectively?*
>
> — Medical student

From the reports written by the superusers in Knowmobile, most of the students requested more training in use of the mobile terminal and more and faster support. The students felt that the training and presentation held the day they got the mobile terminals was all right, but they proposed that there should have been another training day after a couple of weeks. Then they could have gotten some hints from each other, from the super-users, and from the Knowmobile researchers. Then they would also get the possibility to ask questions.

All the students were conducting their practice outside Oslo and the superusers where located at the university in Oslo. The students thought it was difficult to get support. The support had to be conducted via telephone or e-mail, and the students argued that the super-users could not give them as good support as they needed. Occasionally the students got face-to-face support from people from the research group, and master students carrying through their field studies, but then it often was too late. It could take up to two weeks before somebody had time to help them out with the technical problems. The medical students needed support instantly.

The super-users in Knowmobile did not have their own PDA, and could therefore not try out and explore possible solutions to the problems the students had. One student expressed it like this:

> *It is a pity that the superusers don't have a PDA. I called three of them, but that was useless. They couldn't help me because they didn't understand my problem.*
>
> — Problems concerning support

In the start-up of the practical training the students were curious of the terminal and its content, and they tried out many applications and services. But, after a while they reduced the exploration and use. At one hand this was due to the technical problems and lack of support, but also because many students did not understand what opportunities the terminal and its services could give.

> *... and after a while a lost the motivation and stopped using the PDA.*
>
> — Medical student

Students without much experience in using computers thought that the terminal contained too many applications and services. And they did not have time or motivation to explore them. In addition, it was too much to learn in such a short period of time. Other, more experienced students kept on using the mobile terminal, but for personal tasks, games and music.

One student at SiV got some hints from a physician of what and where to download useful software, where to find interesting web-pages and more practical hints on how to use the technology in a better way:

> *I learned from a house physician at the hospital, who also used a PDA, that there were two e-books available on the web page of the Danish medical union (Lægeforeningen). The two e-books were 'a guidance in antibiotic treatment' and 'information about inquiry poisons'. Those two books in addition to the pre-installed handbook, gave me good user value. The problem was that you had to be a member of the Danish medical union to download them, but the Danish physician helped me with this problem. At another web page, which I got recommended from the physician, I found an anatomic atlas. I also found a lot of software, mostly games, for my PDA on the Internet which I downloaded on my PC and installed on the PDA.*
>
> — Medical student explaining why he used the mobile terminal in the hospital (*taken from the reports from the super-users*)

One evening we were visiting the students at SiV in their apartment to give them advice and guidance in the use of the mobile terminal and different services, and especially our prototype. To our surprise, the students did not have much knowledge about the different services and applications that were pre-installed on the terminal. When we explained the e-book and other applications they often said: "Oh, I didn't know that!" and "Aha, that was exciting, could you please show me again." Our visit was conducted together with the contextual after two weeks of use, and they seemed a lot more interested after the 'training'.

6.5.3 The e-book

> *How do I start the e-book?*
>
> — Asked by one of the students at SiV when we asked him to find a topic in the e-book.

The paper-based book was faster to search in because they were “used to it”, the students said, and they knew the structure and sometimes even the page number. The e-book version was new to the students, and navigating in the document seemed unaccustomed to them.

To be able to ’bookmark’ pages with the fingers while reading another page, a student said, is not possible in the e-book. She would prefer the paper-based version of the handbook due to the characteristic of flipping back and forth between pages and chapters in the book.

In Kari Blekastad Ellingsen’s usability test all students had problems with the functionality of the e-book. They had problems with:

- finding the right e-book
- making bookmarks
- searching for words
- navigating in the hyperlinked structure

Another problem we observed was all the steps they had to go through to just get to the index or table of contents:

1. Turn on the terminal
2. Choose the right icon (MobiPocket e-book reader, but Ellingsen found that some clicked the MS Reader instead, which is another e-book reader application from Microsoft. The MS Reader do not support our e-book format)
3. Choose the right e-book (sometimes they came directly to the last book they had used, and sometimes not)
4. Flip the first two pages to get to ’table of contents’
5. Choose chapter or index

Also in this case, with the e-book application, the technology caused problems. Some of the students complained about broken links, which made it difficult to utilize the e-book. As mentioned in Section 6.5.1 the mobile terminal ’crashed’ quite often. When this happened some of the students lost their e-book application and the medical handbook from the terminal.

The students said that they would like to have more books installed as e-books on the mobile terminal. In addition, if it was possible, the e-books should be interlinked with hyperlinks. This would give the terminal much more value, they said. They also put this in a more general perspective; if there were more useful services on the terminal, it would have given them more value and covered more needs in the clinical contexts. They especially thought about having all the medical handbooks they used installed on the PDA, and with hyperlinking between the books.

6.5.4 The PDA as a notepad

The students very seldom used the PDA as a notepad. Their most usual argument for this was the awkward input possibility on the HP 548 and the small keyboard on the HP 720 (see section 6.5.1). The input possibilities were difficult to use and to learn. It required a lot of training if they were supposed to write faster and more effective. But, as we observed when discussing the terminal with the students in the education center and in their apartment, they always sat down and placed the PDA on a steady surface (e.g. a table). One student said he had tried to write notes with the HP 548, but he wrote so many words wrong. He argued that he did not hit the right and small letters or characters:

> *The 'keyboard' has so many small buttons and that make it difficult to hit the right letter. They are placed so close to each other.*
>
> — Medical students explaining why he thought it was difficult to use the PDA as a notepad

But, some students also used the PDA as a notepad, but this happened mostly when they were traveling or had time to play with the device (e.g. at home). In the clinical contexts they hardly had time during the activities and it was much easier and faster to use the paper-based notepad for writing down short notes, such as keywords. At the hospital they always had the paper-based notepad with them anyway, and in the GP office they used the stationary computer (with a much bigger keyboard) or a piece of paper which was located on the office desk.

Chapter 7

Analysis & Discussion

THIS chapter offers an analysis and discussion of the empirical findings presented in the previous chapter. Its purpose is to answer the research question by discussing the empirical findings in relation to specific theories. In particular, the artifact and the contextual aspects are discussed. But first, we give a short summary of our major findings, and reflections related to these findings.

7.1 Introduction

Our initial assumption for this study was that the mobile terminal and its services, especially the e-book would ease the inquiry for needed information when and where the medical students needed it. We also thought that the PDA could contribute in the note taking. Our third idea was that the students would replace some of the information resources they are carrying in their pockets with the mobile terminal. But, the empirical findings are telling a quite different story.

We based our empirical findings on a prototype of a medical handbook and notepad applications which we thought was going to be a good adaptation to the context of use. We have seen from our empirical issues, that the mobile terminal, serving as an information resource, did not give the students more value in their accomplishment of different medical tasks. When moving away from medical tasks the use ascended.

When we were kids we learned that:

> You should not judge people of the color of their skin or by how they look. There is always something hidden in their very inside which you can only reach by getting to know them. Everyone can see their outside. It is visible. But their inside is invisible; unless you start

> searching for the person's values, meanings and feelings. Then, the invisible will turn visible, and you will discover the person's personality. First now, when you have a personal relation to the person, you truly know and understand him or her.

During the field studies we discovered that the characteristics of the artifact in itself affected the use of it. These characteristics resulted in how the artifact is used, how frequently it is used and in which situations it is used. On the other hand, we observed how social and physical objects in the context influenced the use of information resources and the mobile terminal.

In fact, we found that the characteristics of the PDA and the context of use could lead to non-use of the mobile terminal and services in the clinical contexts. The reasons for this may be diverse, and in order to discuss these reasons we chose an approach based upon material and social aspects of the mobile terminal. The analysis and discussion is therefore divided into a "material" part and a "contextual" part. To argue for our approach we use the following statement from Brown & Duguid (1994):

> *... we try instead to understand under what conditions the border develops into a resource. Two things–one material and one social– seem to us to be essential to this development: continuity and community.*
>
> — Brown & Duguid (1994, page 14)

In this way we analyze and discuss the use based on the artifacts' significance for use in the first part (an inside-out approach), looking at characteristics and resources related to the artifacts. In the second part, we focus on how the environment affects the use in the three contexts of focus (an outside-in approach). Together we believe these two approaches embraces the conditions on which the use is based.

7.2 Characteristics of the artifacts

In our study the mobile terminal was supposed to be both a paper-based medical handbook and a notepad in the clinical contexts. Two artifacts were replaced by one, and we thought this could be a major advantage. From our empirical findings we have seen that the use of the mobile terminal in the clinical contexts was very limited. The students choose to use their existing technology, such as paper-based books, notepads and stationary computers. Therefore we will take a closer look at the artifacts and discuss their characteristics in this section.

An artifact is presented more thoroughly in chapter 5.1, but we repeat some of its important aspects. An artifact in its simplest form is termed a *canonical artifact*

(Brown & Duguid 1994). We interpret this as the physical object. The resources of this physical object are the possibilities humans have to utilize the object. Which resources a person think is important, depend on the relationship to the artifact and the context of use (Brown & Duguid 1994).

Just like the stationary computer, the mobile terminal used by the students in our study are a multipurpose device[1]. The mobile terminal contains several applications and services, which range from games, task manager, calendar, text-editors to Internet-browser and multimedia applications. It is therefore not a dedicated-purpose device (Hillesund 2001, Bennahum 2001). The PDA is not designed for a special context, task or user group, but more as a universal device for everybody to use everywhere for everything (Hjelm 2000, Norman 1998). The fact that the mobile terminal is a multipurpose device, leads to an aspect which is, according to (Brown & Duguid 1994) termed as the artifact's *role* . The today's mobile phones, such as the Ericsson R380s, play different roles. It is a telephone, task manager and a messenger (SMS-messages and e-mails) in the work context, and an alarm clock when sleeping. All in the same artifact. The intent of use and also the context decides what role the mobile terminal plays. Humans also play different roles depending on the context they find themselves in (e.g. a husband and father at home, a boss at work, a buddy when watching soccer games with friends and so on). The PDA is, as stated, a multipurpose device, and all the applications and services provided by the terminal leads to multiple possible roles. Here we will focus mainly on two roles: The PDA as a book and as a notepad.

7.2.1 The mobile terminals' technical properties

The mobile terminals produced today have impressive technical specifications, and the terminal used in the Knowmobile project are no exception (see Appendix A.2 for the specifications of HP Jornada 548 and HP Jornada 720). But still, they fail to become a part of our day-to-day life and thus live up to the expectations of the users (Mann 1996*b*), and the students actually found those very impressive characteristics quite annoying after a couple of weeks. Their first complaint was the mobile terminals' technical limitations and problems. Since the students were used to desktop computers they compared those technical properties with the ones of the PDA. The characteristics mentioned by the students were:

- small screen size
- short battery lifetime
- awkward input

[1]The terms device and artifact have the same meaning. We are varying in use between these terms in order to provide a linguistic variation.

- low bandwidth
- unstable network connection
- unstable memory

We present these technical characteristics because they had implications on the use in general and in relation to our two observed services, and they were soon recognized as some of the PDA's negative resources. But, low bandwidth and unstable network connection are mostly related to the use on the train and in the WLAN zones. The technical limitations mentioned above are well-known problems and are often mentioned in the literature when talking about the development of mobile ICT-systems and within the area of mobile computing (see for example (Pitoura & Bhargava 1994)).

These characteristics, in addition to frequent technical breakdowns such as "crashes" where there is no response from the PDA and problems connecting to the network, lead to frustration and irritation. This again lead to reduced use because of decreased motivation and lack of trust in the mobile terminals. McManus (2000) reports the same findings from a project where clinicians used mobile terminals. The technical characteristics were seen as annoying aspects of the mobile terminal (ibid.).

The fact that the mobile terminal went out of battery, or "crashed" and all settings had to be reset, lead to lack of confidence in the mobile terminal as an artifact. The students became unsure whether information and applications was deleted from the PDA when having these blackouts[2], and when and if the terminal would blackout again. In the clinical practice it is important for the students to have access to the medical handbook and the notepad. The use of handbooks and notes are very random. Sometimes they have to search for information right away, and most often they can just note down keywords for what to search for later. Since access to notes and handbooks are critical for the students, the technology has to be stable and confident.

The crashes and blackouts mostly occurred on the mobile terminals with a WLAN card installed. The WLAN cards were just prototypes, and thus not tested properly in advance. This probably explains why the terminals that had a WLAN card installed crashed more often than the other terminals.

Koht-Tøfte & Olsen (1999) and Haugset (2001) also pointed to the technical limitations and problems as a reason for the mobile installers' lack of trust in the mobile terminal. A result of this lack of confidence was that the installers brought other devices with them as well. They did so because they were afraid of not getting access to the system on the mobile terminal (Koht-Tøfte & Olsen 1999). In our

[2]Blackout refers to one of the students statements, where the terminal stopped working, and only a black screen was displayed

case the students could bring the paper-based book and notepad along. But, they often ended up with leaving the PDA behind instead of the paper-based artifacts. They choose to do so because they did not trust the device and they were afraid of not getting access to their notes and the e-book. In this way the mobile terminal became a source for insecurity instead of a useful tool to bring along.

Compared to the paper-based handbook and notepad, which do not have such technical limitations and problems, these characteristics can be seen as the PDA's negative border resources.

The mobile terminal was seen as an obstacle instead of a companion due to its characteristics mentioned by the students

7.2.2 The PDA as an information resource

The technical characteristics of the mobile terminal, mentioned in the previous section, were seen as negative resources. The students compared the technical properties with the ones of a stationary computer. It seems like the students had quite high expectations for the mobile terminal as a computer, and not as an information resource.

Books and notepads do have strong roles and influences in almost every work practices. This is due to the their many hidden characteristics. In this section we will focus on the material characteristics of these artifacts compared to the PDA, serving as a book and a notepad.

The PDA, serving as an e-book

Both the e-book and the paper-based book have a manageable format and they are mobile in the way that they can be carried around, and be available when and where they are needed. They support terminal mobility. The two versions hold exactly the same information. But, in general the medical students preferred to use the paper-based version of *Metodebok for turnusleger* when both of them were available. There were several reasons for this (in addition to the technical limitations and problems mentioned in the previous section):

- They found the e-book a bit hard to read because of the small fonts in the presentation of the e-book (which could be adjusted, but few students knew how to do it).
- In the book there are many tables and figures, which were presented as pictures in the e-book version. Because of the screen size and the resolution of the screen, these pictures were blurry and difficult to read.

- Only one page of the e-book was displayed at a time on the mobile terminal. This gave the student less overview compared to the book, which shows two pages at a time.

- Some experienced "dead" links in the e-book version, which made it impossible to navigate in the e-book.

- To find a chapter in the e-book, the students had to go through at least five steps.

- The students were used to the paper-based version, and needed to go through two steps in general in order to find the current page. Because the students had a long experience in use of the paper-based version, they were able to look up a theme without using the table of content or index. For example: They knew that a certain topic were described in chapter 7, and that chapter 7 is in about the middle of the book. Each chapter is divided into three areas (see Chapter 4), and when they know the area of the topic, they also know were to look in the chapter. They were not able to use this approach in the e-book, because the physical visibility of the paper was not present.

As we see, there are several issues that separate the paper-based book and the e-book as artifacts, even though the content of the initial book is the same. The main difference is the medium or physical object which is "carrying" the content and the new structure. The PDA had many technical limitations which do not exist in a paper-based book. In addition, the hyperlinked structure were sometimes not working and it did not support their kind of use in a good way. A strong indication of this is the ability to use the fingers as temporary bookmarks when making entries in the book. For example, when using the index, there may be several places in the book where the word or phrase appears. By holding a finger on the index page, the user can flip back and forth, and thus focus on several pages almost simultaneously. The new hyperlinked structure in the e-book did not support this kind of interaction. When clicking on the word in the index the user was hyperlinked directly to the page. But, if this was not the right page, the user had to click his way through many links before he could get back to the same indexed word. In this way the paper-based book worked better as a reference book than the e-book. The paper-based book was both faster and easier to use as a handbook or reference book.

Mollerup (2001) points to a paper-based book's collapsible feature. This is probably explaining why the student thought the paper-based book gave a better overview. In a paper-based book the user can view two pages simultaneously, and thus get a faster overview when searching for themes or words. The mobile terminal was a bit smaller than the paper-based book, but when the book is unfolded it gives the user a major advantage. This is not possible with the e-book version. The user can only see a small page at a time.

An observation of a central resource for left-handed users on the PDA is shown in figure 7.1. The figure shows a student reading an AvantGo site on a HP Jornada 720, and it illustrates that a left-handed user gets problems scrolling pages displayed on the screen with a pen. The hand is covering the whole screen and it is impossible to get a overview. In this way, a small (almost invisible) and insig-

Figure 7.1: Illustration of a significant technical limitation for left-handed users

nificant property for many users, got consequences for one left-handed user. The interface is designed for right-handed users, which do not perceive this issue as a characteristic of the PDA.

Reading paper-based books is an almost subconscious activity to most people, and the content is often abundant. Reading the e-book turned the content quite visible. This was due to the small screen, its resolution and the presentation of the digital content. One of the paper-based book's superior presentation is due to its long period of development. Hillesund (2001) says that the traditional book technology, as we know it today, has evolved over five centuries and has reached a very high level of performance. We often take it for granted, but the book is a highly developed and extremely complicated technology. He points to the readability of a book as the result of many interdependent factors and features that affect the rhythm of reading: page size and layout; font face and size; inter-character and inter-word spacing; word shapes (including kerning and ligatures); line length, hyphenation, and inter-line distance (leading); the use of margins and indents, paragraphs, headings, chapters, footnotes, page numbers, pictures, graphics, charts and tables of content; and the quality of paper and print. These factors are based on the knowledge of typographers, book designers, editors and publishers (Hillesund 2001). The e-book technology, which is built up of text documents, stylesheets, digital pictures, meta data, and the PDA's presentation technology (screen size and resolution), was seen as inferior to the paper-based version.

Brown & Duguid (1994) would say that some of the *continuity* was lost during the transformation from paper to digital content. What the students' knew as a medical handbook was now a different artifact. The students compared the PDA, serving as a book, with the technical characteristics of stationary computers. And they also compared the e-book on the PDA with the paper-based book. The e-book was thus perceived both as a computer and as a book. Thus the informally defining features of a book did not appear concrete in the new artifact (ibid.).

Feedback from the students suggested that the PDA should contain more medical handbooks. If the mobile terminal could contain all the medical handbooks they used, they meant that it would give them a higher user value than the paper-based books. But, the e-books then should be hyperlinked with each other. The medical students often used other medical handbooks as well when using our prototyped handbook. Therefore they said, bringing all the books together with hyperlinking would make up for a less stable and usable interface and device.

We have seen that representing a book on the PDA provides new ways of representing the content, and thus it required new ways of utilizing the artifact. The PDA as a book lead to new characteristics which the students did not see as useful compared to the paper-based book. The new characteristics were seen, more or less, as inferior compared to the paper-based book. When making our prototype we also emphasized to conserve the structure of the book, and we forgot about the book as an artifact. In a Norwegian news agency, the transformation from paper-based documents to digital, failed because of the same reason (Braa & Sandahl 2000).

The PDA, serving as a notepad

Paper has many resources which makes it important in work practices, such as its sharable, tangible, flexible, light and adaptible properties (Braa & Sandahl 2000). Micro mobility (Luff & Heath 1998) explains some of the reasons: Paper can be easily shared with others, and in this way support communication, both synchronous and asynchronous. The medical students mostly used paper and notepad for asynchronous communication with themselves. Paper is easy to use in many contexts; paper enables to "set aside" a question or a task, and to "continue" it later. The user can just write down the needed information on a piece of paper, and then he does not have to remember it. The paper's support for asynchronous communication is also pointed to by Haugset (2001). But, the PDA as a notepad could also very well support asynchronous communication. Both the PDA and the paper-based notes are mobile. And we thought that the PDA would be great for gathering all the notes in one place, as well as having the possibility to easily share them with the other students. Sharing the notes could be done in the WLAN area, or transfer them to the stationary computer (synchronizing). So, why did the students prefer paper-based notes? The students gave the following reasons for not using the PDA, serving as a notepad, in the clinical contexts:

- awkward input on HP548
- small keybard on HP720
- they had to go through several steps before they could even start writing
- they had to place the PDA on a stable surface
- they often got a pre-arranged piece of paper (A4) with a list of the patients, and a separate column where they could write keywords beside the patients' names.

In general, the students found it difficult to use the mobile terminal as a notepad in the clinical context. Most of the reason for this, we argue, stems from the awkward input possibilities. The awkward input requires too much of the user's attention. Koht-Tøfte & Olsen (1999) also found that a mobile terminal require more attention than the user is willing to give. An example from the authors of this thesis could explain this: When we worked with this thesis, we often preferred paper-based notepads when writing instead of the stationary computer, even if this would require to write the same sentences twice. The reason for this we argue, is that none of us are well trained typists. In this way the typing, which includes switching the attention frequently between the screen and the keyboard, takes too much of our focus. Therefore we often lose what we were supposed to write, and we have to start all over again. The problem with writing notes on the PDA is not the frequently switching from the screen to the keyboard, but rather the problem of hitting the right virtual letters (HP 548) or the buttons on the small keyboard (HP 720). From this we can say that input on a paper-based note is easier than on the mobile terminal.

The input on a paper note was also faster than the input on the mobile terminal. Since the students often wrote down a couple of keywords, paper and pen was often preferred by the students. We observed that the student often also choose to write on paper notes, even when they sat in front of a stationary computer: In the GP office context we observed that after the student had taken a blood pressure test on one of his patients, that he wrote down the result (for example a blood pressure of 130/80) on a piece of paper. After the consultation, when he was writing in the journal, he picked up the piece of paper and wrote the digits into the journal. The mobile terminal supported instant access to the operating system, because everything is stored in the memory. But, to even start taking notes, the students had to power on the terminal, choose the right application, start writing notes, and then save the notes. Most of the students were used to stationary computers, where you always have to save before you power down the computer, and thus they thought they had to save the note or document. But, since the mobile terminals had RAM, and not a hard disk, the notes would have been available the next time they turned on the PDA. This, most of the students did not know. With pen and paper, the students could start writing at once.

Another problem with the saving of the notes was the unstable memory on the PDA. When saving the note, the student has to trust that the device stores the note "somewhere" in the PDA's memory. It is not longer visible to the user, and this became a huge problem when the terminal "crashed" now and then. They felt insecure of whether the note was stored or not.

Mollerup (2001) says that paper has an exceptional characteristic; it can be folded many times and thus become very small. It is a *collapsible* artifact. Braa & Sandahl (2000) call this the *flexible* characteristic of the paper. When you unfold the paper it can give you a very quick overview. This was especially the case with the pre-arranged paper at the hospital. The students could write on it, fold it, put it in their pocket, and unfold it when they had to. The folded paper was easy to access and it gave them a good and fast overview. Another example is a city map, which usually gives you a very nice overview when it is unfolded. When it is folded it fits easily in your pocket. The main advantage here is the combination of a small artifact (folded) and a good overview (unfolded).

On the train, some of the students found it useful to take notes on the PDA. But, as they said, they had more time available in the traveling context, and they could sit down. The notes taken then were also more detailed, not only keywords. The students that used the PDA for taking notes like this, were mainly those equipped with a HP 720 terminal with a small keyboard.

PDA versus book and notepad

We have, through our study, experienced that:

> *Attempts to separate the material form from an informational content are highly problematic, both in theory and in practice.*
>
> — (Brown & Duguid 1996, p 137)

The characteristics of the paper-based artifact are based upon the hidden aspects of the artifact, or the artifacts' border resources. When those artifacts were translated, transformed and inscribed into the PDA, we have seen that many border resources were removed. This lead to a new artifact that was more difficult to use. The transformation did also bring new characteristics. The "book" and "notepad" suddenly had technical limitations which did not exist before. The technical limitations of the mobile terminals are not even present in a paper-based book or notepad. It is impossible that a book or notepad can run out of battery or "break down" occasionally. The new resources were seen as obstacles instead of useful border resources.

Removing border resources are, according to Braa & Sandahl (2000), a usual problem among designers because they lie beyond what is regarded as part of the artifact. The mobile terminal, serving as a book and notepad, removed important

border resources during the transformation from paper to digital content. Because of the removed border resources the students did not find the terminal useful in the clinical context. Transforming paper documents into digital documents, such as a paper-based medical handbook into an e-book version, may also create new services (Braa & Sandahl 2000). There may be new services where the peripherical properties of the document is altered because of the designer's lack of emphasizing the peripheral properties of the artifact. The PDA had new services and new border resources, but in the clinical context, those resources were seen as inferior to the paper-based artifacts.

Paper has very strong characteristics, and paper as technology has been matured, developed and shaped for centuries (Hillesund 2001). Another aspect which can shed light upon this, but which is not directly linked to the area of border resources, is the amount of paper produced in the world. Hylland Eriksen (2001) refer to the fact that the amount of paper in the world, used for printing, has increased from 28 million tons in 1975 to 50 million tons in 1985, and it was estimated that the amount of paper should increase to 97 million tons by the year of 2000[3]. Even if the number of computers sold has increased and more information is produced in the same interval, we think this shows that people prefer paper. It shows that paper has some very important resources.

In general, by removing the border resources, the PDA was seen as more problematic and slower to use than the existing paper-based artifacts. But, at the other hand the mobile terminal was used as a book and notepad on the train. This implies that there has to be more than just the material characteristics of the PDA that made it neither useful nor usable in the clinical contexts. In the next section we will discuss the context related aspects of the use.

The mobile terminal was not preferred as an information resource, because important resources of the paper-based artifacts for the students in their clinical contexts were removed

7.3 Contextual aspects

When developing IT solutions, an understanding of the use context is important (Kristoffersen et al. 1998, Brown & Duguid 1994, Rodden et al. 1998, Schmidt 1999, Dey 2001, Agre 2001). The use of technology is highly dependent upon the context in which the technology is used. In mobile IT use, the users are finding themselves in many different situations which leads to heterogenous use situations and thus different user needs. The influence of other persons, objects and social structures shape the role and meaning of the artifact in the context. In this way, the

[3]The original source of the statistical numbers is *www.unesco.org*.

border resources are not only developed through the characteristics of the material, but also due to a social process (Brown & Duguid 1994). In the following we analyze and discuss the use in relation to social and environmental aspects.

7.3.1 Community of practice

In the clinical contexts only the students were using PDAs. Nurses and physicians did not use them. At the GP offices the medical student we observed were the only student present, and thus the only person with this kind of mobile terminal. The three students at SiV were the only persons intended to utilized PDA for medical purposes at the hospital.

Brown & Duguid (1994) states that:

> *It is hard to share and coordinate practice if you don't share the same physical space. It is virtually impossible if you also don't share, in some way, the same objects.*
>
> — (Brown & Duguid 1994, page 23)

The mobile terminal was not a shared object among the staff in the clinical contexts of the students. The patient's Journal is shared in the way that is a resource which all physician, nurses and students use frequently. Handbooks are shared in the way that they are often utilized and brought at the hospital, and the same applies to the stationary computer. These shared objects are referred to when discussing an issue or medical theme. When students are receiving guidance related to the practical training these information resources were referred to. The mobile terminal was never referred to.

Wenger (1998) mention three essential characteristics of a community of practice: mutual engagement, joint enterprise and shared repertoire. The fact that the mobile terminal was not a shared object among the clinical staff, resulted in the mobile terminal and its services not becoming a part of the shared repertoire in the clinical context.

To be part of a community of practice the students have to have the possibility to share knowledge and experience. Since the students were in a practice situation they engage themselves highly in others work. Through discussions and meetings they shared experience and meanings, and thus created a shared repertoire. In the clinical contexts they discussed and shared medical knowledge and experience, but they did not have the opportunity to discuss the use of the mobile terminal in the same way. They could not walk over to a colleague to ask for help or just listen to other informal conversations. Because of this, the student were influenced by the other clinical staff, and preferred to utilize what the community of practice perceived as information resources.

In the clinical contexts it seemed to be too few users of the mobile terminal. There were not enough persons that used the same device, and thus they could not discuss or learn the use from others. We could say that the use of the mobile terminal did not reach a critical mass of users. The critical mass of users could be explained according to the *installed base* (Hanseth 2000, Hanseth & Monteiro 1998).

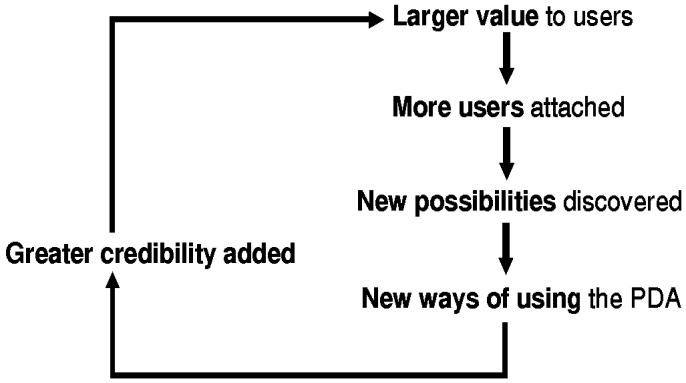


Figure 7.2: The concept of the learning reinforcement mechanism when more users take the technology into use

The more users that adopt the mobile terminal, the more credibility will be added to the use of it (see Figure 7.2). The figure is based upon a similar by Hanseth & Braa (2000). If all, or at least many more, people at the hospital had used the PDA as well, we think the mobile terminal would have gotten a greater credibility and value among the users. Brown & Duguid (1994) talks about overhearing co-workers conversations, which gives the possibility to join discussions or conversations whether they are relevant or just interesting. In this way people can learn things they otherwise would not learn (ibid.) By reaching a larger mass of users of the mobile terminal, the use of it, hint and tips could be a topic of conversations in hall ways and during lunch. The users could share experience and learn from each other, and in this way take more advantage of the PDA's possibilities.

An example of the community of practice as a learning institution is given in a report from one of the super-users. At a hospital there were a student who utilized the terminal quite often. But he, in contrast to the other students, got hints and help from one of the house physicians at the hospital. The house physician gave him advice and guidance on related services, applications and Internet pages. In this way the student saw other and valuable sides of use in the clinical context.

The mobile terminal, serving as an information resource, was not a shared object in the clinical contexts, and hence it did not become a social valuable artifact in the community of practice.

7.3.2 A multidevice paradigm

From the previous section we have seen that the students turned their mobile use context into a stationary one by using the terminal in places where they could sit down and thus had longer periods of time available for interaction. Both the GP office context and the traveling context was characterized by s stationary use context, the difference mentioned earlier was the user mobility. But, we argue, that maybe more important was the presence of other devices. The traveling context was not a complex context. There where no community of practice or other artifacts present, which the PDA was supposed to be a part of. Dahlbom & Ljungberg (1999) also points to this problem. As long as mobile IT users switch between stationary and mobile IT use, they will use the best terminal at hand (Dahlbom & Ljungberg 1999). But, we also found, as mentioned above, that the students preferred to use the existing paper-based information resources when they were present.

The medical students in the hospital context always talked about the superior characteristics of the existing artifacts when they argued for their non-use of the mobile terminal. They preferred, when they had the opportunity, the best device at hand.

The fact that the medical students used many different devices to solve a task or many tasks, is according to Gallis et al. (2001), called *the multidevice paradigm*. The multidevice paradigm refers to use of many different computing devices to accomplish a task. The use of the term in this thesis involves both analog and digital devices. The students preferred, as mentioned above, the best device at hand, and they used many, both specialized and more universal, devices.

When we was carrying through our contextual inquiries at the hospital we pretty soon discovered the quite complex interplay of different artifacts when solving a single task. The opening scenario illustrates this. Figure 7.3 shows the devices and objects that usually are a part of solving a task at the hospital. In the GP context the situation is the same, but there the stationary computer is the main information resource, supplemented by other resources.

The use of the mobile terminal as a book and notepad certainly was a part of a more complex *task chain* (Gasser 1986). A task chain is defined as *a production sequence for an object or event.* The medical student's task chain is the sequence of steps a he has to accomplish in order to solve a task. An in this sequence he is utilizing several information resources and artifacts. We observed that those artifacts was used in an unstructured order, and sometimes they even used different books which had almost similar content. The students often used many different resources in a randomly order, and we observed that the meeting room functioned as their central 'base' or library at the hospital. In the GP offices the consultation office contained all the needed information resources, and thus the students had everything they needed on the office table.

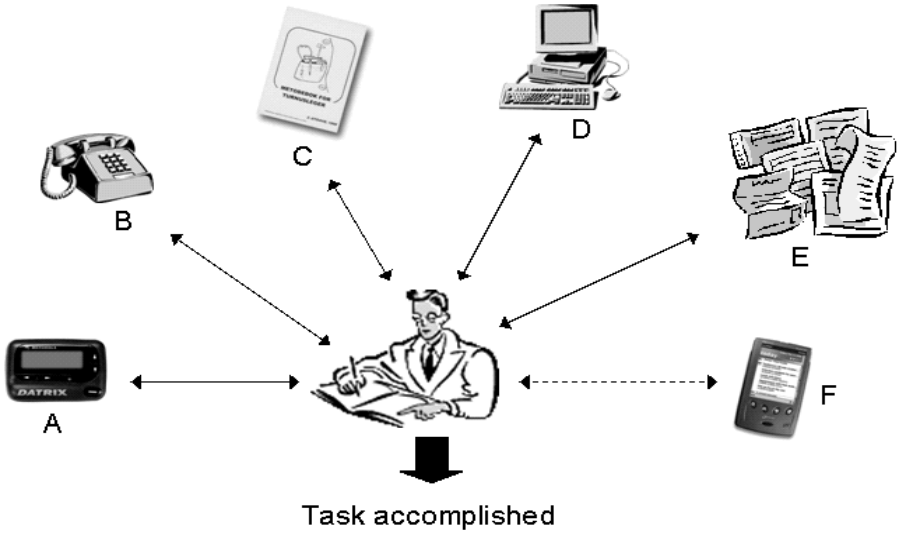


Figure 7.3: At the hospital the students were using many devices to accomplish a task. The devices mostly used where: (A) pager, (B) telephone, (C) paper-based medical handbooks, (D) stationary computer, (E) different paper resources such as Journal and pre-arranged notes, and (F) very seldom they used the PDA serving as a notepad or medical handbook.

The PDA, neither serving as an e-book nor as a notepad, was used in the task chain or in interplay with other artifacts. There were several other paper-based handbooks available, including the paper-based version of the e-book, and then the students expressed that they felt it awkward to utilize the e-book: "Why bother going through many steps in order to utilize the e-book (referring to the five steps described in Section 6.5), as long as I can utilize a paper-based handbook available within reach?"

The mobile terminal serving as an information resource did not contain services to support the whole task chain of the medical students in most instances. The e-book and the notepad installed on the mobile terminal is only sufficient to solve minor parts of a clinical task. In this way, we state that the PDA's ability to support a task is a *slip* (Gasser 1986). The PDA provide an undersupply of resources related to the task chain. A medical student said it in this way:

> *I often have to use other books as well when searching for information. Why should I then use the PDA and after that start searching in other books and information resources. It feels quite awkward to do so.*
>
> — Medical student explaining why he did not use the e-book

Another reason slip is the issue of how long time the student had to use in order to look-up in the e-book or write a note on the PDA, compared to using other resources. The technical problems related to the use of the PDA, is also a kind of instance of slip.

There were sufficient of information resources available in both clinical contexts in order to fulfill a task. Because the students often ended up in the meeting room, or were situated in the office, they had all resources at hand, and why then use the mobile terminal. We think that this situation refers to slack (Gasser 1986). In this way the mobile terminal serving as an information resource refers to both slip and slack in the task chain.

Gasser (1986) says that when there is a misfit between the resources and the work that they are intended to support, the user will try to avoid this in several ways. One of those strategies is *working around* the problem by for example avoid its use and rely on alternative means of accomplishing work. Even if Gasser's (1986) concept of *working around* is used for stationary computing, we think it sheds light upon why the students did not use the PDA. The medical students did not manage or need to adapt the mobile terminal into the task chain or work practice.

The students proposed to gather the core medical handbooks used to solve tasks on the PDA with hyperlinking between related topics across the books, and look-up in different resources could be eased. In this way the PDA would support more of the task chain, and the degree of slip could be reduced. Reflections around this solution are presented further in Section 8.1.

One student stated that he was unsure of what the patient would think of such a device as the mobile terminal. He thought that the patient would be sceptical to the physician's or student's use of the terminal during visits or consultations. We state that this is as another instance of misfit of the mobile terminal in the clinical practice. To reduce the scepticism of the patient we think it is important to let the patient perceive that the PDA is an information resource on the same footing as the paper-based resources or a desktop computer. Brown & Duguid (1994) refers to this as *transmitting authority*. Figure 7.4 shows an example of how we think authority could be added to the PDA and transmitted to the surroundings. The PDA is painted white. White is a widely used color in clinical environments and this could maybe give the patient more trust in the PDA as a clinical artifact.

Because there was a misfit between the mobile terminal, serving as an information resource, and the task chains, the use of it became limited.

7.3.3 Just-in-time

In the previous section, we talked about tasks in the medical students' clinical practice. In this section we are focusing on the single look-ups in handbooks and

Figure 7.4: The picture is arranged to illustrate an approach of transmitting of authority.

databases, and the note taking as a single task. These tasks are done either in relation to a complete task, or as a single task during consultations, visits, meetings or lectures. Just-in-time (JIT) access is a term used in relation to the Knowmobile project, and refers to accessing information *when* you need it. In the clinical practice, students mostly experience JIT tasks in relation to consultations and visits. These situations require JIT look-ups or JIT note taking. The opening scenario describes both JIT place look-ups and JIT note taking. We observed JIT tasks done during our contextual inquiries. At the hospital JIT note taking were very important during visits and lectures, but also JIT look-up. At one incident the medical student had to walk back to the meeting room to inquire about an X-ray picture concerning a patient during a visit. At the GP office we observed the student making look-ups in handbooks available on the desk, in WinMed on the desktop computer during consultations, as well as note taking using WinMed.

According to Kristoffersen & Ljungberg's (1998) *modalities*, the students were *wandering* a lot at the hospital. From the meeting room to the patients' rooms, down the long corridors, to other wards and to the education center. They did not stay very often at one specific place, except from the meeting room. This kind of walking is described by Bellotti & Bly (1996), who found that people often went out of their office to search for other persons or use shared resources. They call this *local mobility* (Bellotti & Bly 1996). Kristiansen (1997) refer to this type of mobility as *user mobility*. The meeting room contained a well of information resources

that the students used regularly, usually between and in advance of different tasks. In the hospital context they also carried the most essential resources with them in their coat's pockets. The ability of a device to be portable refers to the term *terminal mobility* (Thanh 1997, Hegeman & Abarca 1997).

In the hospital context the JIT note taking was done by using a paper-based notepad or a piece of paper. The reason for not using the PDA for this was, according to the students, that the input and interaction with the terminal was very difficult and time-consuming.

Dahlbom & Ljungberg (1999) and Kristoffersen & Ljungberg (1999*a*) point to the concept of mobile users that try to re-configure the mobile use context into a stationary one, by for example sitting down when using the mobile terminal. The students experienced that the use of the PDA was inconvenient when standing or walking. The issue of the technical properties also made the JIT look-ups more difficult. In order just to look up a topic in the e-book, the students had to go through several steps using a pen on a small screen e.g.. Kristoffersen & Ljungberg (1999*a*) and Koht-Tøfte & Olsen (1999) point to the high visual attention the PDA demands from the user as a problem for mobile use, and in this way it became difficult for the students to use the PDA in front of a patient during a consultation, or observing the other physicians. Imagine, hitting small letters with a pen while holding the PDA while you are standing upright. You are not only supposed to write the words correctly into the PDA, but you are also supposed to perceive what you hear and to write down the topics of a consultation or a lecture.

In the GP office and traveling contexts the student was finding himself in a stationary use (Kristoffersen & Ljungberg 1999*a*) situation all the time. The students were located in the office throughout the day, except during lunch. Because of no user mobility (except inside the room) and the presence of a stationary computer and other information resources, there was no need for the terminal mobility of the PDA. We observed that the student used WinMed for both JIT note taking and JIT look-ups. They preferred to use the stationary computer because of a bigger screen and keyboard, rather than the mobile terminal. Using a stationary computer is also more comfortable compared to the small PDA (Kristoffersen & Ljungberg 1999*a*). Occasionally the students used handbooks for inquiries.

On the train, this was quite different. There were no other computers or devices present, and because the PDA was terminal mobile, it could be utilized in this context. The use situation was stationary as well. The terminal was easy to carry, they could sit down, and relax and spend time on using the PDA during the travel. Nothing else demanded their attention – except the train ticket collector. The only JIT tasks being done here, was sending e-mail and SMS.

From this thoroughfare of JIT tasks and mobility in the three contexts, we state that even though the PDA support the JIT tasks, the technical characteristics of the mobile terminal affect the use of it. JIT interactions sets demands for the time

a student can use in order to write a note, and as long as interactions with the PDA requires time and attention, and using it while standing is difficult, the student choose paper-based tools. In the GP context there are no requirements for user mobility and the student could perform JIT interactions sitting down. Still, the student chose not to use the mobile terminal. We believe that the arguments presented above regarding time required to interact, attention and characteristics of the mobile terminal are valid for the GP contexts as well. But in addition, the time available for writing notes were limited during the consultation. One student told use that each consultation should not last for more than 15 minutes, which was too short, he meant. Often he had to type his hand written notes into WinMed when the day of practice was ended, because he did not have time during the consultations. This implies that when there were a need for a JIT interaction, it had to be done quickly. We did not observe these time frames at the hospital.

The mobile terminal was not prefered as an information resource in the clinical contexts because it did not support just-in-time interactions.

Chapter 8

Conclusion

In this chapter we will point to the essence of the discussion in the previous chapter and present the conclusions related to our main research question. Then we discuss possible areas of further work based on our findings.

In this thesis we have studied use of mobile terminals, serving as information resources, in the medical students' practical training. We developed an e-book prototype of a medical handbook, which together with the notepad on the mobile terminal, constituted our main focus. Our empirical investigation was done through interviews and contextual inquiries of medical students related to the Knowmobile project. We have observed use in three different contexts; hospital and general practitioner offices, and traveling by train.

Our main research question was:

> *What are the conditions for the possibility for using the mobile terminal as an information resource in the medical students' clinical practice?*

In general, we found very limited use of the mobile terminal, serving as an information resource, in the clinical contexts. The use increased when moving out of the clinical contexts, and on the train we observed a lot more use of the mobile terminal. This showed us that the use was dependent upon the type of context in which it was used, and the activities the student wanted to accomplish.

Based on the analysis and discussion in the previous chapter, the following statements describe critical factors to why the medical students did not prefer to use the mobile terminal, serving as an information resource:

- The mobile terminal was seen as an obstacle instead of a companion due to its characteristics mentioned by the students.

- The mobile terminal was not preferred as an information resource, because important resources of the paper-based artifacts for the students in their clinical contexts were removed.
- The mobile terminal, serving as an information resource, was not a shared object in the clinical contexts, and hence it did not become a social valuable artifact in the community of practice.
- Because there was a misfit between the mobile terminal, serving as an information resource, and the task chains, the use of it became limited.
- The mobile terminal was not preferred as an information resource in the clinical contexts because it did not support just-in-time interactions.

These are all factors which shed light upon our main research question. And, the conditions these statements imply, explains the limited use of the mobile terminal, serving as an information resource in the clinical practice.

8.1 Further work

In this section we propose some ideas and areas of further work. These propositions are partly based on statements of the medical students, and partly on our own reflections. We also think that these propositions could be an approach to fulfill some of the conditions presented in the conclusion. They are all concerning aspect of use and the usefulness of a mobile terminal in a medical students' clinical practice.

Specialized terminal

An interesting aspect is whether the mobile terminal should be a more specialized device instead of a universal device. The mobile terminals used in the Knowmobile project were universal devices. There already exist many different specialized e-book reader devices (An example is shown in Figure 8.1). The dedicated e-book devices are focused on screen technology and presentation of the content, and they should therefore be more comfortable to read. But, at the other hand they are bigger and more heavy than the PDA. Anyway, there are many interesting aspects regarding the use of such a dedicated-purpose device in clinical contexts.

- Would a specialized device reduce the lack of borderline resources?
- What advantages could such a specialized device give the students?
- Does such a device support the students' need for mobility, and terminal mobility?

Figure 8.1: The RCA REB 1100 dedicated e-book reader device

- What are the characteristics of a device that could fit into the clinical contexts?

Another interesting issue is to investigate whether the mobile terminal should be personal or work oriented. By making the mobile terminal less personal and more adapted to the work context, we think, at least at a hospital, that the users would gain more confidence in the PDA as a clinical artifact.

Several interlinked digital versions of handbooks available on the mobile terminal

A proposal from several students was to implement the most utilized handbooks on the mobile terminal and interlink related themes crosswise between the books. This service would give them more utility value, they said. The linkage could make searching for topics and cross-checking faster. Through this thesis we argue that one reason for not using the mobile terminal, serving as an e-book, is that the medical students had to utilize several other books in their task chain. In this way the mobile terminal could cover a whole task, or a larger range of a task.

There are several interesting aspects to investigate related to this proposition:

- How can the use of the mobile terminal, serving as a collection of medical handbooks, improve the information access?
- What technology should be used? e-books? Databases?
- Should the information be stored on the terminal or centrally on a server? What about the network access?

- Medical handbooks are frequently updated. E.g. “Felleskatalogen” is issued every year. How to manage updates and new issues, and to secure that all students have the most updated version available, seems to us as an interesting question.
- What precautions have to be taken or introduced in order to verify the content and the linkage?
- In difference to a single e-book: Would the student perceive the lack of border resources when using a more extensive service as this proposition? When using an electronic *book*, do they expect the service to be *like* a book? Would the expect the more extensive service as books because the information provided has its origin from handbooks?

Other services

We have in this thesis focused on the mobile terminal as an information resource. We think there would be interesting to identify other useful services, which mobile terminal could provide to the medical students or physicians. There are probably other services which would be useful in the clinical practice.

In order to get some ideas of other useful services for medical students and physicians, we had another conversation with Dr. Med. Lars Aabakken. A selection of his propositions are presented here:

- Implement ICD-10, which is a handbook containing a framework of codes used for all diagnosis. These codes are integrated in journals at hospitals, and should be available where desktop computers not are available.
- “Calculation things” (Aabakken’s own phrase). The PDA could be appropriate to execute calculations of formulas in relation to see implications of a blood sample or a urine sample e.g.
- To support the physician or student to make a correct diagnosis, formulas based on expert systems could be implemented.
- To provide an extract of journals. Aabakken mentioned that the journals not can be taken out of the hospital, which causes problems when doing home visits. Often the physician have to make a phone call to inquire about an issue described in the journal. But, there are too many problems concerning the legal framework to accomplish such a service.
- It would be useful for a traveling physician to be able to connect to a pharmacy and order medicines or prescriptions via the mobile terminal. The service could check the prescription against the patient’s existing medicaments.

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Appendix A

Technical Specifications of the Mobile Terminals

A.1 HP Jornada 548

Figure A.1: Hewlett-Packard Jornada 548

Processor	133 MHz 32-bit Hitachi SH3 processor
Memory	32MB RAM 16MB ROM
Display	240 x 320 pixels LCD rich color display Microsoft ClearType[tm] display technology
User Interface	Pen-and-touch interface Handwriting recognition software On-screen keyboard 4 user-configurable quick launch screen icons 2 quick keys (Record and Scroll/Action) Notification LED
Battery	Built-in Lithium-Ion rechargeable battery 8 hours of battery life
Input/Output	IrDA infrared port RS232 serial port USB cradle CompactFlash Type I card slot AC input jack Stereo earphone jack
Sound	Audio speaker and microphone Built-in voice recorder Digital audio player compatible
Size and Weight	5.2 x 3.1 x 0.6 in (13 x 7.8 x 1.6 cm) 260 g with battery
Included Software (in ROM)	Microsoft® Windows® for Pocket PC Microsoft Pocket Outlook Microsoft Pocket Internet Explorer Microsoft Pocket Word Microsoft Pocket Excel Microsoft Money for Pocket PC Microsoft Reader Microsoft Windows Media Player LandWare OmniSolve? PeaceMaker 1.0 (exchange contacts with other PDAs via IrDA)
Included Software (on Microsoft CD-ROM)	Microsoft ActiveSync® 3.1 Microsoft Outlook 2000 Yahoo!® Messenger Sierra Imaging, Inc. Image Expert® CE MusicMatch® Jukebox 4.4

Table A.1: Technical Specifications for HP Jornada 548

A.2 HP Jornada 720

Figure A.2: Hewlett-Packard Jornada 720

Processor	High-performance 32-bit StrongARM SA1110 processor, 206MHz
Memory	32MB SDRAM, 51MHz
Display	6.5 in (16.5 cm) color LCD display 640 x 240 pixels on screen 2D graphics acceleration
User Interface	Comfortable touch-typeable keyboard (3/4 full-size) Embedded numeric keypad Touch screen
Battery	Rechargeable Lithium Ion battery One 3V CR2032 coin-cell backup battery AC adapter Up to 9 hours of battery life
Input/Output	High-performance internal modem 56Kbps, v.90 One RS232C serial port, 115Kbps One IrDA port, 115Kbps One RJ11 modem port One PC Card Type II card slot One CompactFlash Type I card slot One Smart Card reader card slot
Sound	Audio speaker and microphone Stereo audio jack Built-in voice recorder
Size and Weight	7.44 x 3.74 x 1.34 in (189 x 95 x 34 mm) 510 g with standard battery
Included Software (in ROM)	Microsoft Windows® for Handheld PC 2000 Version 3.0 operating system Microsoft Pocket Word Microsoft Pocket Excel Microsoft Pocket PowerPoint Microsoft Pocket Access Microsoft Pocket Outlook (Calendar, Tasks, Contacts, Inbox) Microsoft Internet Explorer for Handheld PC Microsoft Windows Media Player for Handheld PC Microsoft Voice Recorder Microsoft Terminal Server Client HP ChaiVM 4.1.2 LandWare OmniSolve[tm] (business calculator) Yahoo!® Messenger
Included Software (on Microsoft CD-ROM)	Microsoft ActiveSync® 3.1 Microsoft Outlook 2000 (desktop version)

Table A.2: Technical spesifications for HP Jornada 720

Appendix B

Interview draft (in Norwegian)

Vi må nok også utdype hva vi mener med informasjon. Eller kanskje bedre; hva menes med informasjon.

Stikkord:

- **Hva (Informasjon om hva?):** Diagnoser, bilder, artikler osv.
- **Hvordan:** Bøker, databaser, Internett, forelesningsnotater, samtaler med leger/medstudenter.
- **Hvorfor (Hvorfor henter de inn informasjon)**
- **Når (i hvilke situasjoner henter de inn informasjon):** Før, under eller etter pasientbesøk/undersøkelser
- **Hvor er de lokalisert når de henter inn stoff:** Hjemme, i bilen, på sykehuset, på skolen.

Hvis vi tar utgangspunkt i sist gang du hentet inn informasjon om et tema/problem/sykdom.
Hvilken situasjon var du i?
Kan du fortelle litt om hvordan informasjon du søkte etter?
Hvor søkte du etter informasjon? Bøker/database/notater/personer/tidsskrift.
Hvorfor valgte du å søke etter informasjon på denne måten?
Er dette slik du vanligvis søker etter informasjon?
Hvorfor/hvorfor ikke?
Kan du nevne noen andre informasjonskilder som du har brukt?
Hvorfor brukte du disse informasjonskildene?
Hvor ofte har du brukt disse informasjonskildene?
I hvilken forbindelse har du brukt disse informasjonskildene?
Hvor finner får du tak i den informasjonen du stoler mest på?
Hvorfor stoler du mest på denne informasjonen?

Hvilken informasjon stoler du minst på? Hvorfor?

Informasjonskilder: For å innhente informasjon; hvor ofte bruker du:

- Notater
- Foreleser
- Veileder
- Medstudenter
- Lærebøker
- Andre bøker

Er det situasjoner der du har følt at du har trengt informasjon, og ikke hatt tilgang til informasjon?
Synes du det er vanskelig å finne frem til den informasjonene du trenger?
Hvorfor/hvorfor ikke?
Har du noen formeninger om hvordan informasjonssøking og innhenting kan skje på en enklere måte enn i dag?

Gjenta spørsmålene over med fokus på notatskriving.

Du skal snart ut i praksis. Hvor skal du ha praksis?

Kommer du til å jobbe mest alene eller i samarbeid med andre? I så fall; hvem vil du jobbe sammen med?

Hva tror du vil bli din viktigste informasjonskilde i denne perioden?
Hvorfor?

Appendix C

Data Collection Procedure

Focus

The collected material will be used in the masters project to make a picture of the context in which the medical students works. The primary focus for the context data collection is "describing current situation". We want to investigate how and when different devices are used in this context, and how the electronic version of 'Metodebok for turnusleger' is utilized and used. Getting ideas for further design has secondary priority.

Target Group

The target group for the user support and this contextual inquiry is the group of medical students placed at Vestfold Sentralsykehus in Tønsberg:

- Name Withheld
- Name Withheld
- Name Withheld

Target Situations

The target situation here is the work of the medical students at Vestfold sentralsykehus, and other locations such as when the students are travelling, or are at home doing various tasks. We are not focusing on a special task or situation, but the general tasks and problem solving using different terminals or devices (both electronic and paper based).

Method outline

The information gathering will take one day. You will hopefully spend:

- $\frac{1}{2}$ day at the hospital

- $\frac{1}{2}$ day at the student's current home

The method used will be contextual inquiry. This is basically a structured field interviewing method, based on a few core principles that differentiate this method from plain, journalistic interviewing. Contextual inquiry is more a discovery process than an evaluative process; more like learning than testing.

In each location observation will be conducted. It is impotant to watch the people from the target group, other people in the surrounding, places, etc. and take notes about what people actually do. Documentation will be made by taking notes and with a camera.

When discovering something interesting, we'll try to get in touch with the student after she has finished what she was doing, and start an informal dialogue. We need to know the following:

- What was she doing?
- Why was she doing it?
- Was she solving a problem? In that case what kind of problem was she solving?
- What need instantiated the action she took?
- What kind of technology did she use in this situation?
- How did she use this technology?
- How did the patient react to the use of this technology?
- How did she inform the patient about the use of technology?
- How did this technology help her in solving the task?

Input to Data Collection

The following list in Table C.1 can be used as input to the data collection.

Data may be supplemented with conclusions and ideas relevant to the project.

Photographing

Photographing in context may be a bit problematic. We suggest the following procedure:

- Step1 - Take some general shots showing the situations and area with little focus on individuals and tasks.

Category	Comments
General description of situation	people, buildings, location, time of day, how long do they stay, technology, equipment
Tasks	what do people do, what is their main focus in the current situation, personal or job tasks?, how are the tasks performed
Motivation	main focus of attention, why do they do what they do
Communication	how do the students communicate, frequencies, with whom, in what situation
Tools	What tools do people use (electronic and non-e) in the situation
Social information	Social organization, groups, inter-group communication

Table C.1: Input to the data collection

- Step 2 - If possible, get material describing tasks, people or other interesting details in the situation.

Ethical Issues

The hospital context includes civil patients in consultations and in treatment. This involves restrictions concerning privacy in that restricted information could be exposed during this inquiry. Photographing cannot be done if patients are exposed or identified; neither can we access information concerning the patient, except when the patient specifically approves this.