6

Studying Knowledge Work

It has been mentioned earlier in this thesis, but it is worth to repeat that the part of the population that has information as a major working object will continue to grow in both size and importance. There are several indications that we are entering a society in which information, knowledge and competencies are becoming resources more important than the material resources that the industrial society is founded on. All this sets up needs and requirements on the members of society, but also on the educational system and companies.

What it means to be a knowledge worker is very much an open question. The process to answer that question involves both theoretical work, like that in the first part of this thesis, but also work that is more practical, such as studies and implementations. This chapter and the next three chapters take a practical perspective on the question of what it means to be a knowledge worker. The purpose with this chapter is to introduce and discuss ideas about how to study knowledge work. The first section discusses motives, aims, methods, etc. The next two sections present two studies of knowledge work, both are carried out as a part of my current research. The first study is a periodical study of people's view on computers and computer systems, which was carried out in 1998 for the first time. The second study is a study of today's knowledge workers. This study is carried out together with Telia, one of the largest telecom companies in Sweden, as part of the FIOL research program.

1. To study knowledge work

In some sense, it is hard two find studies with an explicit purpose of studying knowledge work or knowledge workers, like Kidd's study (Kidd, 1994). On the other hand, there are many studies and experiments in a wide range of research areas carried out that benefit our general knowledge about knowledge workers; e.g. Kuhltau's study of the process of information retrieval (Kuhltau, 1993), Marton's study of the learning process (Marton, 1974), Bengtsson et. al's studies of virtual communication (Bengtsson,

1999), Sissi Ingman's study of how use of computer artefacts could be understood from the aspect of trust (Ingman, 1997), etc. These studies and experiments make a contribution to our understanding of knowledge work, but it is a huge and not always uncontroversial task to compile this manifold of studies into one theory or picture.

If one accepts my view of knowledge society and all that it entails, there are mainly three motives to study knowledge work. First, even if the studies and theoretical works about knowledge work and knowledge workers reported in the literature are many, still there are open questions, such as:

- Which are the problems that knowledge workers meet in their work?
- Which attitudes and values prevail among knowledge workers?
- Are there different kinds of knowledge work?
- What is it that unifies all kinds of knowledge work, what is the archetype for a knowledge worker?
- From their own experience, what tools/support do knowledge workers need?

Second, in order to create and design tools and support for knowledge workers to better cope with their working situations in a physical-virtual working environment, we need a deeper and broader understanding of *knowledge work*, and the *working situation* for today's knowledge workers. Third, in order to verify the ideas that the knowledge worker approach to learning are based on, it is necessary to carry out studies with a goal to clarify what it means to be a knowledge worker.

If the study object is knowledge work, what does it means to study it and what are the methods that one has at one's disposal? Methods from psychology, pedagogy, and other behavioural sciences are those that are most natural to adopt, such as: questionnaires, field observations, interviews, and experiments in controlled laboratory set-ups as well as on-site experiments. All these methods imply almost the same phases: design, data collecting, processing of data, and presentation of the results. Questionnaire is the main method for the two studies reported in this chapter, but with elements of field observations and interviews.

Some interesting future projects are experiments (both on-site and in laboratories) concerning the use of various kinds of tools (search engines, email, Post-it™ notes, where the main question is if the tool supports the knowledge worker in a satisfactory way. Another relevant project is to carry on with Kuhltau's studies of information retrieval and study how knowledge

workers establish and keep focus with help of tools, such as paper and pencil, palm computers, etc.

2. The study of people's conception of computers

People's picture of computers; what they are good at, how to use them, etc. (people's conception of computers) vary among individuals, some of these differences can be traced to the level of education, the level of experience of computers, and professional category (Ingman, 1997). I also believe that some of the differences can be traced back to the values that guided the design of the system. Hence, to claim that peoples' conception of computers changes over the time is not controversial. All this gives us the possibility to trace changes or a progress of computers and computer systems in the changes in people's conceptions of them. The idea is to utilise this in order to identify values that the knowledge worker approach stands for in the design of today's computer systems.

The study

The aim with this study of people's conception has been to verify and follow up concepts and ideas from the theoretical work concerning tools for knowledge work. Running this study periodically gives us a possibility to follow a development in both peoples' conception of computers but also a development in the design of computer artefacts. In the spring of 1998 the study was carried out for the first time, and the plan is to run it every third year, hence the next time will be in year 2001.

The study is based on a WWW-based questionnaire, and it is mainly directed to relatively experienced users of computers. Except from the background questions about sex, age, etc. the questionnaire consists of four parts.

- questions about the use of computers;
- questions about the view on computers;
- an evaluation of the computer as an artefact;
- an evaluation of a possible scenario for the future.

Some results from the first run

When the study was carried out 1998, one of the goals with it was to get more experience from running this kind of study. In order to get subjects for the study an invitation to take part in the study was announced via email to

staff at the Umeå University, and this resulted in a group of 22 subjects. The age of the subjects were equally distributed over the range 20 to 45 years, with males in the majority, and none of the subjects judged themselves as inexperienced with computers. I believe that this group mirrors the situation in many of the technical departments.

Questions about the use computers

The purpose with this part is to collect data about the purpose of the subjects' use of computers, and whether they use them only in the profession or also for more private use. A clear majority of the subjects use computers also in their spare time.

Purpose	#	%
Developing software	18	95%
Searching for information	19	100%
Control or supervise	6	32%
Constructing	6	32%
Designing	9	47%
Editing	18	95%
Play games	15	79%
Communicate	18	95%
Learning	14	74%
Enter and register data	13	68%

Table 3. The purpose of the subjects' use of computers.

To complement the closed question about the subjects' purpose with their use of computers, the subjects had an opportunity to freely give examples on other ways they use computers, such as: "*writing entertainment*", and "*as an object for research*".

Questions about the view on computers

The purpose with this group of questions is to collect data about the way people understand computers or their view of them – is it a person or a tool? There were two questions: a closed and one open question complementing the closed question.

Conception of computers	#	%
Automaton	10	53%
Communication channel	14	74%
Co-ordinator	2	11%
Expert	0	0%
Fellow-worker	1	5%
Game	4	21%
Gold-mine	2	11%
Knowledge bank	7	37%
Oracle	0	0%
Person	0	0%
Personal amplifier	5	26%
Social actor	1	5%
Tool	18	95%

Table 4. The personal view of computers.

"computers are simple machines that can be designed to do anything imaginable"

"It's a great help in my daily work and communication. For me it is mostly a tool to get the job done"

"The computer is a powerful tool that can enhance the performance of an individual or group"

"I see the computer as a tool to make my work easier"

"A good tool for communication"

"Creativity enhancer and activator"

"Dumb thing that most of the time do as I say"

Citation 1. The view (metaphor) on computers.

Evaluation of the computer as an artefact

The purpose with this group is to apply the nine dimensions of artefacts from chapter 2, on computers and computer systems in order to evaluate the status of today's computer artefacts.

Directness	
This does not correspond at all with my views	16 %
This corresponds poorly with my views	32%
This corresponds in part with my views	32 %
This corresponds well with my views	16 %
I couldn't say it better myself	5 %

Table 5. Computer systems are artefacts that often affect objects directly when they are used.

Interface	
This does not correspond at all with my views	5 %
This corresponds poorly with my views	21 %
This corresponds in part with my views	42 %
This corresponds well with my views	21 %
I couldn't say it better myself	5 %

Table 6. Computer systems are artefacts through which a user can interact with the object, serving as a medium for interaction.

Control	
This does not correspond at all with my views	21 %
This corresponds poorly with my views	10 %
This corresponds in part with my views	37 %
This corresponds well with my views	21 %
I couldn't say it better myself	5 %

Table 7. Computer systems are artefacts that are controlled by the user, little or none of their functions are hidden.

Generality of the object	
This does not correspond at all with my views	0 %
This corresponds poorly with my views	0 %
This corresponds in part with my views	26 %
This corresponds well with my views	37 %
I couldn't say it better myself	37 %

Table 8. Computer systems are artefacts that often can be applied to a wide range of materials.

Generality of the method	
This does not correspond at all with my views	0 %
This corresponds poorly with my views	5 %
This corresponds in part with my views	32 %
This corresponds well with my views	32 %
I couldn't say it better myself	32 %

Table 9. Computer systems are artefacts that are often general-purpose.

Combinability	
This does not correspond at all with my views	5 %
This corresponds poorly with my views	5 %
This corresponds in part with my views	68 %
This corresponds well with my views	5 %
I couldn't say it better myself	16 %

Table 10. Computer systems are artefacts that are easy for the user to combine, to get a more powerful and new use of them.

Complexity/simplicity	
This does not correspond at all with my views	32 %
This corresponds poorly with my views	47 %
This corresponds in part with my views	16 %
This corresponds well with my views	5 %
I couldn't say it better myself	0 %

Table 11. Computer systems are artefacts that in general are very simple constructions, both regarding the number of parts and as an idea.

Flexibility	
This does not correspond at all with my views	0 %
This corresponds poorly with my views	5 %
This corresponds in part with my views	42 %
This corresponds well with my views	32 %
I couldn't say it better myself	21 %

Table 12. Computer systems are artefacts that can be used for performing tasks that they are not dedicated for. Much of the strength of computer systems is the possibility for users to invent new methods and purposes of using them.

Skill	
This does not correspond at all with my views	0 %
This corresponds poorly with my views	0 %
This corresponds in part with my views	16 %
This corresponds well with my views	47 %
I couldn't say it better myself	37 %

Table 13. Computer systems are artefacts that users, through constant practice, can master.

Evaluation of a possible scenario for the future

The aim with this part is to collect data about people's thoughts, and ideas for the use of computers in the future. After the subjects have read a scenario (presented below) they estimate the probability that this scenario will become reality, and if they want the future to be like the scenario.

Scenario: The information and knowledge society is already a reality. Today, there are many people who could be called knowledge workers, and in a scenario for the future the number of people professionally involved in producing, consuming, processing, and managing information will increase. As we enter the information society, our attention shifts from machines to information and representation, and we are faced with a working and living environment as different from the industrial society as it was from the rural society. To get along in this new environment we need tools (cognitive tools) that supports us to find, extract, examine, modify, organise, create and interact with symbolic representations of different kinds. Such a cognitive tool can typically be moved between different environments and situations, can be applied to various types of objects for a number of different purposes, and will allow its user to invent new purposes and new methods of use. The advantage that good cognitive tools bring to their users implies a growing market of tool buyers, suppliers and inventors.

John is a nurse working in a small village on the country side. John has through the years grown a deep interest in asthma, mostly because the patients he has met has affected him, but also the fact that he himself suffers from asthma. Much of his genuine competence he has acquired through his practice. Because of his interest for asthma, he has also studied asthma more theoretically. John's competence and interest for asthma is well known by many of his colleagues.

It is Monday morning and John is sitting in front of his computer at home doing some of his administrative work when he is interrupted by a message from his conference system. It is Lisa, a colleague of John. She has met some patients during the last weeks who seem to suffer from asthma but there is something that worries Lisa, and she has decided to contact John. John and Lisa decide to start collaborating with Lisa's patients and her thoughts in focus.

The first thing they do is to set up a common work environment with some tools, tools that John has rather good experience with from his earlier work, but also some tools suggested by Lisa. Typically, it is tools for browsing, communicating ones work and results, keeping focus, and a number of tools for visualising information. Among other things, they use some of the values

from laboratory experiment that John has collected, and a database with articles.

Lisa's idea has to do with one of the more established theories about asthma. One thing that they do is to use a tool which calculates the difference between the actual values and expected results on the basis of the well-known theory. When they do this they find an interesting correlation between Lisa's patients. They decide to work further with this correlation in focus.

Then they start looking for information that concerns the recently found correlation. They do not have any clues about which authors might have written something about their discovery. Lisa gets an idea to apply the same tools that they recently used on the database with articles, which results in a list of articles. The articles can be categorised into two categories: one where their discovery is treated rather deeply, and one where the keywords that they have used for the search occur rather sporadic. John and Lisa assume that the latter category of documents refer to the documents in the first category.

Suddenly, during their work, John's emergency telephone rings, and John must turn out to an accident where a person has fallen down from a roof. John and Lisa break up from their joint work, but before they stop they both are asked by their electronic calendar if they want to be reminded to continue with the work they have done at a later stage - they both accept.

On the place of the accident, John begins to examine the injured, John feels a little bit confused over the situation. John takes his address book and inputs some data for the patient and what it is that worries him. The address book returns a list of experts that John can consult.

John gets in contact with Anna, a neuro physician. She starts to examine the patient, via a portable video system and some measuring instruments that John has applied to the patient. Anna tells John what to do. After John is finished with the patient he decides to go to the office. It is time for lunch when he arrives, and he eats lunch with the other persons that work there.

Some days later, when John enters some new data into his database with values from laboratory experiments, he gets a reminder from his electronic calendar telling him about his and Lisa's work a couple of days earlier. He has some messages in the conference system from Lisa, but because of the low priority that John has given to this work he has not got any notices about Lisa's messages until now. It becomes clear to John that Lisa has worked quite much from where they started together. John decides to contact Lisa to get some information about her progress.

Lisa has been curious on the authors to the articles in the category that examined their discovery deeply, and tried to get more information about

them. Lisa has by using some bibliometric tools, found that these authors are all in the periphery of the medical society. After that, Lisa has been even more curious about the authors, and she has decided to establish contact with some of them. It is clear that both Lisa and John has much in common with these authors, among other things they are all working much out in the field and have much contact with the patients.

After this contact with the authors she was able to compare the way they all have worked and what kind of articles and other materials that all the persons have studied. One thing that she has found was that all of them have studied much of the same material, but also some articles that some of the authors have studied but not John and Lisa and vice versa. It was this that Lisa had tried to tell John.

The majority of the subjects estimate the probability that the presented scenario will become reality as high, and also agree that this is desirable.

> *"Computing and communication technologies will surely become ubiquitous and applied in every facet of everyday life, but the details are very hard to predict, as they depend on so many different factors hopefully, technology will soon assist us better in finding relevant contacts and information fast today, things are still too complicated and expensive to reach the public, and [to] be universally accepted and adopted we also need a great deal more commonality and combinability when it comes to different protocols, software, and hardware"*
>
> *"The different tools need to be pretty 'common' and intuitive in order for professionals of a variety of fields to be able to use them without suffering from some sort of threshold effect. In other words - the tools must feel natural."*

Citation 2. Comments about the scenario.

Discussion of the results

The number of subjects was quite low in this first run of the study, hence it would be pointless to make a deeper statistical analysis of the collected data. The results from this the first study serves more as a base for further studies with a focus on trends and the developments. This is the point of departure for the discussion below.

There is little to comment about how people in this group use their computers. They use them as one expects, (see Table 3), which means that

developing software, searching for information, communicating, and editing are all common tasks in the group, but also playing games[18]. The dominating view (95%) on computers and computer artefacts is as tool, but viewing computers as automata is also quite common; 53% of the subjects have also this view, (see Table 4). My results verify the results from Ingman's study. If this view is so dominating, it must be possible to identify it in an evaluation of computers as artefacts where the nine dimensions of artefacts are used. This means that the more the subjects support the assertions in this part, the more the design of today's computer artefacts is permeated by values that the knowledge worker approach stands for, where a tool view is a natural basis for the design computer artefacts.

The summary in Figure 16 is an identification of the nine dimensions of artefacts in today's computer systems. The evaluation gives a view on computer artefacts as things that are quite general both regarding to object and method, and they are things that users, through constant practice, can master. This confirms the knowledge worker values. On the other hand, there are things in the evaluation pointing in the other direction. For example, the ideas that the dimensions of directness and complexity/simplicity stand for seem to be lacking in today's computer systems. It is harder to get a clear idea for the dimensions of interface, control, combinability, and flexibility where some of the subjects totally disagree at the same time as some of the subjects completely identify these dimensions in today's computer artefacts

One conclusion that is possible to make from the study is that even if the dominating conception of computers and computer systems is a tool view, there is a gap between this conception and how well values, ideas, and needs from the knowledge worker approach are implemented. Hence, there remains much work to do before the knowledge work approach is adequately implemented.

[18] One can hope that they play games in their spare time.

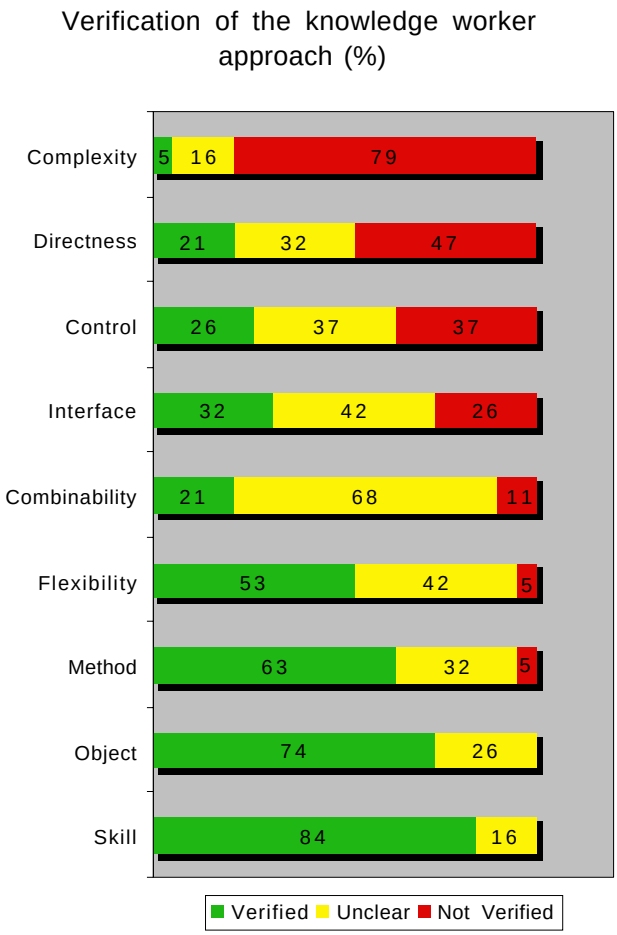

Figure 16. A summary of Table 5 to Table 13. Here, verified *is the sum of the "This corresponds with my views" alternative and the "I couldn't say it better myself" alternative;* not verified *is the sum of the "This does not correspond at all with my views" alternative and the "This corresponds poorly with my views" alternative; and* unclear *is the neutral alternative "This corresponds in part with my views.*

3. The study at Telia

The aim with our study at Telia has been to make some clarifications and to find answers on questions related to knowledge workers' working situation, such as:

- What tools are needed to make the knowledge work more easy?
- What kind of support is there a need for?
- On what basis do knowledge workers choose their tools?
- On what basis do knowledge workers choose their information sources?
- To identify work tasks and sub categories of work tasks typical for knowledge work.
- To study the working procedures for knowledge workers regarding activities in the physical versus the virtual working environment and the relation between them.

The study can be categorised as basic research and it has not as aim to generate any kind of direct changes for Telia. On the other hand, we expected that the study could increase the consciousness for all involved parties in the study, about knowledge work and working situation.

The work categories of interest

We have just entered the knowledge or information society. It is a society where the number of people working with knowledge and refinement of information is increasing. Journalists, stock brokers, information brokers, researchers exemplify this, but in all kinds of works, knowledge work tasks are becoming more and more involved, and therefor more and more of the labour force can be categorised as knowledge workers. For that reason it is very hard to exclude any kind of job from a listing of jobs involving knowledge work. On the other hand, there are some categories of jobs that we believe are to a greater extent associated with knowledge work than other – kinds of job that we today see as typical knowledge work, heavily influenced by IT, very dynamic, etc. To identify characteristics of knowledge work we have a focus for the study on these job categories. Below is a list of positions that we have seen as interesting for the study, and have tried to cover.

• librarian /information manager	• executive
• controller	• researcher/scientist
• informant	• journalist
• consultant	• lineman
• doctor	• broker
• public relations officer	• product developer
• project leader	• repairer
• co-ordinator	• secretary
• system manager	• seller
• educator/trainer	• purchaser

Table 14. Work categories of interest.

In consultation with personal managers at Telia, adequate staff on the company was selected by matching the existing staff with the professional categories in Table 14. It was done in a way so that the examiners should get answers on the questionnaire from subjects, equally distributed among the categories[19].

The phases of the study

The study consisted of two distinct phases – a pre-study and a questionnaire – but we have an option to extend the study with a third phase of field observations and interviews. The purpose with the third optional phase is to complement the questionnaire and in more detail work with some of the general questions or with questions that have emerged from the analysis of the results from the questionnaire. Hence, the extent of the interview depends on the outcome from the questionnaire.

The pre-study

The first phase of the study was a pre-study, where visits and discussions with personal administrators at Telia were the main activity. The purpose with this first phase was to give the examiners a feeling for the working environment and the working situation at the parties at Telia concerned with

[19] It was a quite laborious and impossible task for the personal managers, especially to find doctors and some of the other work categories at a telecom company, but taken as a whole we got a quite good distribution among the work categories.

the study. The results from the pre-study were used as input to the next phase of the study, the design of a questionnaire.

The questionnaire

The second phase of the study was a WWW-based questionnaire. Based on our pedagogical framework (Broberg, 1997; Pederson, 1998) and phenomenographic approach to learning and knowledge (Marton et al., 1986), a questionnaire was designed. The purpose with the questionnaire was to get a broad view over what it means to be a knowledge worker.

The implementation

The implementation of the questionnaire consisted of seven stages: design of the questionnaire, pilot-study, redesign of the questionnaire, study with 30 subjects, analysis of the first study, the main study with the rest of the subjects, and analysis of the main study.

The design of the questionnaire

In an early phase of the project, several brainstorming activities were carried out which resulted in a set of general questions of interest expressing our focus for this part of the study. The questions were grouped into five sub categories, and used as the basis for selecting and formulating the final set of questions to b used. The general questions and sub-categories were:

How are the working activities distributed between the physical environment and the virtual environment?

- How large share of the knowledge work tasks involve only one environment and how many involve both?
- What criterias are important when choosing environment?
- How much cognitive effort is needed to manage the situation of working in two environments?
- What criterias are important for a good working environment?
- What different conceptions of computers exist among the knowledge workers?

Artefacts

- Which physical, virtual and physical-virtual artefacts (info entities, tools, and agents) are used?
- For each artefact, discuss possible environment-bridging extensions
- What criterias are important when choosing artefacts (tools)?
- Wishes for new artefacts, kinds of support...

Information Flow

- In which way or ways do the knowledge workers' working objects affect knowledge workers' state of knowledge?
- What criterias are important when managing information flow?
- What do knowledge workers think about the vision of ubiquitous computing and an increasing amount of physical-virtual artefacts?

Spending Time

- How much time is spent in the physical environment and how much time is spent in the virtual?
- How much time do the knowledge workers think that they spend doing what they are supposed to do/what they want to do?
- How much time is spent on creative thinking?
- How much time is spent bridging the environment gap manually?

Location

- How much time do they spend in their own office, in meeting rooms, travelling, in environments that are not job-related?

The final questionnaire that the pilot-study resulted in, consists of 32 questions. It takes 35 to 45 minutes to fill in. The questions are divided into seven groups: personal data, work tasks, work environment, computer support in the work, things they use in their work, information sources, and working with and without computers. The questionnaire is a mix of closed and open questions, but closed questions are in the majority.

Personal data – The purpose with these questions is to get a view of the composition of the test-group regarding their age, sex, level of education, and experience of computers.

Work tasks – The purpose with this group of questions is to get a view of what kind of work tasks that knowledge workers do. The focus is on what kind of qualities or abilities that are important for the kind of work they are doing, and how well these required qualities match with their own personal qualities. There was also a question about how much of the time at work the subjects spend on tasks that they think they are hired to do, and how much of the work tasks that they really want to do or enjoy doing.

Work environment – The purpose with this group is to get a better view of knowledge workers' working environments: where they work, what factors they find important for a good working situation. How much time they spend on making changes in their physical virtual working environment. How much time they spend on further education and developing their competencies.

Computer support in the work – The purpose with this group is to get a better view of how the knowledge workers of today utilise IT in their work. How much of the work they do with and without computers. How much the subjects can influence the level of computerisation in their work and what kind of factors that govern their decisions concerning the level of computerisation of a work task.

Artefacts in the work – This group of questions are aimed to make an inventory of the tools (physical, virtual, mental) that knowledge workers utilise in their work, and to find out for what purpose they use them and how they evaluate similar tools. There are also questions in this group aimed to catch new or unusual ways of using well-known tools, and discover needs for new tools or kinds of support.

Information sources– The purpose with this group is to get a better view of how knowledge workers judge different kinds of well-known sources of information, with a focus on being able to cope with their tasks. There is also a question aimed to examine the factors that are important when they evaluate information sources.

To work with and without computers – The purpose with this group of questions is to evaluate what the problems are that knowledge workers have working in a physical-virtual working environment, and how they actually cope with the physical-virtual gap.

Data collection

The questionnaire is WWW-based, which means that the subjects sit in front of a computer when they fill in the questionnaire, and no papers are needed in they data collection. Moreover, the examiners get all data in a digital format, which makes the analysing part simpler than with a paper-based questionnaire. All subjects have been informed by some superior that they should answer a WWW-based questionnaire about their working situation, and they also get a message from the examiners with some information about the purpose of the study.

The questionnaire was distributed to 130 employees at different Telia companies, the distribution was carried out in two stages. In the first phase during the late spring 1999, 30 subjects were involved in the study, and in autumn 1999 the rest of the study was carried out with 100 subjects.

Some preliminary results

The second phase study is still going on, therefore only preliminary results can be presented based on 81 questionnaires, which is a reply frequency of 63 %. A more complete report of the study will be presented in a technical report when the second phase is completed, but we do not expected any major changes from the preliminary results that are presented and discussed in this thesis.

This study covers a wide range of aspects of what it means to be a knowledge worker of today. Some are beyond the scope of this thesis and for that reason excluded. The focus in this section is on those parts of the study that concern important qualities and abilities for knowledge workers, how knowledge workers evaluate computer artefacts, and how knowledge workers evaluate information sources.

The personal data

All the subjects were involved in this study via a collaboration with Telia, hence most of them are employees at Telia. The subjects' age vary from under 20 up to over 60, and most of the subjects are in the range of 31 to 45 years. It was a rather even distribution of gender in the group with 46 males and 34 females[20]. The level of education in the group was quite high (see Figure 17), 44 % of the subjects with some kind of academic education.

The majority of the group judged themselves as quite experienced with computers and only 2 % judged themselves as inexperienced with

[20] One of the subjects did not answer this question.

computers. One of the goals with the study was to get a broad view of knowledge work. In order to fulfil and verify this goal a number of work categories of interest for the study (see page 114) were identified. Even if there are more project leaders, helpdesk/support and consultants than any other category in the study, for almost every category we have one or more subjects that have identified themselves with the category, (see Table 15).

Profession	%
Project leader	24.7%
Helpdesk/support	23.5%
Consultant	21.0%
Co-ordinator	14.8%
Other	13.6%
Researcher	12.3%
Informant	11.1%
Information broker	11.1%
Product developer	9.9%
Service/maintenance	8.6%
Seller	7.4%
Controller	7.4%
Secretary	6.2%
Boss	4.9%
Teacher/instructor	4.9%
Repair man	4.9%
Planner	3.7%
Librarian	1.2%
Buyer	1.2%
Superintendent	1.2%
Journalist	1.2%
PR-responsible	1.2%
Lineman	0.0%
Medical doctor	0.0%
BLANK	2.5%

Table 15. Kinds of profession.

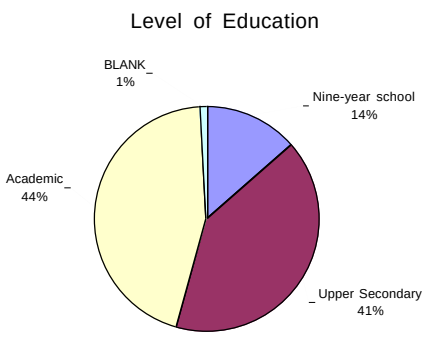

Figure 17. The level of education.

Important qualities and abilities for a knowledge worker

There were two questions in the *work task* part aimed to identify the kind of qualities or abilities that are important for the kind of work they are doing, and how well these qualities match their own personal qualities, the subjects selected 10 qualities/abilities from a list of 38 that best matched their view.

Qualities	Overtasked	Required qualities	Existed qualities
Managing stress	24.7%	55.6%	30.9%
Take decisions	16.0%	38.3%	22.2%
Communicate	14.8%	66.7%	51.9%
Power of initiative	12.3%	69.1%	56.8%
Simultaneous	12.3%	61.7%	49.4%
Planning	11.1%	50.6%	39.5%
Define/find the problem	11.1%	39.5%	28.4%

Table 16. Qualities with a miss-match between qualities needed for the job and personal qualities greater than 10%, which means that knowledge work in general requires more of these qualities than the knowledge workers have.

Qualities	Difference	Required	Existed
Establish/maintain contacts	8.6%	33.3%	24.7%
Seller	7.4%	9.9%	2.5%
Pedagogic	6.2%	19.8%	13.6%
Give a concrete form to	4.9%	19.8%	14.8%
Independence (lonesome)	3.7%	61.7%	58.0%
Creative	3.7%	53.1%	49.4%
Convince	3.7%	13.6%	9.9%
Self motivated	2.5%	32.1%	29.6%
Co-operative	1.2%	55.6%	54.3%
Inspire with enthusiasm	1.2%	12.3%	11.1%
Authority	1.2%	3.7%	2.5%
Analyst	–	57%	57%
Learnability	–	26%	26%
Linguistic	–	25%	25%
Intuition	–	17%	17%
Multilingual	–	5%	5%
Physiological	–	1%	1%
Mediation	-1.2%	2.5%	3.7%
Orator	-1.2%	14.8%	16.0%
Generalisation ability	-2.5%	7.4%	9.9%
Beauty	-3.7%	7.4%	11.1%
Ability to think in abstract terms	-3.7%	12.3%	16.0%
Openness for new technology	-4.9%	38.3%	43.2%
Problem solving	-6.2%	50.6%	56.8%
Social (EQ)	-7.4%	32.1%	39.5%
Critical thinking	-8.6%	24.7%	33.3%

Table 17. Qualities with a difference between qualities needed for the job and personal qualities less than 10 %, which means that there is a balance in these qualities/abilities between required and existent.

Qualities	Unexploited	Required qualities	Existed qualities
Openness for new ideas	18.5%	33.3%	51.9%
Diplomatic	14.8%	7.4%	22.2%
Punctuality	12.3%	14.8%	27.2%
Empathy	11.1%	3.7%	14.8%

Table 18. Qualities with a difference between personal qualities and qualities needed for the job greater than 10%, which means that knowledge work in general requires less of these qualities/abilities than the knowledge workers have.

View	#	%
Type writer	68	84%
Communication channel	68	84%
Tool	63	78%
Knowledge bank	60	74%
Library	49	60%
Calculator	46	57%
Organiser	30	37%
Fellow-worker	30	37%
Game	12	15%
Personal amplifier	11	14%
Co-ordinator	11	14%
Gold-mine	8	10%
Oracle	6	7%
Other	5	6%
Automaton	4	5%
Expert	3	4%
Social actor	1	1%
Person	0	0%
BLANK	1	1%

Table 19. Personal view of computers.

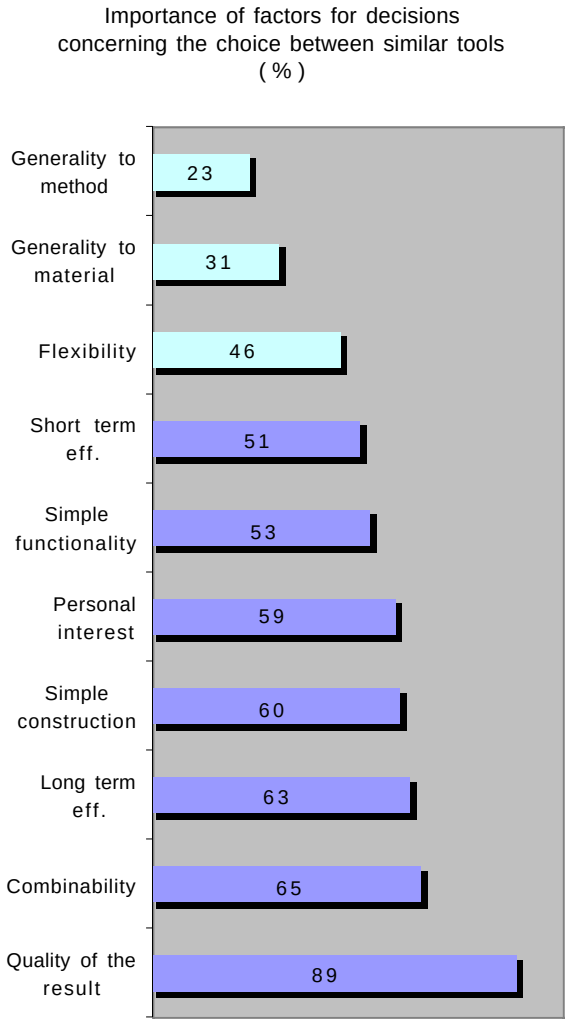

Figure 18. Evaluation of factors for decisions concerning the choice of computer artefact.

How knowledge workers evaluate computer artefacts

One important issue for designers of artefacts but also for the knowledge about knowledge workers and their tools, is the question which factors determine the choice between alternative artefacts. There were two questions in the questionnaire concerning this issue. First, the subjects judged the importance of 10 different factors for the choice between two artefacts with

similar function. Second, the subjects stated their understanding or their view of computers and computer systems. There was a similar question in the study of people's conception of computers, discussed earlier in this chapter.

How knowledge workers evaluate information sources

Information seeking has a distinguished role in knowledge workers' working situation. Therefore, it is of the utmost importance to get a view of how the knowledge workers of today judge various information sources such as libraries, WWW, etc.; i.e. which factors guide them in their information seeking/retrieval. It is also interesting to get information about which sources they view as important for their job.

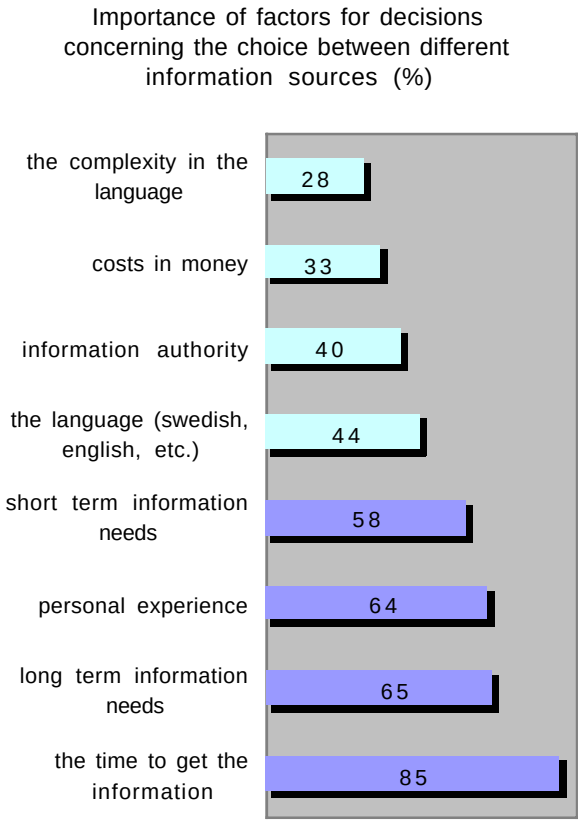

Figure 19. Evaluation of factors for decisions concerning the choice of information sources.

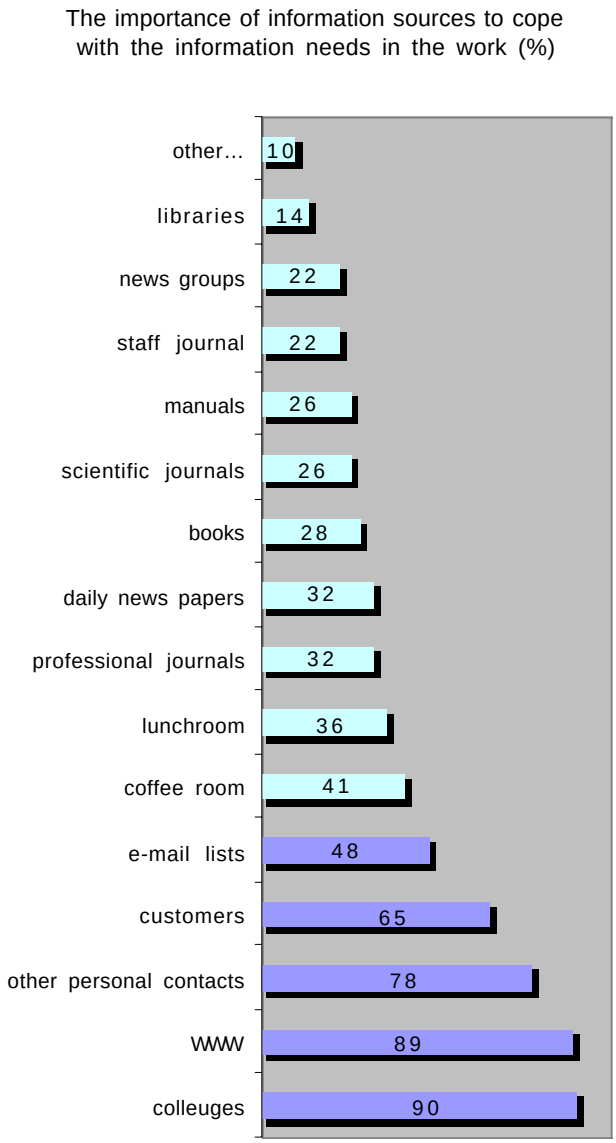

Figure 20. Importance of different information sources.

The Discussion

Even if the study is not completed and this preliminary report of the results is not complete, it gives indications and a rather good view of knowledge work, especially those aspects of knowledge work that are in focus in this thesis.

The study seems to verify a view of knowledge work where openness for new ideas and technologies are important qualities, especially the part of the study where the subjects judged qualities needed for the work and personal qualities. The ability to communicate, managing stress, analyse, solve problems, work independent, power of initiative, and co-operate are highly ranked qualities. In addition, this part also seems to confirm the creative nature of knowledge work. For the majority of the qualities in this part there was balance between job required and personal qualities, but there were several qualities in unbalance. I believe that too big a difference between required and existent personal qualities (overtasked) will cause stress, as with those qualities in Table 16. The other way around, I believe that too big a difference between existent and required qualities (unexploited) can cause frustration in the work situation, as with those qualities in Table 18[21].

The part of the study about information sources adds more to this view of knowledge work, when modern information sources such as WWW and e-mail lists are ranked as important to cope with the work, while more traditional sources such as books, libraries, scientific papers, staff journals are ranked as quite unimportant, (see Figure 20). The fact that the communicative qualities are ranked high seems natural when colleagues, customers, and other personal contacts are also judged as highly important sources of information. This "IT-view" of knowledge work is ambiguous, when IT related information sources such as news-groups and manuals appear to be unimportant. In addition to this, it is worth to notice that the time factor, long-term needs, personal experience, and short-term needs as factors for judging information sources are higher ranked than costs, and authority. That the information authority is ranked low is alarming, especially when WWW and e-mail lists which both are rather anonymous sources, are judged as important, and considering the high level of education in the group. On the other hand, the part of the study about evaluation of artefacts and computer systems gives a view of knowledge workers as very quality-conscious, since they single out the quality of the result as the most important factor in the choice between two similar artefacts, (see Figure 18). Other highly ranked factors are the possibility to combine the artefact with

[21] This is beyond the scope of this thesis, but I believe that it is worth to take note of this, and maybe get back to it later.

other artefacts, and long term effects, but it seems that almost every alternative factor suggested in the question is important. The exceptions are the factors of flexibility and generality.

This study also confirms that the tool is a common metaphor for computers and computers system among knowledge workers of today. But, only 74 % are familiar with this view compared to 95% in the study of people's conceptions of computers discussed earlier, (see page 105). Also the fact that 84 % of the subjects are familiar with a typewriter-view and that 57 % of the subjects are familiar with a calculator-view confirm the tool metaphor. There are some remarkable differences between the result from these two studies. First, the automaton has dropped from 53% to only 5%, which also adds to an increased familiarity with a tool metaphor.

Second, it is possible to identify a trend with an increased familiarity with information based metaphors. For example, the knowledge bank view has increased from 37% to 74 %. Other changes in the same direction but not as dramatically as the knowledge bank view are the increased familiarity with the communication channel view from 74% to 84% and with the fellow worker view from 5% to 37%. The fact that 60% have a library view of computer systems verifies this trend even more.

To summarise, the study seems to confirm a view of knowledge workers as open for new ideas and technologies and quality-conscious in their choice of tools. In the same time they judge modern information sources such as WWW and e-mail as equally important for their work as human sources of information such as colleagues, and customers. Regarding their view of computers and computer systems a tool view is very common, but information based views will most likely become more and more common.

7

Text-Col – a tool for active reading

The knowledge worker approach encourages the development of new tools aimed to support in a broad sense the learning process. Traditionally, much of the efforts to develop computer based tools has been concentrated on developing production or authoring tools, such as word processors, drawing programs, etc, and not so many consumption or reading tools have been developed except web-browsers and different kind of media players. Authoring plays an important role in the learning process and good tools are needed, but reading and exploring is at least as important and especially active reading, hence more efforts must be put into the development of reading and exploring tools. We believe that computers give us good opportunities to develop and implement many interesting ideas for this kind of learning tools.

TEXT-COL is a reading tool aimed to make the reading process more active (see Figure 21), developed at the Cognitive Tools Workshop. As a reading tool and exploring tool, it is designed to work together with standard WWW-browsers. The purpose with this chapter is to introduce and discuss the *TEXT-COL* tool in order to give a sense of how it can support the readers to be more active in their readings. The first section presents the basic ideas and concepts. Next section presents the application, and the interface. The last section discusses how the tool can be used. The following chapter presents a study of some of the basic ideas of *TEXT-COL,* and summarises the discussion about *TEXT-COL.*

1. The basic concept

Reading documents from computer screens can be a very frustrating experience, and many prefer to print out a paper copy and read this version instead of reading directly from the monitor. There are several reasons for this behaviour. One common explanation is the difference in legibility between the two mediums: the paper version is more comfortable to read. Another explanation has more to do with the possibility or support the medium has for an active way of reading. Traditionally, computer mediated

texts have little support for an active way of reading. This means that reading computer-mediated texts, as on the WWW, tends to be a very passive form of reading, where the reading has more the characteristics of a scanning process. This is very sad especially in view of the fact that the WWW is one of the highest ranked information sources among today's knowledge workers (Broberg & Pederson, 1999).

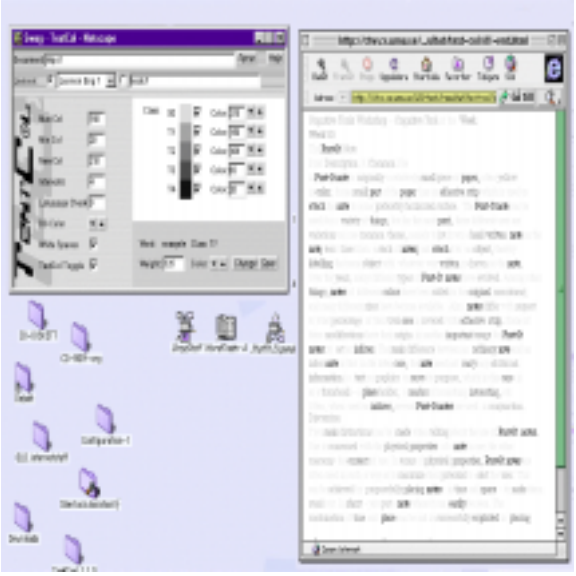

Figure 21. The user interface of the Text-Col tool.

The development of *TEXT-COL* addresses this problem. *TEXT-COL* is a tool designed to support readers in deep processing of texts by letting the readers change appearance of the text based on different strategies for categorising words. This section discusses the basic concepts of *TEXT-COL,* such as interaction with texts, categorisation of words, level of saturation, document based models of focus.

Categorisation of words

There are many system for categorising words: general categorisations like parts of speech and more contextual categorisations like keywords for a topic, but also very personal categorisations or valuations of words exist. In other words, the information values of words differ between individuals, with the time, and with the context, etc., (see the discussion in section 7 *Perspective of information science* of chapter 4). There are techniques to express differences in information value of words in a text, both techniques

used by authors and techniques used by readers. There are typographic variations, such as **bold face**, *italic*, and underlining used by authors' to signal personal values of words or concepts. This gives the authors a nominal scale by which they can express eight categories of words – but without any form of order between the eight categories. It is almost the same situation for the readers. Readers utilise colour mark up pens or underlining to record their personal values of words and concepts, and some readers use different colours to express their categorisations of words. The main difference compared to the author's situation, is the factor that limits the number of possible categories. For the readers it is the number of colours of their pens that sets the limit and for the authors it is the number of widely accepted typographical variations. Norman (1991), arguing for the importance to minimise the cognitive gap between a representation and the represented in order to get a natural interaction with artefacts. None of the methods, the readers' or the authors' offer the user a natural way to keep track of any kind of ordering between the categories of words. Hence, there is a risk for a mismatch or gap between the encoding and the interpretation. There are situations where it would be desirable if one as author or as reader had access to a natural way to express some kind of order between categories of words in texts. In other words an ordinal scale to express or record categorisations of words – especially in learning situations where the text is viewed as a means to active learning.

This is an example of the use of saturation to express differences in words' information value.

Figure 22. Example of a text coded by words' information value.

TEXT-COL utilises differences in contrast between the background and the words in a text. For texts on light backgrounds, words printed with higher degree of saturation is normally taken as words more worth or highly rated than words printed with a lower degree of saturation (see Figure 22). For texts on dark backgrounds, the relation is inverse. This creates an ordinal scale that can be used by *TEXT-COL* users to express categorisations of words and keep track of the order between them. It is worth to mention that the subjective part of the study of *TEXT-COL* (described in chapter 6) verifies this idea.

To support active reading

Text is a medium for communication of ideas, concepts, knowledge, etc. Texts are traditionally, and for obvious technical reasons viewed as very static entities, with respect to both content and appearance. With computers and Internet, totally new conditions for texts as medium for communication are set up. Internet is an infrastructure that bridges various kinds of distances between authors and between readers, but also between authors and readers. It is very easy to make changes in computer based texts both for readers and for authors, and the distribution of a new or different version of a text is quite easy. Hypertext exemplifies another feature that computers can add to the texts, the interaction. Hence, computer mediated texts need not be as static as paper mediated texts. Our hypothesis is that it is good for the outcome from the reading process if this old, static view of text changes so that texts are viewed as entities that are more dynamic. With this in mind, *TEXT-COL* is a tool designed to support the users with active reading (to interact with texts), by letting them work with the outlook of texts.

Metaphorically, to read solid black texts compared to grey-coded texts is like the difference in experience between driving a car on a superhighway at the same speed mile after mile and driving on a local curvy road. The driving culture or atmosphere differs. The superhighways are just a way to get from point A to B as fast and easy as possible, it is forbidden to stop at interesting sites, turn around, etc. Therefore, if one is interesting to see and explore interesting sites, local roads are to prefer. In the case of reading: instead of reading the text at almost constant speed (the highway style), to read texts where the saturation varying the reading speed follows these variations (the local road style). I.e. with high reading speeds at lighter parts, lower reading speeds at darker parts.

Our hypothesis is that variation in saturation can be utilised in order to raise the level of activation in the reading process. We believe that readers of a grey-coded text both unconsciously and consciously react to words' degree of saturation in relation to the way they comprehend the text. This will cause a deeper processing of the text than with a standard way of reading. The idea is that to react on the way a word is presented in a text it is necessary that the readers match the proposed way of interpreting the word with their own mental model or conception of the text.

TEXT-COL offers the readers a more sophisticated and deliberate way of raising the level of activation of the reading process.

Users of *TEXT-COL* can:

- set or change a word to a category, and thereby they have performed an action that is related to the way they comprehend the text or a collection of texts
- select which of the categories of words that will be visible, and thereby actively explore texts
- select or change which kind of categorisation a text should be grey-coded with, thereby actively exploring texts from multiple perspectives

To summarise, *TEXT-COL* utilises some of the opportunities that the computer gives to make reading of computer mediated documents more like reading paper documents and to extend the reading process with new feature that neither paper nor computer mediated documents normally can offer.

Information value lexicon

TEXT-COL bases the grey coding of documents on information value files (IV-lexicon). An IV-lexicon is a data file containing information about a set of words. Each row in an IV-lexicon has three fields: <concept>, <code>, and <value>. The concept-field holds the entry word. The code-field is a parser-specific field (e.g. it can be used to hold part of speech information). The value field holds a numerical value used by *TEXT-COL* to place the word into a specific category.

One of the strengths with the Text-Col tool is the high degree of control that the user has over the behaviour. For example, it is very much up to the user to select the strategy by which the words are categorised. Some examples of strategies for categorisation of words are: key words for an area, the origin of words, the length, random, etc. It is possible for a user of *TEXT-COL* to have a collection IV-lexicons. These IV-lexicons can model different areas of interest, different perspectives of an area of interest, and it is also possible to use shared IV-lexicons such as IV-lexicons authorised by an organisation, a colleague, friend, etc. This feature gives the readers the possibility to easily walk between different readers' and persons' valuation of words, or to set the text into different contexts.

There are several ways of constructing and editing an IV-lexicon. First, the simplicity of the format makes it possible to manually create and edit lexicons with the help of a simple text editor. Second, an IV-lexicon tool has been developed which lets the user construct IV-lexicons based on different strategies mostly derived from the areas of information theory and computational linguistics. IDF, information weight (Church & Gale, 1995),

and entropy (Shannon, 1948) are some examples of strategies to base an IV-lexicon on. The motivation for this lexicon tool is the idea of modelling areas of interest or focus with the help of collections of documents. Modelling of knowledge is a comprehensive area of research within computing science, especially in the AI field. Broberg (1997) discusses different perspectives on knowledge and learning and some of the more traditional techniques for modelling knowledge such as rule-based systems and semantic networks. Generally, we are interested in ways of modelling personal interests or focus. Chapter 9 will discuss the character of focus as a complex entity, which is vague, personal, dynamic, and possible to describe in various levels.

Third, *TEXT-COL* supports interactive editing of IV-lexicons, e.g. one can change the weight of a word, delete a word from an IV-lexicon, and add a word to an IV-lexicon.

With this in mind, *TEXT-COL* is a tool designed to support the users with active reading (exploring collections of documents) by letting them work with different categorisations of words based on different foci and strategies.

2. The *TEXT-COL* application

The purpose with this section is to discuss the functionality and user interface of the *TEXT-COL* tool

The development of *TEXT-COL* has passed from a prototype implementation partly implemented with java-script and partly with cgi-script to a more product-like implementation as a java-applet[22]. Both the prototype and the second implementation are tightly coupled to standard WWW-browsers and the idea is that they should extend the functionality of them. The *TEXT-COL* application window (see Figure 23) is divided into four distinct areas: an address field, a parser control, a colour control, and IV-lexicon control. The functionality of each of these areas is discussed below.

[22] Most of the implementation work has been done within the scope of a team project oriented software-engineering course at the department of Computing Science at Umeå University.

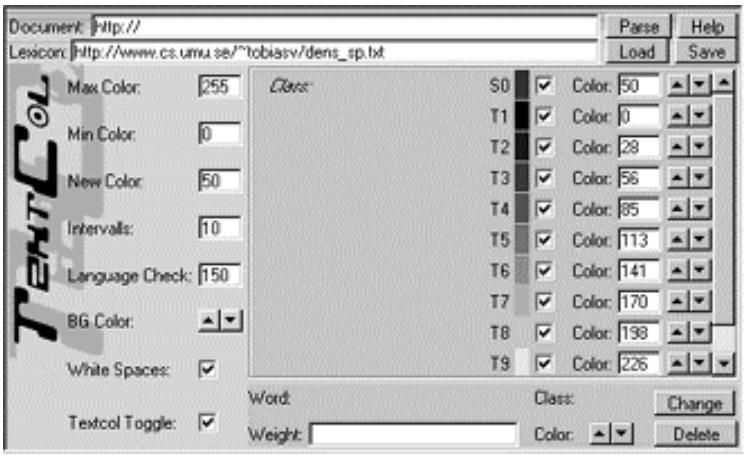

Figure 23. The application window of Text-Col.

Parser control panel

In this part of the application window the user can control some of the basic characteristics of the grey coding of a document, (see Figure 24). The parser control panel contains 8 fields, (see Figure 26):

1. Max Col field – input field to set the colour for the highest ranked word category.
2. Min Col field – input field to set the colour for the lowest ranked word category.
3. New Col field – input field to set the colour for words not in the current IV-lexicon.
4. Intervals field – input field to set the number of intervals or categories that the current document should be parsed with.
5. Language check field – settings for an upper limit of non-existing words in the current document before the application warns the user. The function is disabled when the value is set to a negative value.
6. Background colour buttons – buttons to adjust the background colour of the current document.
7. White spaces button – controls whether the white spaces that will result when a word category is hidden should be shown or not (see Figure 27 and Figure 29).
8. Text-Col toggle button – selects whether the current document should be shown in normal mode or in Text-Col mode.

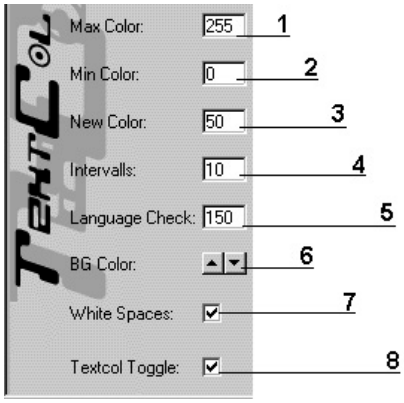

Figure 24. The parser control panel.

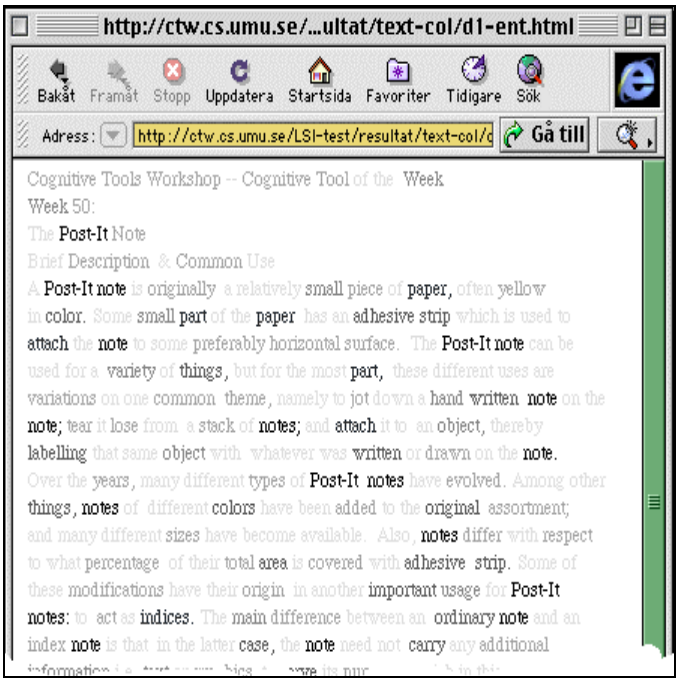

Figure 25. Browser window, with a Text-Col parsed document.

The document in Figure 25 is parsed with six levels of saturation (one for non-lexicon words and five for lexicon words). The document is parsed with an IV-lexicon, that expresses information weight of words, based on a small corpus of seven documents about cognitive tools.

The IV-lexicon control panel

In this part of the application window, the user selects which IV-lexicon the documents should be parsed with. There are also other functions that are related to IV-lexicons. When the user clicks on a word in the browser window, information about the word is presented in this area: information about which category it belongs to and what colour (weight) it has. It is also possible to change which category a word belongs to. This can be done in two ways. First, by selecting one of the current categories – this means that the numerical value changes to the middle point for the new category. Second, it is possible to directly adjust the value in the <value-field>, which does not necessarily mean that the word moves to another category. These changes can be temporary or permanent, permanent meaning that one saves the changes to the current IV-lexicon, (see Figure 26):

9. Selected word – when the user selects a word by clicking on it, the word (*example* in Figure 26) appears here.
10. The weight field – displaying information about present weight of the selected word (*125* in Figure 26).
11. The class field – displaying information about which category the selected word belongs to (*T1* in Figure 26).
12. Weight adjusters – buttons to stepwise decrease or increase the weight of the selected word.
13. The change button – to update the current page with the selected word's present weight.
14. The delete button – to delete a word from the current IV-lexicon.

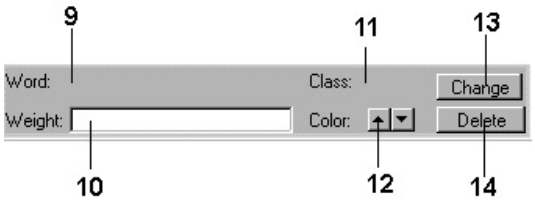

Figure 26. The IV-lexicon control panel.

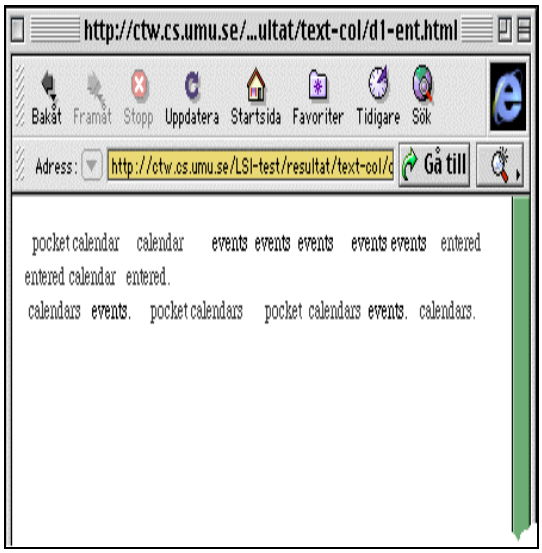

Figure 27. A document with only the two highest ranked categories visible and the white space flag set to off.

The colour control panel

In this part of the application window the user can adjust the grey levels for each of the categories of words, and also turn on and off the visibility of each of the categories in order to hide or show categories of words (see Figure 27 and Figure 29). The colour control panel has 5 items, (see Figure 28):

15. Visible mark – check button to make a word category visible or not.
16. Grey level display – a field showing the current grey level of each of the word categories.
17. The category name – each category is labelled with a sequence number, the S0 is for words that are not accessible in current IV-lexicon.
19. Buttons for adjustment of the grey-level for each word category.
18. Colour value display – showing the current grey-level values for each category.

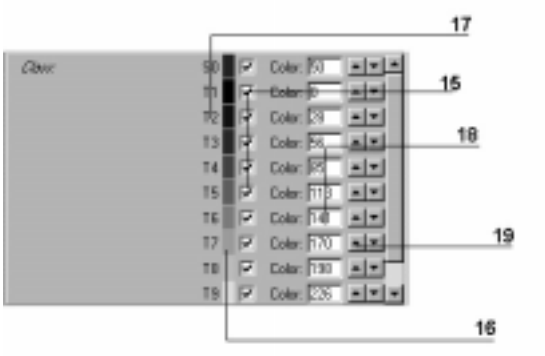

Figure 28. The colour control panel.

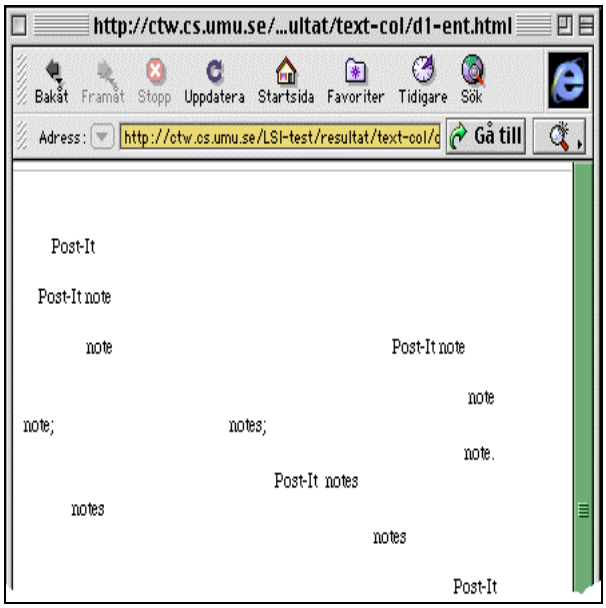

Figure 29. A document with only the two highest ranked categories visible and the white space flag set to on.

The address field

In this part of the application window the user selects which document to parse. There is also a help button in this area, (see Figure 30):

20. Document address field – to input the Internet address to the current document that has been or should be parsed.
21. IV-lexicon field – displaying the name of the current IV-lexicon (*InfoWeight* in Figure 26).
22. The parse button – to parse the current document.
23. The load button – a dialog pops up where one can select an IV-lexicon.
24. The save button – a dialog pops up to save the current IV-lexicon.
25. The help button – to access the help system for *TEXT-COL*.

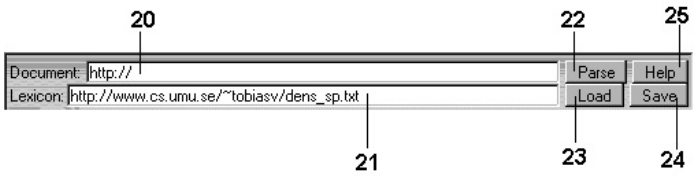

Figure 30. The Address field.

3. How to use *TEXT-COL*

One of the basic characteristics of a tool is that its users develop their own ways of use and develop their skill in using the tool, by using it. For a new tool like *TEXT-COL* for which no rules, praxis, or community have been established, this is particularly true. Even if *TEXT-COL* is aimed to support readers/users to take a more active role in their readings of computer mediated texts, it is for these reasons very hard to predict how it will be used. From the very beginning ideas have existed about hypothetical uses and through the development of *TEXT-COL* new ideas of hypothetical uses of the tool have emerged. The purpose with this section is to give a broader picture of the *TEXT-COL* tool and the possibilities it has to support the reader by briefly discussing some of the ideas of alternative uses.

Virtual mark-up Pen

One of the major drawbacks with computer-mediated documents and specially WWW-based documents is the lack of possibilities to mark words or pieces of texts as interesting. *TEXT-COL* has the possibility to work as a kind of virtual mark-up pen by constructing an IV-lexicon consisting of those words that the reader picks out as being of particular interest. There are some major differences between the virtual version compared to its physical counterpart. First, the virtual pen offers the user an ordinal scale to be used for the classification of words and the physical only offers a nominal scale. Second, with *TEXT-COL* it is very easy to change to another IV-lexicon, i.e. to change the strategy by which words in a document should be categorised. With a physical version, this is hard and time consuming. Third, once a word is marked or adjusted every occurrence of it is affected, where the particular IV-lexicon is used.

Exploring tool for meta-information

Meta-information and its role in knowledge work and in learning situations are discussed in the summary of chapter 4 and in chapter 5 on page 96. We believe that meta-information and tools for processing meta-information plays an important role in a learning situation – for the way a reader adjusts the conception or the understanding of a text or a collection of texts. For example, a document that has been conceived as very central can drop in ranking when one discovers that very few persons refer to that document. The way *TEXT-COL* works gives the users a possibility to work with meta-information. Working with IV-lexicons based on: the length of words, the origin of words, part of speech, and the age or date of introduction of words give information about the character or the genre of documents. Other examples are IV-lexicons based on names of important persons, the authority of references, and keywords, which will give information about a document's relevance to other documents.

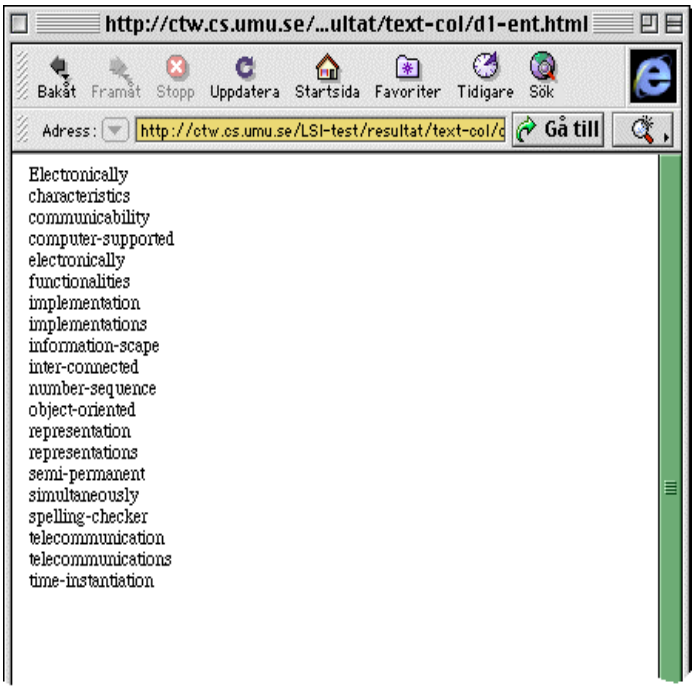

Figure 31. IV-lexicon based on word length parsed using itself as IV-lexicon, with only the longest words visible.

TEXT-COL gives the user/reader the ability to make meta-information-based visualisation of texts. The tool also offers the user/reader possibilities to actively explore meta-information in documents. For example, users have the possibility to visualise the same document with different kinds of IV-lexicons but also the other way around: keeping the IV-lexicon fixed and changing the document. This could be used to explore a set of documents and to see, for instance how different authors tend to use foreign words or extremely long words etc. *TEXT-COL* allows the user to interact with the document, for instance hide/show categories (see Figure 31), get information for a particular word, adjust a word's weight, etc.

Indexing documents

Very much of a knowledge worker's daily work is to find suitable information. Search engines play an important role in this process of seeking information. Even if a search engines has found documents that matches one's intentions it can be very tough to find *where* in a document the interesting parts are, and to extract the information that one has a special

interest in (a focus). *TEXT-COL* can make it easier find where in a document the interesting parts are, visually the interesting parts stand out when words of interest are darker than other words. It is also possible to get a picture of how dense documents are by the intensity and the distribution – based on this one gets support to decide whether it is worth to read the document or not.

Looking for new concepts

Documents with more than one author are common, and collaborative authoring demands a great deal of cognitive efforts from all the involved. For example to keep track of changes between revisions which new ideas, which new concepts are introduced and by whom concept is introduced. By utilising the fact that concepts that are not found in the current IV-lexicon is marked as a special category (S0), Text-Col can be used to find new concepts between different versions of a document. The feature that makes it possible to easily switch between different revisions of IV-lexicons makes it possible trace of the history concepts in a document.

8

A Legibility Study of Saturation Coding

The previous chapter introduced the *TEXT-COL* tool. This chapter presents an empirical study of one of the very basic ideas with *TEXT-COL*. The overall design criterion for the study was to evaluate how the grey coding of text affects the reading process. The primary target for the study was to get some preliminary answers to the question of how the fluctuations in saturation and the strategy behind the grey coding affect the readability/legibility. Of course, questions concerning learning effects are also important to study, and a secondary target for the study was to get some preliminary indications whether this way of coding text has any effects on the quality of the outcome from the reading process. The first three sections of the chapter present the study in detail, the set up etc. The next section presents the collected data; mainly the objective measures and subjective measures are presented, but also some data from the learning effects and the interview part are presented. The last section discusses the results from the study, and how to proceed with the development of *TEXT-COL*.

1. The subjects

The study involved 90 subjects divided into 3 groups with 30 subjects in each group. There was one control group (group C), and two test groups (group A and group B). The subjects were randomly placed into the three groups. The subjects were mainly students and employees at Umeå university. There were 64 males, 24 females and 2 persons who did not state their sex. The majority judged their reading capability to be normal or good, and most of the subjects judged themselves as very experienced or experienced users of computers.

2. The texts

Each subject read four texts. With regard to the content and the basic layout all 90 subjects read the same four texts. The variations between the groups was in the first and third text, where group A's texts were coded with

information weights (Church & Gale, 1995), group B's texts were randomly coded, and the texts for the control group were all solid black. The second and the fourth text were both solid black texts for all groups. All four texts were in Swedish and taken from editorial and debate pages in Swedish daily and evening papers. The motive for this choice of texts was simple: the texts should have a clear message and a language that every subject should be familiar with. The mean length of the texts was 524 words (see Table 20), hence with a normal reading speed the reading times for each of the texts should be in the range of 1 to 4 minutes.

Text	Length
Text 1	593
Text 2	562
Text 3	433
Text 4	508
Mean	524

Table 20. The lengths of the four texts expressed in number of words.

3. The procedure

The procedure was almost the same for all the subjects, they were invited to take part in a study of readability/legibility of texts from computer screens. All the subjects were informed about the procedure in the same way, that they would read four texts, and the way of measuring readability/legibility. They also knew that the reading time would be measured and that they would answer a questionnaire with questions about the content of one of the texts. There was one major difference in the procedure between the control group C and groups A and B. All the subjects in group A and B were interviewed about how it was to read the grey coded texts compared to solid black texts. This phase of the study was the last. The purpose of this interview was to collect ideas on how to utilise this kind of variation in saturation in the text. From an experimental point of view, this study was a between-subjects design with one independent variable to study.

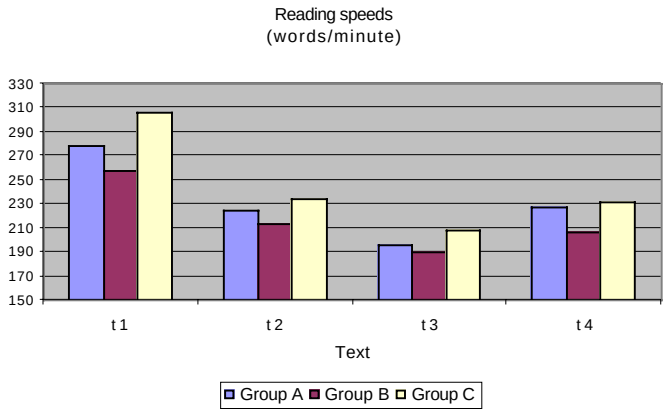

Figure 32. Comparison of the means of reading speed among the texts and test groups.

4. The results

Both objective data and subjective data have been collected in the study, both for the evaluation of legibility effects and the evaluation of learning effects.

The objective measure of legibility

One common way of measuring changes in legibility is to study how the reading speed changes, i.e. changes in number of words per minute.

	Group		
	A	B	C
$\overline{X}$	278	258	306
median	282	258	303
σ^2	8313	5982	5251
σ	91	77	72

Table 21. Descriptive statistics for text 1, grey coded for group A and B.

	Group		
	A	B	C
$\overline{X}$	225	214	234
median	218	213	224
σ^2	6028	3328	4173
σ	78	58	65

Table 22. Descriptive statistics for text 2, black text for all groups.

	Group		
	A	B	C
$\overline{X}$	196	191	208
median	191	191	209
σ^2	4478	2221	3345
σ	66	47	58

Table 23. Descriptive statistics for text 3, grey coded for group A and B.

	Group		
	A	B	C
$\overline{X}$	228	206	231
median	222	207	228
σ^2	5453	3289	4608
σ	74	57	68

Table 24. Descriptive statistics for text 4, black text for all groups.

Table 21 to Table 24 present descriptive statistics from the study. The ranking between the groups is the same for all texts, i.e. on average group C reads faster than group A that reads faster than group B.

Source	df	SS	MS	F
Between groups	2	36274	18138	
Within groups	87	566890	6516	2.78
Total	89	603164		

Table 25. A summary of one-way ANOVA-test for text 1. F(2.87)=2.78, p<0.1, Fcv= 2.37.

The question is, if any of the variance in means of reading speed between the groups is significant. In order to evaluate this, four one-way ANOVA tests were performed (one for each text). The result from this is that the only text for which one can show any significance between variations in means is text 1, where F(2.87)=2.78, p<0.1 F_{cv}= 2.37. For all of the other texts F(2.87) < F_{cv}. and for text 2 and 3 F(2.87) < 1.

The results of the ANOVA suggest a significant difference among the means of reading speed of the three groups. Tukey's Honestly Significant Difference (HSD) is used to make pairwise comparisons among the means.

Tukey's HSD:

Equation 1 $$HSD_{.05} = Q_{.05}(3.87)\sqrt{\frac{MS_w}{n}}$$

Equation 2 $$HSD_{.05} = 2.8135\sqrt{\frac{6516}{30}} \Rightarrow$$

Equation 3 $$HSD_{.05} \approx 41$$

From equations 1 to 3 the smallest difference between any two means in the study that still is significant with α=.05 is 41.

	C	A	B
C	–	28	49
A		–	20
B			–

Table 26. Differences between each pair of means in the legibility study of text 1.

It is only the difference between group B and C (the control group) that is significant, i.e. greater than $HSD_{.05} \approx 41$, (see Table 26).

The subjective measure of legibility

In order to evaluate what influence the grey coding of texts has on the subjective experience of reading, the subjects answered questions related to how it was to read the grey coded text compared to solid black texts. There were questions concerning this both in the written questionnaire and in the interview. The first question in the interview was – *Concerning the layout, how was it to read the grey-coded texts compared to traditional texts?* Figure 33 and Figure 34 shows a difference between group A and group B. 52 % of the subjects in group A felt that it was easier to read the grey coded text than black texts, and 21 % had a more neutral experience of reading the grey texts. 24 % of the subjects in group A felt that it was harder to read the grey-coded texts. For group B the experiences of the subjects go in the opposite direction. 62% felt that it was harder or much harder to read the grey coded texts than solid black texts, and 17% had a neutral experience. 21% of the subjects in group B had a positive experience of reading grey coded texts.

Another question in the questionnaire which also concerned the readers' subjective experience of reading grey-coded texts was – *with respect to the layout of the text, do you have any comments about how it was to read it?* The results from this kind of open question is much harder to process and analyse compared to objective measurements and multiple-choice questions, but it is possible to catch more spontaneous views from the subjects (Lindblom, 1999).

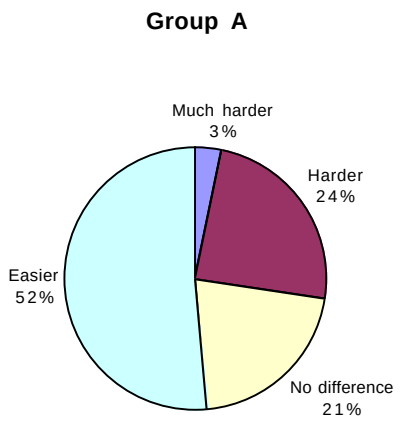

Figure 33. The subjective experience of the difference between reading grey coded texts and solid black (group A).

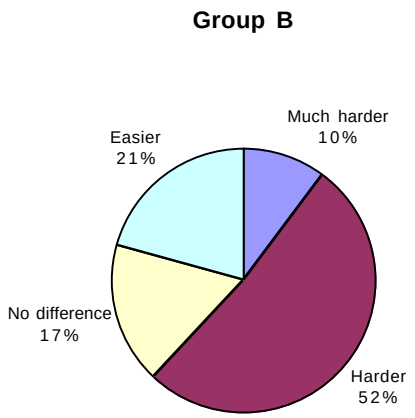

Figure 34. The subjective experience of the difference between reading grey coded texts and solid black (group B).

Almost every subject in both groups had comments about the grey coding of the texts, but there is a clear difference between the two groups. The

majority of the comments from group B are negative and the majority of the subjects from group A have a positive attitude in their comments.

The negative comments from group B are stronger than those from group A, and they are unanimous – it is hard to keep the flow in the reading, and it is common that the readers are forced to jump back in the text, (see Citation 3). Even the positive comments are quite unanimous between the subjects, and many of the comments give an expression of a factor of familiarisation when reading grey coded texts. Also, it is common in this category with comments about the use of the saturation level to express some kind of information value for the words, (see Citation 4).

> *"Got stuck on the words with the lowest level of saturation. It was hard to get continuity in the text."*
>
> *"Hard to read the words that were grey shaded in combination with solid black words."*
>
> *"Horrible, it was terribly irritating with characters that disappear, consequently one was forced to read the same pieces several times when one loses the thread "*
>
> *"The words that were marked with solid black disturb and get a stronger meaning than they normally should have."*
>
> *"It is quite clear that it was heavier going with some of the words in a higher level of saturation than other words. In the beginning it was heavy, but after a while I became used to it."*

Citation 3. Examples of negative comments, the first four are from group B and the last is from group A, (all the comments are translated from Swedish).

The learning effects

Even if the primary target of the study was to test the effect on legibility, part of the study concerned learning effects – is it possible to identify any significant differences between the groups in terms of: comprehension, recall test of important words, and word recognition? The questions in this part of the study were all about the first of the four texts. Half of the subjects in each group performed the word recognition test and the other half performed a word recall test.

"First, I thought it was real unpleasant, but when I got used to it, it became to feel quite good to read with different levels of saturation …"

"It was of the difference s comfortable to read, but one felt that the black colour words were amplified, which sometimes was against one's own comprehension "

"It felt a little unfamiliar to read a text with different levels of saturation, but anyway it was quite nice to read. It was easier to keep track where one was in the text.."

"Very pleasant for the eyes, felt easier to read…."

"It does not feel so uncomfortable, but it is clear that one sometimes get stuck on words with a higher level of saturation. At the same time they make it easier to grasp the meaning of the text if the keywords are marked "

"Very readable, nicer to read with grey-levels. Good flow in the reading, it was not so compact."

Citation 4. Examples of positive comments, the first five are from group A and the last is from group B (all the comments are translated from Swedish).

In the word recognition test, the subjects were asked to check words recognised in a list of 30 words of which 12 were from the first text. The rest of the words were in three categories: closely related words to the first text, words similar to the 12 selected words, and non-related words. They got no hint about how many words they should check. For all groups the means of checked words were almost the same, namely 11 and no one had checked all the correct words.

In the word recall test, the subjects were asked to list a number of representative words from the text. To find any significant differences between the groups in this part is hard, but some interesting indications are possible to identify. More of the subjects in group A than the other two groups tend to give words that exist in the text and are marked with a relatively high information weight. For example, *women* ("kvinnor") is a high-rated word for both group A and B, and 87% in group A has *women* among their words, but only 40 % in group B and 33 % in group C.

The main idea with the test of how the subjects understand the meaning of the text, was mainly as some sort of motivator to make the subjects read all texts in a serious way, and at this time no deeper analysis of this part has been done.

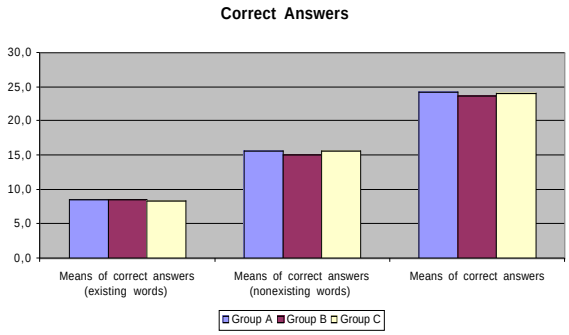

Figure 35. Number of correct answers in short time word recognition test of text 1.

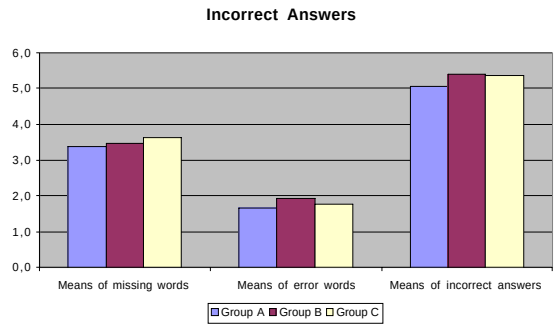

Figure 36. Number of incorrect answers in short time word recognition test of text 1.

The interview

As mentioned earlier there were mainly two purposes with the interview part of the study – to catch ideas and to get comments on the experience from reading grey-coded texts. Apart from the question about the subjective experience between reading solid black texts and grey-coded (see Figure 33 and Figure 34), the data from the interview part has not yet been analysed in detail, and for the moment only some preliminary results can be reported from this part. The subjects' attitudes to a demo of a prototype implementation of *TEXT-COL* are mainly positive. Also it possible to identify a clear difference between subjects of group A and B in how they respond to a question concerning a hypothetical use of *TEXT-COL*.

- In group A it was more common with comments on a hypothetical use of *Text-Col* where the subjects discuss in terms of "reading for comprehension" or "grasp the meaning of the texts".
- In group B it was quite common to discuss a hypothetical use of *Text-Col* in terms of indexing, scanning, and browsing texts.

5. Discussion of the results

The basic idea with *TEXT-COL* is to amplify the reading process of on-screen texts by utilising the level of saturation to express differences between information values of words. The amplifying of the reading process has not so much to do with increase of reading speed, instead it concerns the quality of the outcome from the reading process in terms of conception. Therefor, the small negative impacts of the objective legibility are not to be considered as a negative result for us, especially when the response from the subjects were mainly positive.

When the reader read random-coded text for the first time was the only condition where the difference in means was significant. One possible explanation is that humans are very good at adapting to current circumstances, but in the long run we believe that no one would prefer to read randomly coded texts compared to texts with a more normal look. There is proof for that in the study.

The evaluation in subjective terms of the impact on the legibility from the variations of the level of saturation shows a big difference between group A (texts coded with information-weight) and group B (texts randomly coded) in how they perceive the reading of the coded texts. That means that the semantic content of the coding has effects on the legibility. On a direct question about how it was to read the coded texts compared to solid black texts, group A had mainly a positive attitude to the coding of the texts, group B had mainly a negative attitude. Also in a more open question about the reading experience from coded texts there was the same relation between the groups, with many positive comments from group A and few negative and vice versa from group B. A tentative conclusion from this is that although it may reduce the reading speed, many readers prefer grey-coded texts to traditional solid black texts, but they must be coded with some relevant strategy/method like keywords or information weight. To summarise, semantic coding of the text implies “good” reading, and “good” reading is more important than high reading speed. Again, metaphorically the experience of reading solid black texts is like driving a car on the

superhighway at constant speed, and the experience of reading grey-coded texts is like driving on a local road where it is necessary to make variations in the speed.

The main purpose of the study was to study the impacts from grey-coding on legibility and the results from that part of the study is in a positive direction. A second purpose was to collect ideas and experience from the subjects about how to utilise this kind of coding of texts in practical situations.

A third purpose was to make some observations on learning effects. Is it possible to identify any significant differences between the groups in terms of comprehension, recall test of important words, and word recognition?

From the study it is not possible to identify any significant variation in any of the three categories of tests. We can point out several reasons for this. First, the questions about the content of the texts serve as a brake holding down the reading speed, i.e. to keep the readers focused at the task and motivated to read all the texts seriously. A second reason has to do with the choice of text to ask questions about. The questions were about the first of the four texts, which was perceived as the most interesting text of the four. The third reason is the short time between the reading phase and the question phase: less than 15 minutes. The fourth and perhaps most important reason concerns one of the basic ideas with *TEXT-COL,* namely to support readers to be more active in their reading process. In the study, however, the subjects did not have access to the parts of the tool that would enable them to work actively with the texts – the texts were static and there was no way for the subjects to change the appearance of the texts.

6. Summary

The purpose with this section is to summarise this chapter and the previous chapter, but also to look forward and discuss future work related to *TEXT-COL*. Two relevant question are, what is it that makes *TEXT-COL* a cognitive tool for learning, and how is the functionality of *TEXT-COL* anchored in the knowledge worker approach?

Chapter 3, *Computers in Learning Situations*, discusses different kinds of cognitive tools for learning and the ideas behind. From this, it is possible to relate the underlying mechanisms for learning in the cognitive tools for learning approach to the theoretical suppositions of the knowledge worker approach (Broberg, 1997). First, in the phenomenographic view of learning and knowledge the level of activation in the learning process and the factors of relevance and motivation are important for the level of outcome from the learning process (Marton, 1974; Marton et al., 1984). Second, one of the

common characteristics of cognitive tools for learning is that they all offer the learners the ability to create, process, and view knowledge structures, i.e. learners as knowledge workers learn by working with information, data, and knowledge.

One of the basic ideas with *TEXT-COL* is to function as a tool for working with computer mediated texts in a structural way which in some sense anchors it in the knowledge worker approach. In addition, texts and corpora can be viewed as a kind of micro-world, with words, paragraphs, and other linguistic constructions as building blocks. This qualifies *TEXT-COL* as a cognitive tool for learning in the same manner as hypertext, micro-worlds, etc.; are classified as cognitive tools for learning. Regarding the discussion in Chapter 7, the grey-codings and the possibility to manipulate with these are stressed as a important elements serving to raise the activity level of the reading process, and thereby important for how the tool supports changes in readers' conceptions. The proofs concerning *TEXT-COL*'s ability to support the readers to raise their activity level in their reading from the study discussed in this chapter are few. The main reason for this is that the study of the basic concepts of *TEXT-COL* was mainly aimed to ensure that the grey-coding of texts did not seriously impede reading, and not on studying and evaluating the underlying learning mechanisms promoted by *TEXT-COL*. The data in the study that supports *TEXT-COL* as a cognitive tool for learning are found in the subjective part of the study. Even if the data that confirm the hypothesised underlying learning mechanisms supported by *TEXT-COL* and the basic ideas of the knowledge worker approach are few, there is nothing in the data that refuses the basic ideas, therefore, the results from the study encourage us to proceed with the development of *TEXT-COL*.

Part of this work is more studies and experiments. We are already in the next phase with experiments with new ways of coding texts, where we incorporate a more sophisticated parser, both in the creation phase of IV-lexicons and in the reading tool (Björkäng, 2000). Now when we know that the grey-coding does not have any greater impact on the reading speed and many readers have a positive attitude to variations in the level of saturation, the next step of *TEXT-COL* will be more focused on learning effects, and on evaluations of the hypothetical positive effects for the outcome from the reading process that we believe *TEXT-COL* can give.

A second track for the future work is to utilise the same principles as *TEXT-COL* utilises in order to create visual representations (icons) of text documents that gives an idea of a context dependent information density in the document. To express each word's information value with a coloured block of pixels where the colour tells something about the information value

in the same manner as the grey-code in *TEXT-COL* is an example of such a representation.

9

FOCI – an environment to work with focus

A point of departure for this thesis is the ongoing shift in the view of learners, from seeing them as passive receivers of knowledge to seeing them as active creators of knowledge. This change in view forces a development of new learning tools that support the learners to take a more active role in their learning process.

Information seeking and learning, are two processes that are closely related, and the boundaries between them are beginning to loosen up. To establish and keep focus are two of the hardest problems to overcome in information seeking, and thereby in learning situations based on information seeking, such as problem-based learning and the knowledge worker approach. The problems of keeping focused have their roots in information overload. The fact that the goals constantly change, and the fact that it is often a question of keeping track of many parallel goals, are other things that cause problems for the process of keeping focused.

These things indicate the importance for the learners to have access to support or help to establish and keep focus. The computers give us opportunities to implement new kinds of learning tools, such as tools for working with foci.

At the Cognitive Tools Workshop we have developed an environment aimed to support learners/knowledge workers in the process of establishing and keeping foci – the *FOCI* environment, (see Figure 37). The current status of *FOCI* is that it exist as an early prototype, where many of the logical units such as the user interface and the mechanism for modelling foci are separated, and no evaluations or studies have yet been performed to evaluate how well it supports the learners to establish and keep the focus. The *FOCI* environment is a WWW-based environment working together with standard WWW-browsers. This chapter discusses the *FOCI* environment – how it works, and the basic concepts.

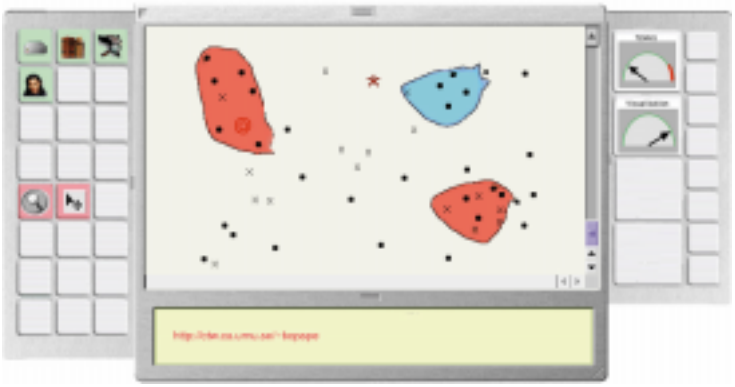

Figure 37. An overview of the FOCI environment.

1. The basic concepts

Kuhltau has studied the process of information seeking (Kuhltau, 1993), and some results are very interesting and relevant for the work in this thesis. Her results present similarities between the process of information seeking and the learning process. According to Kuhltau, both processes are a matter of constructing knowledge. Kuhltau points out how important it is for the outcome of the process of information seeking that the information seekers are focused during the whole process. Therefor, it is important for the quality of the outcome that the learners can establish and maintain their focus or goal for the learning activity.

What is a focus, and what does it mean to be focused? This section addresses these questions, by a discussion of the basic concepts of the *FOCI* environment, such as areas of interests, modelling areas of interests, the processes of establishing and keeping focus, operations on foci and visualisation of focus models.

Area of interest

Scientists or researchers and their working situation can serve as a model for knowledge work in general, especially the kind of learning situation that the knowledge worker approach implies. Access to and search for relevant information plays a significant role in their daily work, also the task to keep up dated in their areas of interest is important.

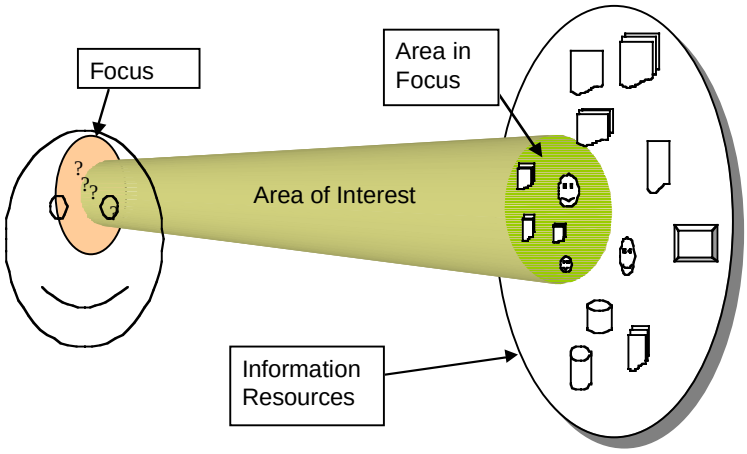

Figure 38. The relation between area of interest and focus.

What is an area of interest? Figure 38, shows the terminology I will use for the concept of area of interest. First, even if one can talk about an organisation's area of interest, in this context an area of interest is a *highly personal* entity. Second, it can be characterised, as something that one is interested in or is *focused on*. Third, an area of interest is something *vague*, *abstract*, and *dual*: the individual interest (focus) and the externalisation of the focus (the area in focus). An individual's focus is defined by an individual's personal interest, ideas, questions, etc., and of course, other persons or organisations can share many of these. Fourth, a person can and almost always has *multiple foci*, some related to the work or different parts of the work and some are related to more private interests; a focus can also be a mix of personal and professional interests. Even if one side of the coin is that an area of interest is a highly personalised entity, the other side is not. To great extent, the area in focus consists of non self-related entities or resources such as documents, persons, organisations, events, working questions, issues etc. Among other things, these resources are utilised in one or another way in order to seek answers to questions that define the focus.

In today's information society where the production and the flow of information increases, one big issue for a knowledge worker is to know what resources are the important ones related to a specific focus. A focus is a very *dynamic* entity. For example, the importance or priority of a focus varies over the time, the questions that define a focus also vary with the time. The area in focus also changes with the time: the persons that are central, what documents to read, the hottest issues of the field, etc. are always changing.

The total picture of a person's areas of interest is a collection of sub-areas, some of them interconnected. Therefor, it is meaningful to talk about *the*

organisation of foci and the *granularity* or level of description of foci. In short, foci are entities with a complex character that are hard to handle for a knowledge worker. This is quite an unexplored area , and there are few tools designed with a purpose to support the knowledge workers to work with foci.

Establishing and keeping focus

The process of establishing a focus has much the character of a process of exploration (Kuhltau, 1993). Often, knowledge workers come into this process with a rather vague view of what they want to know (focus), defined by a set of interesting questions and by an idea of relevant and interesting resources (material, persons, competencies, etc.). By exploration of similar resources the idea of what they want becomes clearer – they get more focused. In practice, the knowledge worker is exploring a field, and among other things they discover documents that are closer to ones interest, they get a better idea of important people, they make changes in their defining questions, etc. Hence, the more they work with a topic the focus tends to stabilise, and the problem to *keep* the focus is beginning to play a larger and more important part of the cognitive workload. It is worth to notice that we do not believe that this process of establishing a focus follows a continuous process of restriction. Instead, we believe that the focusing process is a matter of drifting by alternating between narrowing and widening the area of interest. In the narrowing phase, differences are observed and a sub-set is selected based on such assessments. In the expanding phase, the information space is foraged for more resources related in some chosen way to the current set. This is repeated until the focus and the area in focus are in balance.

The process of keeping a focus during an information seeking task and consequently during a learning process is closely related to the process of establishing focus (even if a focus seems stable it is constantly drifting). On the other hand, the problems with keeping focus are also closely related to information overload and the problems that have its origin in that situation. (Wilson, 1993) describes information overload as a situation full of stress where it is hard for the affected to concentrate on long term goals (investments) and instead keeps jumping between short term goals (consuming). This has become extremely visible when more and more of the information seeking has moved from libraries to WWW. If one compares with traditional information systems WWW is a medium where the information is much easier to access and more directly exposed.

Modelling foci

A focus is a very complex entity, dynamic and individualised. These characteristics define the requirements and prerequisites for modelling foci. We believe that the traditional ways of modelling knowledge such as rule-based systems and semantic nets are not suitable to use to model foci. The major reason to reject systems that are in fact successful in modelling expert knowledge is that they are not so suitable to model vague ideas of personal interests/preferences. Another alternative is to use a parameter-based model, which is quite common to use in information filtering and information seeking system to personalise the delivery of information. In order to model an individual's interests these systems store data about the user's interests in a user-profile, which very often is some sort of system-defined weighted checklist. The main advantage with this kind of models is the easiness of handling matching-rules for delivery of resources. Some of the major drawbacks with this technique are that it is hard to define the key-parameters in an appropriate way, and that it takes much work to categorise the resources. The drawbacks make it inappropriate to use for modelling foci. An alternative that matches our purposes better is different kinds of document-based models.

The basic idea with this way of modelling or representing knowledge is to gather documents into collections of related documents (corpora). A corpus is or can be viewed as a representation of the cumulated knowledge of an area defined by someone. The size of a corpus can vary from quite small person-defined areas to huge collections of documents distributed by some organisation (in organisation-authorised corpora). In this kind of modelling it is natural with sub corpora, to define structures such as hierarchies of sub corpora, and to define relations between sub corpora.

Our idea is to use the same technique in order to model areas of interest. The basic concepts of our modelling system are:

- A corpus is a dynamic collection of documents representing the cumulated knowledge of an area.
- A focus is modelled by a user-defined dynamic collection of relevant and descriptive documents.
- This collection of modelling documents represents or models the status of the focus.
- The modelling documents can be produced by other authors or be own documents such as own papers, documents with relevant questions etc.
- The focus is sub-corpus that semantically spans up the area in focus.
- Foci can be incorporated into larger corpora.

Operations on foci and corpora

To establish and keep focus are two major tasks connected with foci, but more concretely, what kinds of operations are possible to do on foci? Foci and corpora can both be considered to be sets or containers, hence many of the common operations on sets are quite natural as operations on foci and corpora, but there are needs for other kinds of operations too; for example to extract different kinds of relation between foci, sub corpora, documents, concepts, persons etc. There are two categories of operations on foci: operations for the maintenance (see Table 27) and operations for extracting information from foci, (see Table 28).

Name	Description
Define	Define a set of resources as a focus or corpus
Merge	Merge two foci or corpora into one
Divide	Divide one focus or corpus into two
Insert	Insert a resource into a focus or corpus
Delete	Delete one resource from a focus or corpus
Set Priority	Assign a priority value to a resource, focus or corpus
Destroy	Decompose a focus or corpus

Table 27. Operations for maintenance of foci.

Name	Description
Nearness	Compute the conceptual nearness between two resources, foci, or corpora
Priority	Return the priority value for a resource, focus, or corpus
Relevance	Compute the relevance a resource has for a focus or corpus
Subset	Compute if a set of resources is a sub-set of a focus or corpus. This is a set-operation
Member	Return true if a resource is a member of a focus or corpus. This is a set-operation
Difference	Compute the difference between two foci or corpora. This is a set-operation
Intersection	Compute the intersection between two foci or corpora. This is a set-operation
Choose	Return a member of a focus o corpus, i.e. one example of a resource. This is a set-operation

Table 28. The extraction operations on foci and corpora.

This is not any attempt to give a complete list of operation for a focus/corpus data type, but is useful as a starting point for designers of tools for working with foci and corpora.

Infoscape maps

In some sense, both corpus and area in focus are representations of the cumulated knowledge in an area. In addition, we argue above that there is a need to express or extract nearness, likelihood, relevance between corpora and entities in a corpora, etc. Geographic metaphors for collections of documents are common to use when discussing information and knowledge systems. In these metaphors a corpus is viewed as an information landscape and information seeking and retrieval are discussed in terms of travelling, navigation, orientation, distance, position, landmarks, etc. There are several relevant questions associated with this kind of geographic metaphor. What does an information landscape look like? Is there any common view, etc?

If we take a closer look at our conception of the world, it took quite a long time and many steps to get the picture of the physical world that is accepted among the majority of people today. The tools that we have today that help

us to travel the physical world are quite good: we use maps, compass, GPS, radar, traffic signs, etc, and most of the modern people are quite skilled at physical travel.

We have now entered the information and knowledge society where knowledge-work tasks become every day chores for most of us. This implies that travels in abstract information landscapes will be a part of our everyday life, both in our professions and in our spare time. In spite of the fact that we do many typical knowledge works tasks, the situation is that most of us are quite inexperienced and poor at making virtual travels. Likewise, the tools that exist today for virtual travelling are few and most of them are underdeveloped. In the near future, we will need new and better tools for coping with the situation information overload, and for easier travels in the information landscapes. In geographically travels, the map has been a useful tool and so will the maps over the information landscapes (infoscape maps) be. Land surveys and land-survey tools will play almost the same prominent role for the development of knowledge about the information and knowledge society as they have had for establishing the view of the physical world that we have today. We need to develop virtual land-survey tools that help the knowledge workers to explore information landscapes, and extract relations among the entities in the landscapes, such as distance, nearness, etc. In other words, we need a good way to visualise knowledge models, and we need good tools to extract information from these models.

An area of interest is a very individualised and dynamic entity, which has to be reflected in an adequate model of it, and in an appropriate visualisation of the model. For example, when the focus-model is updated, normally caused by changes in a learner's focus, this implies that the corresponding visualisation of the information landscape (infoscape map) that the externalisation of the focus is a part of also must be changed.

The infoscape maps, support travellers in keeping focus by offering some sort of navigation aid, as maps always have done. On the other hand, a map is not the only way to visualise knowledge models. Another way can be gauges that show how relevant a document is to different foci.

2. Using semantic spaces to model foci

The basic idea with the *FOCI* environment is to model an area of interest (a focus) with a representative collection of documents. The *FOCI* environment utilises LSI (Latent Semantic Index) created semantic spaces (Berry & Dummais, 1994), to model corpus and focus. The purpose with this section is to give an overview of Latent Semantic Index (LSI) as a method or

tool to model foci. For a more detailed description see (Berry & Dummais, 1994).

Latent Semantic Index

The way one indexes corpora in information systems plays an important role for the performance of the retrieval of resources. Most of today's information systems uses either keyword-based indexing methods or lexical matching where the corpus is indexed by a term frequency matrix. Normally, each row in the matrix represents one term, the columns represent the documents, and each cell in the matrix represents the number of times a term occurs in a particular document. For many concepts there are many ways to express it (synonymy), but it is also quite common with the other way around where the same word represents several concepts (polysemy). Both synonymy and polysemy cause problems for the performance of keyword and lexical indexing methods. It is desirable with an indexing and retrieval technique based on the conceptual topic or the meaning of the documents and the questions. One possible approach is to use some sort of conceptual mapping (Lanzing, 1996) or semantic network technique for this purpose. (Berry & Dummais, 1994) propose the Latent Semantic Index (LSI) as an alternative indexing method for large corpora, which organises the information into a kind of semantic structure (semantic space), thus avoiding the problems that are associated with lexical matching. The LSI method starts with the same kind of word by document matrix as the traditional lexical matching methods do, but it utilises a truncated singular value decomposition (SVD) in order to produce the indexing structure, i.e. to place documents and terms into a semantic space.

The three resulting matrices from the truncated SVD describe a semantic space, where the left matrix U holds positional information for the terms, the right matrix V^T holds positional information for the documents, and the Σ matrix holds information about the extent of the semantic space. In other words, both the terms and the documents are placed into the same k-dimensional semantic space and it is meaningful to talk about similarity (nearness) between two documents and between two terms, but also between a term and a document.

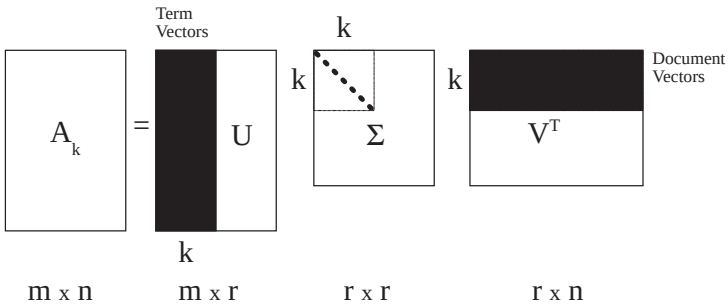

Figure 39. The singular value decomposition of matrix A, where A_k = best rank-k approximation of matrix A, U = term vectors,∑ = singular values, V = document vectors, m = number of terms, n = number of documents, k = number of factors, and r = rank of matrix A. Adapted from (Berry & Dummais, 1994).

For purposes of information retrieval, the first phase is to compute a representation of the query in the indexing structure, a k-dimensional semantic space. The idea is that a query is a collection of words and a query q can be represented as a term vector or pseudo-document $\hat{q}$ in the k-dimensional semantic space, (see Equation 4, Equation 5, and Equation 6). The second phase is to compare this pseudo-document against every document in the semantic space, and return the documents that meet a nearness/similarity condition (different approaches for measuring nearness/similarity are discussed in the next section). This method for information retrieval allows a document or a corpus to be used as a 'query'.

Equation 4 derives an expression for column i of matrix V^T (the index structure for documents) [23].

Equation 4. $$V^T = \Sigma^{-1} U^T A \Rightarrow V^T_{:,i} = \Sigma^{-1} U^T A_{:,i}$$

Some algebra gives the expression for row i of matrix V, (see Equation 5).

Equation 5. $$V_{i,:} = (A_{:,i})^T U \, \Sigma^{-1}$$

Reducing the index space to a k-dimensional space and substituting $A_{:,i}$ with q in Equation 5 gives a representation of the query as a pseudo-document in indexing space, (see Equation 6).

[23] Both matrix V and matrix U are orthonormal and matrix Σ is a diagonal matrix.

Equation 6. $\hat{q} = q^T U_k \Sigma_k^{-1}$

Corpora are dynamic entities and there is an inherent need for updating the model. Basically, there are two alternatives to handle the updating of a LSI–based semantic model: re-computing the model or folding-in the new terms and documents. In order to keep the correctness of the model the re-computing alternative is the best, but this method requires more computation than the folding-in alternative. To re-compute implies that one extends the document set (corpus) with the new documents, and re-compute the entire matrix decomposition.

To fold in a new document is in practice to compute a pseudo-document representation of the document, and it is the same when folding in a new term. This is done in the same manner as one does to represent queries, Equation 7 is used to fold in a document and Equation 8 is used to fold in a term. The only difference between folding in and the query case is that in the updating case the model itself is extended with the pseudo-document vector, instead of using the pseudo document to search for similar documents. The major drawback with the fold-in strategy is that the accuracy of the mathematical model is diminished. To keep the accuracy of the model, it is necessary to regularly re-compute the model. How often one has to do that depends on the size of the model, in general a smaller model is more sensitive for changes. The periodicity in needed re-computations is also dependent on the kind of application and the uses of the application.

Equation 7. $\hat{d} = d^T U_k \Sigma_k^{-1}$

Equation 8. $\hat{t} = t V_k \Sigma_k^{-1}$

Some of the critical issues for the performance of LSI are the extensive use of computational resources needed, choosing the dimension (k) of the semantic space, term weighting, and the measurement of nearness (Dumais, 1989). Dummais, also discusses the applications of LSI as a critical issue; as I interpreted this, if LSI is to be anything than as just a research product, it is necessary with a wide range of applications.

Measurement of nearness

In generally, how do we compare two vectors, and more specifically, how do we measure the similarity of two semantic vectors? There is no obvious way of measuring similarity between two n-dimensional vectors. Some of the existing methods from the literature are to compare the norms of the two vectors or to use the cosine of the angle between them, (see Figure 40).

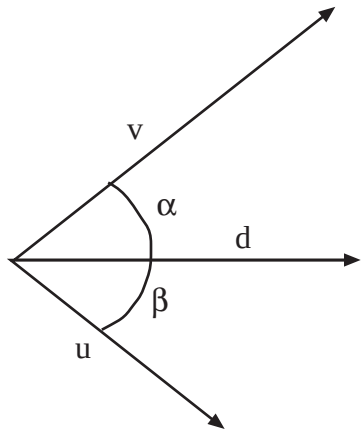

Figure 40. Traditionally, the angels α and β are used in order to decide which of the vectors v and u that are most similar to vector d.

The resulting value from cosine is in the range [-1…1], where 0 means that the two vectors are identical. One major drawback with this method is the existence of both negative and positive values, e.g. in Figure 40, there is no obvious way to interpret $\cos(\alpha)$= A and $\cos(\beta)$= -A.

Equation 9. $$\delta_{trad} = \cos(\alpha) \Leftrightarrow \frac{(\vec{v}_1 \bullet \vec{v}_2)}{\|\vec{v}_1\| \times \|\vec{v}_2\|}$$

We propose an alternative method of comparing (measuring similarity of) two vectors, which combines the length and the angle in the measure, and with a value between 0 and 1. This measure is computed by taking the *length* of the resulting vector from a *subtraction* between the two compared vectors. In order to get a value in the range [0…1], where 1 means that the two vectors are identical, (which better mirrors the conception of similarity). The length value is normalised by the 2-norm of the sum of the two leading vectors in matrix Σ, (see Equation 10).

Equation 10. $\delta_{prop} = 1 - \frac{\|\bar{v}_1 - \bar{v}_2\|}{\|\bar{s}_0 + \bar{s}_1\|}$

The 2-norms for *v´* and *u´* in Figure 41 are equal, hence the two vectors *v* and *u* are at equal distance from vector *d*, this is also true for $\forall \bar{x}(\|\bar{d} - \bar{x}\| = \|\bar{d} - \bar{v}\|)$. That is, all vectors that touch the circumference of the grey circle are interpreted to be at equal distance from vector *d*.

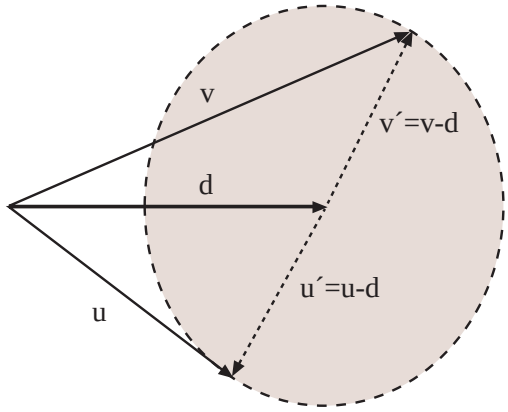

Figure 41. A proposed way of comparing two vectors similarity based on the 2-norm of the difference between them. The 2-norm of vectors v´ and u´ are used to decide which of the vectors v and u that are most similar to vector d.

Applications of LSI

LSI is a very general method for modelling conceptual relations, hence the applications cover a broad field. From the beginning, LSI was developed to be a method for indexing large corpora for the purpose of information retrieval. This is a quite important and common application for the knowledge workers in an information society. Another kind of application of the SVD-based method is the class of analysing applications; in this field the method is named Latent Semantic Analysing (LSA) (Deewester, Dumais, Furnas, Harshman, & Laundauer, 1990; Foltz, 1996). The purpose with this section is to give an overview of the kinds of applications of LSI/LSA that exist.

LSI was developed to be used as an alternative method in information retrieval. It has been shown that LSI both copes with the synonymy and

polysemy problems better than the traditional indexing methods and therefor outperforms them in both precision and recall (Dumais, Furnas, Landauer, Deerwester, & Harshman, 1988). The LSI method utilises statistical data on how words are distributed among the documents in a corpus. Basically, no semantic or syntactical information is utilised. Hence, it is very simple to apply the method to any language, but it also makes it possible to create a cross-language semantic space. Berry and Dummais (1994) describe Landauere and Littman's method for creation of cross-language semantic spaces. One of the ideas behind this is that concepts are equally distributed among the documents independent of the language of the document.

For most documents there are one or more authors, and in some sense a document mirrors some of the interests and competencies that the authors have. This makes it possible to index a set of persons by letting individuals be represented by their production of documents, thereby indexing human competencies and interests. The Bellcore Advisor is one example of this kind of application of LSI discussed in (Berry & Dummais, 1994)

There is a need for tools in the information society which restrict or filter the information flow based on personal preferences (information filtering). There are attempts to utilise LSI-methods for filtering e-mail (Knowledge Analysis Technologies, 1999a), and filtering Netnews articles (Foltz, 1990; Foltz & Dumais, 1992).

All the applications above are more a less applications of LSI. There are also applications where the SVD is used for other purposes, such as analysing or comparing the semantic similarity between pieces of textual information (Foltz, Britt, & Perfetti, 1996), modelling human knowledge, and spelling correction. An example of the first kind of application is the Intelligent Essay Assessor™ from Knowledge Analysis Technologies, LLC, which is a system for automatic characterisation of the quality of essays (Knowledge Analysis Technologies, 1999b)

There is a strong correlation between SVD and methods for unsupervised training of artificial neural networks, and therefor LSI/LSA is also interesting from a cognitive science perspective, especially from an AI-perspective. In other words, LSA can be used as a theory of acquisition, induction, and representation of knowledge (Landauer & Dumais, 1997; Landauer, Laham, & Foltz, 1998).

As a last example of the broad field of application of LSI and LSA an application where the SVD-based methods are used for spelling correction. (Berry & Dummais, 1994) discuss Nielsen, et al attempt to use the method in an OCR application in order to correct scanning errors. Kukich has used LSI for similar purposes, namely in a spelling correction program (Kukich, 1992a; Kukich, 1992b).

LSI/LSA to model foci

We believe that the characteristics of the LSI-method make it very suitable to use for our purpose to model the complex characteristics of foci. First, the broad field of LSI/LSA-based applications show the possibility to construct a model that in some sense represents conceptual knowledge. Such a model involves cross-language resources, the dynamics of the knowledge, diverse kinds of resources (which can be described or represented in textual form), sub-areas, etc. Second, it is possible to give the model a spatial interpretation. That is, the model is a k-dimensional space in which the resources are positioned, which is a requisite for the construction of a visual representation. Third, linear algebra gives us a broad range of well-defined operations on foci.

Fourth, the method can be used both for quite large corpora as the LSI method is aimed for, and for application with quite small corpora mostly used in the analysing kind of application (LSA-based). In our application of LSI/LSA we want to represent both quite small user-defined corpora (personal foci), as well as larger corpora defined by organisations (organisational foci).

3. The functionality of *FOCI*

The basic purpose of the *FOCI* environment is to support the user in developing and establishing foci as well as keeping the focus during the information seeking/learning process. The way the *FOCI* environment offers this support is by providing an environment for visualisation of corpora (infoscape maps). In this visualisation, the dominating dimensions of the SVD based model (semantic space) are used to create the infoscape maps (Figure 42 is an example of a 2D infospace map). The *FOCI* environment is based on the conception of the establishing process as an explorative process. Therefor, it is natural to view the *FOCI* environment as an exploration environment for information landscapes or as search engine with a graphical user interface. For example, it is possible for the user to get an idea of the conceptual similarities among different resources, see a document's conceptual relevance to different foci, use it as a navigation tool, and to trace and predict changes or movements over time in an information landscape. Examples of such changes are: areas that merge or split, the emergence of new areas, the activity in an area, etc.

The *FOCI* environment is modular, which means that users can add and remove tools or functionality. For that purpose, the *FOCI* environment has an application-programming interface (API). The basic configuration includes some basic tools for working with foci, for example tools to create

a model, define foci, redefine foci (by adding and deleting resources merge two foci and split one focus into two foci), get information about an resource, measure similarity or nearness between two resources, access resources, relevance meters, relevance alarms, and tools to create an animation of the changes in a model.

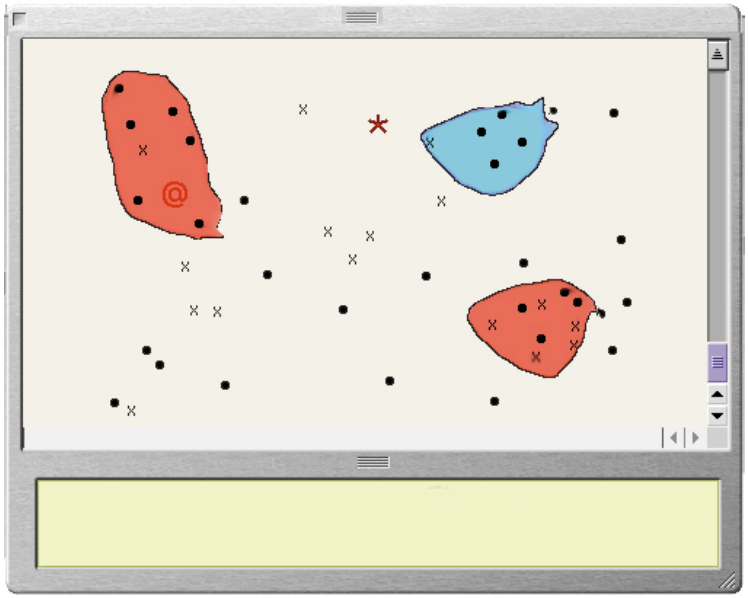

Figure 42. FOCI window with a 2-D infoscape map over computing science.

The *FOCI* environment allows the user to have several models opened and visualised in a FOCUS-window. A FOCUS-window has four sub-areas: toolbox, the infospace window, the information display, and the control panel.

The Toolbox is divided into a general toolbox and a model toolbox. The difference is that the tools in the general toolbox are accessible from every model, i.e. exist in every open *FOCI*-window, whereas the tools in the model toolbox associated with are one particular model only are accessible from that model. A user can have the same kind of tool in several toolboxes.

The infospace window presents the n-dimensional visualisation of the model. The user has control over the visualisation by the possibility to:

- adjust the number of dimensions of the visualisation,
- define the representation of each of the dimensions; e.g. the most significant dimension of the model should be represented by the x-axis, the second most significant dimension should be represented by the y-axis, etc.
- select the representation for both the column and row entities in order to make it possible to distinguish between them in the infospace map, (dots and crosses in Figure 42),
- hide and show the row or column entities in an infospace map,
- choose the representation of a particular entity in the model; e.g. the @-sign in Figure 42 represents a document selected by the user as a user-significant document, and the big star represents the current document in the web-browser or word-processor.

Other features related to the infospace window are the possibilities for a user to define clusters of resources, where one such cluster can represent a focus. There are three clusters in Figure 42, which marked with a boundary by the FOCI-environment.

The information display is the window in which tools present their information to the user. For example the selection tool presents information about the selected entity in the model, title of the document, URL, position, etc. and the similarity tool presents the semantic distances between two entities.

The control panel is divided into a general panel and a model-associated panel like the toolbox window. The control panel has similar functionality as the information display, that is, to function as area for visual output for the tools. The user has the possibility to decide if a visual output from a tool (independent of whether the tool is a model specific or a general tool) is to be associated to one specific infospace-map (model-associated) or to be visible in all infospace maps (general). One example is the similarity tool, which it is possible to attach a relevance meter to, (see Figure 43). The general meters are visible in every *FOCI*-window, and the model-associated meters are only visible from the model that it is attached to. In the example, the relevance meters express a relation between the document in the web-browser, word processor, or selected resource in an infospace window with the attached resource. It is also possible to set an alarm to a relevance meter

which will go off if a document's relevance level becomes higher than a user-defined level (see Figure 43).

Figure 43. The control panel with two meters, for which the alarm function is activated for one of the areas of interest (tennis).

4. How to work in the *FOCI* environment

The discussion in section 3 and 4 gives an idea of how to use the *FOCI* environment. The fact that users of a tool develop their own ways of use and develop personal skills in using the tool is also true for the FOCI environment and the tools in it. Hence, it is quite hard to predict every way that tools will be used, especially since the FOCI environment is a quite new kind of environment of which we do not have any experience. This may justify an attempt to speculate or predict ways of using the environment. The purpose with this section is to give a broader picture of the *FOCI* environment and the possibilities it has to support the user to get answers to questions concerning navigation in an information landscape. Questions like where to start, where to go next, which person to contact, etc.; but also how the environment can arouse a user's curiosity for alternatives or new ways to proceed. This is done by briefly discussing some task or use scenarios.

Search engine for general resources

In the knowledge-society we are just entering, more and more of the information is accessible via Internet. Also, it becomes more common that organisations shift the responsibility for the access of their information to the individuals – the information is there, and if you need it, it is up to you to get it. *Learning on demand* and *just-in-time learning* are two similar concepts, which are fruits of the information society. Both of them are characterised by being driven by short-term goals and needs and are useful learning strategies for long-term investment. Good media and language independent mechanisms for searching and retrieving knowledge resources such as a person, a part of an organisation, an organisation, a document, a course, a learning object, etc.; are extremely important for both. In addition, the problem to find knowledge resources that match one's needs is not only relevant for organisations and employees in organisations, it is also an important question for private persons, learners, etc.; i.e. it concerns most of the citizens in a knowledge society.

The character of the underlying mechanisms in the *FOCI* environment for indexing resources, where it is possible mix documents in different languages, and have text documents that represent knowledge resources, etc, gives the *FOCI* environment the potential to serve as a general search engine of media and language independent knowledge resources. It is possible for an organisation or individual to create a semantic space that models the collected knowledge resources of an organisation. The individuals in the organisation that use the *FOCI* environment can utilise this model and use it as a search engine with a graphical representation (infospace map). For example, by clustering, marking or just knowing where in the infospace map interesting resource are located and resources in the vicinity known to be similar in some conceptual meaning. Another way of use is as traditional text-based query system to access knowledge resources related to the organisation, with one major difference, namely the possibility to use documents or sets of documents as queries.

Extracting meta-information

There are several tools or features in the *FOCI* environment, which help learners or knowledge workers in extracting and exploring meta-information. First, the geographic interpretation of an area of interest (infospace map) makes some meta-information visible; for example, the existence of clusters of resources, how similar resources are in some semantic sense, which persons or organisations that belong to different clusters. There are movements and activities (new resources are added to the

model, users make changes in their foci, etc) in areas of interest. The possibilities that the FOCI environment affords to trace changes over time in a model gives the learners a support to explore and predict such movements and activities. There are also tools in the environment for measuring different kinds of relations in an infospace map such as nearness, distance, etc.

To focus and be focused

An individual's foci are changeable and personal entities that can be viewed as drifting sub-corpora of some larger corpus. To establish focus is much a question of getting a better idea of what one wants to know or to learn. To establish focus seems to be a process of exploration and changes of conception (Kuhltau, 1993). The FOCI environment supports the user in establishing a focus using a method that alternates between narrowing and widening the area of interest. As the focus stabilises, the process changes character to become a process of being focused.

To illustrate how the FOCI environment can support the users to establish and keep focus a hypothetical scenario is discussed below.

Scenario: *An engineer at a process industry has a feeling that the risk of losing his job is increasing. This feeling occupies his thinking more and more and makes him mull over how to cope with this situation. Further education seems to be the solution for him. Even if he is afraid of loosing his job, he is interested to do similar work in the future. Since long time, he has grown a private interest in philosophy and psychology, and he has read lots of literature in these fields during the years. Most of the literature has been web-based material downloaded to his computer at his work place. In order to widen his interest and get a better idea what to study, he gathers all the downloaded documents and reports and other documents he has written in his profession. Based on this corpus he creates an infospace map in the FOCI environment. He also downloads a corpus-model from a psychology department at a well-reputed university, which he merges with his own. He defines two foci, one with documents representing his professional production, where many of the documents concern computer-aided control of industrial process, and one represents his private interest in psychology and philosophy.*

With help of the infoscape map, he starts to explore the information landscape, reading documents that are close to his two foci, but also documents quite far from his foci. He keeps adding documents to the two foci, both external documents that the alarm has signalled as relevant and documents already in the model, that he has found interesting, but also

deletes some of the documents. Caused by these modifications of the foci they start drifting and seem to collide. Soon he decides to merge them into one focus. After that, this new focus tends to stabilise. In parallel, driven by curiosity he has explored a new focus, which he defines by some interesting resources. The new focus is neurophysiology. During this process, he has contacted some of the authors to articles in his foci, whom he has discussed his problem with, and two of them has directly proposed that he should start studying cognitive science.

Even if this is a short and constructed scenario with a happy end, we believe that it gives an idea of how the FOCI environment can be used. Both in order to get a better idea of what one wants to know (to establish foci), and also to keep the concentration on it (to be focused).

5. Summary

The purpose with this section is to summarise the discussion about FOCI, but also to look forward and discuss future work related to FOCI. The two questions from the summary of *TEXT-COL* are also relevant in a summary of FOCI. What is it that makes FOCI a cognitive tool for learning, and how is the functionality of FOCI anchored in the knowledge worker approach?

In short, the arguments for FOCI are almost the same as for *TEXT-COL*. FOCI is intended to be an environment in which the learners work with knowledge structures such as documents and corpora in an explorative way. Except from some experimental tests of the LSI as a base for foci-modelling system, no direct studies of FOCI have been carried out, but the study at Telia encourage us to continue the work with FOCI. From my point of view, there is a large potential for the FOCI environment or similar environments. That there is a need for new tools aimed to support the user to establish and keep focus is evident, considering that the importance of the huge, chaotic, and anarchistic WWW as a source of information keeps growing, and information related views of computers such as library, knowledge bank, and communication channel are growing in familiarity, and the factor of time to get the information stands out as the most important factor in the choice between sources of information, as the study at Telia indicates.

There are several ideas for future work related to the FOCI environment, the most prominent is to make a complete implementation, in which the LSI-based indexing structure of documents and foci, and the graphical user interface are smoothly integrated. Other items on the agenda are:

- additional tools to be used in the FOCI environment, such as measuring tools, extraction tools, a probe for self assessment, etc.
- to empirically study the process of establishing a focus;
- to empirically study and evaluate the learning mechanisms supported by FOCI as a cognitive tool for learning;
- to evaluate the validity of different ways of measuring nearness between vectors;
- to experiment with ways to visualise conceptual nearness among documents.

…I Still Haven't Found What I'm Looking For…

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