

# Time Allocation in Knowledge Work 

## Evaluation of Time Efficiency at a Task Level

Helga María Jónsdóttir


Faculty of Industrial Engineering, Mechanical Engineering and Computer Science University of Iceland

2016

# TIME ALLOCATION IN KNOWLEDGE WORK 

Helga María Jónsdóttir

60 ECTS thesis submitted in partial fulfillment of a
Magister Scientiarum degree in Industrial Engineering

Advisors<br>Guðmundur Valur Oddsson<br>Helga Guðrún Óskarsdóttir<br>Faculty Representative<br>Ari Jónasson

Faculty of Industrial Engineering, Mechanical Engineering and Computer Science
School of Engineering and Natural Sciences
University of Iceland
Reykjavik, June 2016

Time Allocation in Knowledge Work
Time Allocation in Knowledge Work
60 ECTS thesis submitted in partial fulfillment of a M.Sc. degree in Industrial Engineering
Copyright © 2016 Helga María Jónsdóttir
All rights reserved

Faculty of Industrial Engineering, Mechanical Engineering and Computer Science
School of Engineering and Natural Sciences
University of Iceland
VR-II, Hjarðarhagi 2-6
107, Reykjavik, Reykjavik
Iceland
Telephone: 5254000

Bibliographic information:
Helga María Jónsdóttir, 2016, Time Allocation in Knowledge Work, M.Sc. thesis, Faculty of Industrial Engineering, Mechanical Engineering and Computer Science, University of Iceland.

ISBN XX
Printing: Háskólaprent, Fálkagata 2, 107 Reykjavík
Reykjavik, Iceland, June 2016

## Abstract

Time efficiency in knowledge work is explored by evaluating what types of tasks knowledge workers are performing. The research scope was based on literature review of knowledge worker productivity. The assumptions were that knowledge workers spend a lot of their time at work performing non-knowledge intensive tasks or non-value adding tasks that causes decrease in time efficiency. A small-scale case study was performed to record tasks performed by knowledge workers. The data was gathered with direct observations and semi-structured interviews. The research design followed the dissemination process by Stuart et al. (2002). Four workers in the healthcare industry participated in the study and the observations took place in Landspítali University Hospital. Three techniques to evaluate time efficiency were proposed. Two of the techniques generate knowledge work time efficiency (KWTE), and the third generates work time efficiency (WTE). The KWTE techniques were developed from the definition of white collar work by Hopp et al. (2009) and Ramirez and Steudel's (2008) knowledge work quantification framework. The techniques were applied to the data recorded. Results were that the WTE was on average $>90 \%$, while KWTE was from $45 \%$ to $72 \%$. That is, at least $20 \%$ of the time spent on work related tasks is spent on performing non-knowledge intensive tasks.

## Útdráttur

Tímanýting bekkingarstarfsmanna er metin með bví að skoða tegundir verka sem unnin eru af bekkingarstarfsmönnum.Ályktað var að bekkingarstarfsmenn eyða einhverjum hluta af tíma sínum í verk sem krefjast ekki beirrar bekkingar sem beir búa yfir og eru ekki virðisaukandi, sem leiðir til minnkunar á nýtingu tíma. Tilfellisrannsókn var framkvæmd til bess að safna gögnum um bau verk sem bekkingarstarfsmenn vinna, par sem bekkingarstarfsmönnum var fylgt eftir í starfi og peir spurðir spurninga. Rannsóknin fór fram á Landsspítala Háskólasjúkrahúss og fjórir starfsmenn í heilbrigðisgeiranum tóku pátt. Prjár aðferðir voru lagðar til með bað að leiðarljósi að meta tímanýtingu. Tvær beirra meta tímanýtingu m.t.t. bekkingarvinnu, en sú briðja tímanýtingu í heild. Með bví að nota aðferðinar á gögnin fengust pær niðurstöður að tímanýting í heild var að meðaltali $>90 \%$, á meðan tímanýting m.t.t. bekkingarvinnu var allt frá $45 \%$ til $72 \%$. P.e. að minnsta kosti $20 \%$ af tímanum sem pekkingarstarfsmenn vinna fara í að framkvæma verk sem ekki eru metin sem pekkingarvinna.

## Contents

List of Figures ..... ix
List of Tables ..... xiii
Abbreviations ..... xv
Acknowledgments ..... xvii

1. Introduction ..... 1
1.1. Research Scope ..... 3
2. Methodology ..... 5
2.1. Case Research ..... 5
2.1.1. Define the Research Question ..... 6
2.1.2. Instrument Development and Site Selection ..... 6
2.1.3. Data Gathering ..... 7
2.1.4. Analyze Data ..... 7
2.1.5. Disseminate and Research Findings ..... 7
2.2. Observation Methodology ..... 8
2.3. Semi-Structured Interview Methodology ..... 9
2.4. Research Design ..... 11
2.4.1. Research Scope ..... 12
2.4.2. Instrument Development ..... 12
2.4.3. Data Gathering ..... 15
2.4.4. Ethical Issues ..... 16
2.4.5. Data Analyzes ..... 16
2.4.6. Disseminate and Research Findings ..... 17
3. Theoretical Background ..... 19
3.1. Knowledge Workers and Knowledge work ..... 19
3.2. Task Dimensions ..... 21
3.2.1. Autonomy ..... 22
3.2.2. Structure ..... 22
3.2.3. Tangibility ..... 23
3.2.4. Knowledge ..... 23
3.2.5. Creativity and Innovation ..... 23
3.2.6. Complexity ..... 24
3.2.7. Routine and Repetitiveness ..... 25
3.2.8. Physical effort ..... 25
3.3. Time Allocation ..... 25
4. Time Use Techniques ..... 29
4.1. Dimension Technique ..... 30
4.2. Group Technique ..... 34
4.3. Work Time Efficiency ..... 38
5. Time Use Results ..... 39
5.1. Verification of Method ..... 40
5.2. Results From Observing Medical Specialist ..... 50
5.3. Results From Observing Project Manager ..... 55
5.4. Results From Observing Shift Supervisor ..... 60
5.5. Results From Observing Nurse ..... 65
6. Summary and Comparison ..... 71
7. Discussion ..... 77
7.1. Limitations ..... 78
7.2. Further Research ..... 79
References ..... 81
A. Handout to Participants ..... 85
B. Data ..... 87
B.1. Verification of method ..... 87
B.2. Medical Specialist ..... 92
B.3. Project Manager ..... 99
B.4. Shift Supervisor ..... 104
B.5. Nurse ..... 121

## List of Figures

2.1. Research design process ..... 5
2.2. Observation process ..... 8
2.3. Semi-structured interview process ..... 9
2.4. Research design ..... 11
2.5. Data gathering process ..... 16
4.1. Time use techniques ..... 29
4.2. White collar vs. blue collar work ..... 35
4.3. Six task groups matrix ..... 35
4.4. Knowledge work group matrix ..... 37
5.1. Gantt chart of tasks before data processing ..... 42
5.2. Data processing algorithm example ..... 43
5.3. One dimensional timeline of the tasks in example ..... 43
5.4. Verification of method: gantt chart of tasks after data processing ..... 44
5.5. Verification of method: one dimensional time line of tasks after data processing ..... 44
5.6. Verification of method: one dimensional time line idle time gaps after data processing. ..... 46
5.7. Verification of method: cumulative time per KWTS intervals ..... 48
5.8. Medical specialist: One dimensional timeline of tasks after data pro- cessing ..... 51
5.9. Medical specialist: one dimensional time line of idle time gaps data processing. ..... 52
5.10. Medical specialist: cumulative time per KWTS intervals. ..... 53
5.11. Project manager: one dimensional time line of tasks after data pro- cessing ..... 56
5.12. Project manager: one dimensional time of idle in data set ..... 57
5.13. Project manager: cumulative time per KWTS intervals. ..... 58
5.14. Shift supervisor: one dimensional time line of tasks after data processing ..... 61
5.15. Shift supervisor: one dimensional time line of idle time gaps data processing. ..... 62
5.16. Shift supervisor: cumulative time per KWTS intervals. ..... 63
5.17. Nurse: one dimensional time line of tasks after data processing ..... 67
5.18. Nurse: one dimensional time line of idle time gaps data processing. ..... 68
5.19. Nurse: cumulative time per KWTS intervals. ..... 69
6.1. Summary of KWTS results for each participant ..... 73
A.1. Handout ..... 85
A.2. Handout ..... 86
B.1. Gantt Chart plot of data recorded from shadowing medical specialist ..... 90
B.2. Gantt Chart plot of data recorded from shadowing medical specialist after algorithm running ..... 91
B.3. Gantt Chart plot of data recorded from shadowing medical specialist ..... 97
B.4. Gantt Chart plot of data recorded from shadowing medical specialist after algorithm running ..... 98
B.5. Gantt Chart plot of data recorded from shadowing project manager. . ..... 102
B.6. Gantt Chart plot of data recorded from shadowing project manager after algorithm running ..... 103
B.7. Gantt Chart plot of data recorded from shadowing shift supervisor ..... 119
B.8. Gantt Chart plot of data recorded from shadowing shift supervisor after algorithm running ..... 120
B.9. Gantt Chart plot of data recorded from shadowing nurse ..... 132
B.10.Gantt Chart plot of data recorded from shadowing nurse after algo- rithm running ..... 133

## List of Tables

2.1. Research questions and objectives ..... 12
4.1. Knowledge worker, knowledge work and task definitions ..... 30
4.2. Eight tasks dimensions (Ramirez and Steudel, 2008). ..... 31
4.3. Eight tasks dimensions evaluation guidelines. ..... 32
4.4. Illustrative example for calculating KWS ..... 34
4.5. Concepts determining whether a task is routine vs. creative. ..... 36
5.1. Participants schedule ..... 39
5.2. Tasks evaluation for chosen tasks from prepared data set. ..... 41
5.3. Total appearances and cumulative time for chosen tasks before and after data processing. ..... 45
5.4. Illustrative example for calculating KWS ..... 47
5.5. Group segmentation and cumulative time for tasks in the data set ..... 48
5.6. Interview questions answers. ..... 50
5.7. Total appearances and cumulative time for chosen tasks before and after data processing. ..... 52
5.8. Total appearances and cumulative time for chosen tasks before and after data processing. ..... 53
5.9. Interview questions answers ..... 54
5.10. Tasks evaluation for chosen tasks from prepared data set. ..... 55
5.11. Total appearances and cumulative time for chosen tasks before and after data processing. ..... 57
5.12. Group segmentation and cumulative time for tasks in the data set ..... 58
5.13. Interview questions answers ..... 59
5.14. Tasks evaluation for chosen tasks from prepared data set. ..... 60
5.15. Total appearances and cumulative time for chosen tasks before and after data processing. ..... 62
5.16. Group segmentation and cumulative time for tasks in the data set. ..... 64
5.17. Interview questions answers. ..... 65
5.18. Tasks evaluation for chosen tasks from prepared data set. ..... 66
5.19. Total appearances and cumulative time for chosen tasks before and after data processing. ..... 67
5.20. Group segmentation and cumulative time for tasks in the data set ..... 69
5.21. Interview questions answers. ..... 70
6.1. Three methods results summary for the participants. ..... 71
6.2. Group segmentation for each participant ..... 73
6.3. Group segmentation along two dimensions ..... 74
B.1. Medical specialist data set ..... 87
B.2. Medical specialist data set ..... 92
B.3. Project manager data set. ..... 99
B.4. Shift supervisor data set. ..... 104
B.5. Nurse data set. ..... 121

## Variable Names

KWTE Knowledge Work Time Efficiency<br>WTE Work Time Efficiency<br>KWS Knowledge Work Score<br>KWTS Knowledge Work Task Score<br>TKIS Task based Knowledge Intensity Score

## Acknowledgments

I would like to thank my supervisors for the help and interest in the research process and access to the organization and participants included in the study. Also, i would like to thank the participants at Landspítali University Hospital for willing to be a part of the research, and other workers at the organization who showed interest and came up with ideas about the subject matter.

## 1. Introduction

Currently, increasing knowledge worker productivity is a big challenge in the developed countries (Drucker, 1999) where the knowledge worker workforce have become larger than manual workers (Nickols, 2012). That is, organizations depend on knowledge workers and their contribution. The workers knowledge, intelligence, creativity and innovation to solve complex tasks and create value is important. On the opposite, manual work is structured, routine and repetitive and the methods used in 20th century that resulted from fifty-fold increase in manual-worker productivity does not apply directly to increase productivity in knowledge work (Drucker, 1999; Paton, 2013; Ramírez and Nembhard, 2004).

There are many aspects to take into consideration when managing, improving and measuring knowledge work and no universally accepted techniques have been developed yet (Ramírez and Nembhard, 2004). It is important to focus on improving knowledge worker productivity to gain or maintain competitive advantage in the knowledge economy (Drucker, 1999). Therefore organizations must find ways to affect the productivity of knowledge workers to improve their business and success.

This research approaches this new productivity challenge by examining how knowledge workers use their time at work in relation to the tasks that they perform. The assumptions are that knowledge workers use a specific amount of their time at work performing routine and non-knowledge intensive tasks. Those tasks that are not considered as knowledge work could then take time from them in performing value adding tasks. The reasons for this could lie in the organizational environment such as organizational structure and design, management, interruptions, information technology investments, etc. Research findings, such as Birkinshaw and Cohen (2013), Perlow (1999), Donnelly (2006) and Drucker and Maciariello (2008) support these assumptions.

To approach the solution towards knowledge work productivity challenge, the following two research questions are to be answered

- How do knowledge workers use their time at work?
- What types of tasks are the workers performing?


## 1. Introduction

A case study was used to record tasks performed by knowledge workers and map the time duration to answer the research questions. Observation and semi-structured interviews were used for data gathering in the case study. The research design followed the Stuart et al.'s (2002) dissemination process. The scope was based on literature reviews and participants were chosen conveniently. The author observed four workers in the health care industry at Landspítali University Hospital. Each of the workers were shadowed for one work day, except for one worker who was shadowed for two work days where the first observation was to verify the research design methods.

Three techniques to generate time use and evaluate tasks from the data gathered were developed. The first one called the dimension technique was drawn from Ramirez and Steudel's (2008) knowledge work quantification framework where the time use was found from evaluating tasks by Ramirez and Steudel's (2008) eight dimensions. The second technique, called the group technique was drawn from Hopp et al.'s (2009) definition of white collar work. The author defined six groups of tasks for the tasks to be assigned to and time use was calculated from the division of tasks into the six groups. The final technique was work time efficiency where the time performed on work related tasks was defined and divided by the total time. The results from the three techniques were found for each of the cases in the study.

In this work the research questions are answered with the purpose of giving insight into knowledge work by examining the tasks performed and evaluate the time use of knowledge workers. Answers will be addressed by conducting a case study research. The following chapters will cover the methodology used and research design, theoretical background, time use techniques, results from the three techniques for each case, summary and comparison of the cases and discussion. Data and other material is found in appendices. To prepare the reader for further readings, the research scope is introduced in following section.

### 1.1. Research Scope

The research scope is drawn from current literature on knowledge worker productivity reviewed by the author. Worker's time use is evaluated from the tasks that he or she performs. That is, the characteristics of the tasks that a worker performs determine the time use. The time use can be determined as time efficiency, i.e. how much of the time is spent on knowledge intensive tasks as a proportion of the total time working. Time effectiveness and personal productivity are not included in the scope.

Taylor first studied the work at a task level to improve manual worker productivity (Drucker, 1999). This research focuses on the task that knowledge workers perform, at individual level. Thus, the system that the scope is based on, consists of work process performed by an individual worker. Time is considered as an input to the system. The work process is examined by evaluating the tasks that the works consist of in relation to knowledge intensity. Thus, with the time as an input and therefore, knowing time duration and knowledge intensity of each task in the process, time efficiency can be found.

## 2. Methodology

The methodology consists of a case study research, observation and semi-structured interviews. This case research is both quantitative and qualitative, with combination of direct observation and semi structured interviews. Data is to be gathered systematically and descriptively. Following sections cover a case research process that is to be used in the research design, observation and semi-structured interviews methodology, followed by the research design. In the research design, inspiration was drawn from Arman et al. (2009), Biron et al. (2009), Perlow (1999), Su et al. (2013) and Tucker and Spear (2006).

### 2.1. Case Research

The case study design methodology used in this research is mainly based on three articles. First, Effective case research in operations management: a process perspective (Stuart et al., 2002), second Case research in operations management (Voss et al., 2002), and third The scientific theory-building process: a primer using the case of TQM (Handfield and Melnyk, 1998). Stuart et al.'s (2002) design process is used as fundamental basis for the research design, and the other two for support and more detailed information when needed. Stuart et al.'s (2002) five step design process is illustrated in figure 2.3.


Figure 2.1: Stuart et al.'s (2002) design process.

Stuart et al.'s (2002) five stage process in case research in operations management consists of; (1) Define the research question, (2) Instrument development and site selection, (3) Data gathering, (4) Analyze data, and (5) Disseminate the research findings. Each step in the process is discussed further in following subsections.

## 2. Methodology

### 2.1.1. Define the Research Question

Handfield and Melnyk (1998) state that observation is the start of scientific process where the researcher discovers a problem, and all research are based on previous findings or theories (Stuart et al., 2002). Conceptual framework of the subject matter provides a good direction to value and selecting the constructs and variables to include in the research (Voss et al., 2002). Research questions can be drawn from the conceptual framework (Voss et al., 2002).

Definition of the research questions can be for several purposes. Stuart et al. (2002) mention six of them; discovery, description, mapping, relationship building, theory validation and theory extensions/refinement. The research questions proposed in introduction in chapter 1 have the purpose of mapping and describing how knowledge workers spend their time at work. Thus, the focus in next steps of the research design process will be guided with those purposes.

### 2.1.2. Instrument Development and Site Selection

After the research questions have been defined, the next step is to develop research instruments and select site to obtain the data needed to answer the research questions (Stuart et al., 2002). The methods used to collect evidence are selected in this step (Voss et al., 2002). The instrument design is an important protocol to gather information as efficiently as possible (Stuart et al., 2002). If something changes further in the design process, this step can be revisited (Stuart et al., 2002).

When selecting site and sample in a case study, the cases should be exemplary rather than representative (Handfield and Melnyk, 1998; Stuart et al., 2002) and trade-off between efficiency and richness of data should be considered (Voss et al., 2002). If cases are many, it reduces the depth of the research but fewer cases limit the generalizability of the findings (Voss et al., 2002).

Instruments are protocol that contain procedures and general rules to provide focus, organize and document (Stuart et al., 2002; Voss et al., 2002). So, how the data will be gathered and documented is decided in this step, with respect to what data is needed to answer the research questions identified in previous step. Data sources are identified, such as observations, interviews, informal conversations, meetings and events (Voss et al., 2002). As introduced previously, this research consists of observation and semi-structured interviews. Reliability increases if more than one source of data is for the same phenomenon (Cooper and Schindler, 2013; Voss et al., 2002).

### 2.1.3. Data Gathering

When instruments have been developed and the sample and site decided, data collection takes place. The instruments in pervious step are used to collect and store the data needed. Data gathering in the field starts with gaining access by writing or calling, followed by a research meeting which can be in the form of a letter to set-up visits, to gain access to the site (Voss et al., 2002). Seeking out persons who know where to find the best respondents can provide support and open doors (Voss et al., 2002). When conducting the research, it's important to build trust with participants quickly (Stuart et al., 2002). When the field research takes place, multiple sources of data provides a better understanding for the researcher (Stuart et al., 2002) and helps to find convergence of views and information to address gaps (Voss et al., 2002).

### 2.1.4. Analyze Data

When the data gathering is done, it's necessary to analyze the data. In previous stages of the research, this part should have given thought (Simpson et al., 1995; Stuart et al., 2002). Knowledge and understanding is required to conceptual thinking and making sense from all the data collected (Stuart et al., 2002). Much of the data come into existence in this step of the process (Stuart et al., 2002). Data analyzes challenges include extracting significant patterns, simplifying informations from descriptive data and to think laterally (Stuart et al., 2002). In this research, data for each case is to be analyzed and then the cases are compared to identify patterns among workers to answer the research questions.

### 2.1.5. Disseminate and Research Findings

When disseminating the research findings from a case research, the validity is often questioned and are subject to criticisms, some valid and some invalid. (Stuart et al., 2002). Four logical tests that may be applied and concern are; construct validity, internal validity, external validity and reliability (Stuart et al., 2002). Five characteristics of an exemplary case study stated by Yin (1994) are that the study must: be significant, be complete, consider alternative perspectives, display sufficient evidence and be composed in an engaging manner.

## 2. Methodology

### 2.2. Observation Methodology

The observation methodology in this research was mainly based on Simpson et al. (1995) book Using Observations in Small-Scale Research. A three step process was drawn from the book and is illustrated in figure 2.2. The three steps are (1) Selecting what to observe and how to record data, (2) Managing the activity of observing, and (3) Processing the data. The first step falls under instrument development, the second step corresponds to data gathering and the third step refers to analyzing the data in Stuart et al. (2002) process. The directness, concealment and participation of the relationship between the observer and participants can vary in observations. In the current research the observation is found to be direct, with participants having the known presence of the observer. That is "the observer is physically present and personally monitors what takes place" (Cooper and Schindler, 2013).


Figure 2.2: Observation process.

The first step in figure 2.2 guides to solve the problems regarding the focus of the research and recordings of the observations (Simpson et al., 1995). The choice of constructs and variables to focus on and include in the study have to correspond to the scope of the research (Voss et al., 2002). Before selecting what to observe and how to record data, it is important to have in mind how the data must be analyzed (Simpson et al., 1995), i.e. identify the preferable data needed to get the results to answer the research questions. Recording strategies can be completely unstructured to highly structured. Recording systems can be divided into systematic, descriptive/narrative and technological recordings (Simpson et al., 1995). An important part of the observation and analysis is to keep additional notes, such as ideas that come up and impressions (Eisenhardt, 1989; Voss et al., 2002) and to ask questions to push thinking (Eisenhardt, 1989).

The second step in figure 2.2 deals with issues associated with where to observe, problems that might come up and the supplementary information which might be necessary. Following aspects should be considered when managing the activity of observing; the physical setting, roles and relationships, and ethical issues. Before the actual observation and settings are known, it is useful to visit the place at least once to get to know the situation and identify practical problems (Simpson et al., 1995). When observing other people, a few ground rules apply and the participants must be aware of that they have the right to refuse, know what exactly is involved
in the study and know what will be done with the information and notes accounted (Simpson et al., 1995). Ethical issues refer to (Simpson et al., 1995):

- adopting coping strategies
- establishing the researcher role
- reducing the level of threat
- avoiding confrontation
- turning a blind eye

The third and last step deals with data analysis. In this step, information gathered should be transformed to provide statements (Simpson et al., 1995). Analyzing data can be different whether the recordings are systematic, descriptive/narrative or technological, as covered in step 2, and whether the data is quantitative and qualitative (Simpson et al., 1995). Processing of data collected systematically from observations can be from simple descriptions of individual categories to identify relationships between variables (Simpson et al., 1995). Descriptive and narrative data is an iteration process of focusing, refining, verifying, organizing, reducing and presenting the data (Simpson et al., 1995). Note that data analyzes from observations are not unlike analyzing data from other sources (Simpson et al., 1995).

### 2.3. Semi-Structured Interview Methodology

The interview methodology used in the research was mainly drawn from Drever (1995) book Using semi-structured interviews in small-scale research. A four step process was drawn from the book and is illustrated in figure 2.3. The four steps are (1) Developing the interview schedule, (2) Planning and preparation, (3) Conducting the interview, and (4) Analyzing the interview. The first two steps fall under instrument development in Stuart et al. (2002) process. The third and fourth steps correspond to steps three and four in Stuart et al. (2002) process. A semistructured interview usually starts with specific questions, followed by participants thoughts and researcher's probes (Cooper and Schindler, 2013). Semi-structured interviews can yield different kinds of information, such as factual, preferences and opinions and experience, motivations and reasoning (Drever, 1995).


Figure 2.3: Semi-structured interview process.

## 2. Methodology

The interview schedule in the first step guides the interview and causes consistency between separate interviews. Interview schedule is a tool that includes the main questions, prompts and probes, and short checklist where the interviewer asks the questions, leads the interview, makes notes and marks off points. The order and wording of the questions are important (Drever, 1995). First, the main questions are drawn from the research questions which have been defined earlier. These questions should lead the researcher through the topic, in a logical order. Prompts and probes are used to help people say what the want to say and must be used when appropriate (Drever, 1995).

The next step is to decide who to interview, get them to agree to that, and prepare necessary the instruments needed. Then approaching the participants by contacting and stating the request in some form. The request should include an introduction of the researcher and his/her interest, why the participant was chosen, what is expected of the participants, why and for whom the research is done, and promise of confidence and feedback (Drever, 1995). An estimate of time required, location, at what time the interview takes place are decided. Another aspect should be taken care of such as negotiation with authorities, permissions needed, which could include a description of the subject matter, copy of schedule (Drever, 1995).

Third step is conducting the interview. The researcher should develop tactics and his/her interview skills (Drever, 1995). In a small-scale study the first interviews sets a precedent for the next. How long it takes, where difficulties occur, etc. so the schedule can be improved for further interviews (Drever, 1995).

The last step involves preparing and analyzing the data. Included in analyzing is data preparation that makes it easier to analyze the data later on. Preparation is done to make the data manageable without loosing information and to avoid distortion (Drever, 1995). The researcher can transcribe, partly transcribe or summarize the interview from records. When transcripts and notes are ready the text is reorganized, categorized and summarized to match the research questions. Each answer must be linked to a participant and interview question (Drever, 1995).

### 2.4. Research Design

The design of current research was based on case study, observation and semistructured interview methodology covered in previous sections. The research design follows Stuart et al. (2002) process and consists of defining the research scope and developing protocols for data gathering and analyzes. Dissemination of the findings of the research are discussed. Figure 2.4 illustrates the design process for current research.


Figure 2.4: Research design.

## 2. Methodology

### 2.4.1. Research Scope

From literature of knowledge worker productivity, the research scope was identified. From many factors of determining knowledge worker productivity, it was decided to take a look at efficiency at knowledge work. It was found that time efficiency in knowledge work does not link directly to the productivity, but it's a substantial parameter that can be considered. Therefore, development of techniques to calculate time efficiency for real cases address the following two research questions defined in table 2.1 along with their objectives.

Table 2.1: Research questions and objectives.

| Research question | Objective |
| :--- | :--- |
| How do knowledge workers use their time <br> at work? | Evaluate time efficiency by examine real <br> cases. |
| What types of tasks are knowledge work- <br> ers performing? | Evaluate tasks related to knowledge <br> work. |

The scope is based on Hopp et al.'s (2009) definition of white collar work and Ramirez and Steudel's (2008) quantification in knowledge work and eight task dimensions. Hopp et al. (2009) and Ramirez and Steudel (2008) both define white collar worker and knowledge worker by looking at the task involved in the work. The scope is limited in two ways, it only considers the individual worker and the tasks included in the worker's job. Team and organizational level is not involved in the study, but it helps to contextualize the research matter.

### 2.4.2. Instrument Development

Instrument development in this work consists of identifying data sources, selecting the site and participants and developing the software application, data processing algorithm and interview schedule. The data sources are from literature review, observations and semi-structured interviews. Time use techniques are developed from the literature review and used as protocols to analyze data, further description of those instruments are covered in chapter 4 as a result from the literature review.

The search strategy used in the literature review was mainly the snowball method, with systematic method used when searching for narrower and side information. Fist, twelve articles were read carefully and snowball method applied for broad
searches by following authors, references and citations. To gain narrower information about specific subjects, search terms were entered in Web of Science and Google Scholar search engines.

## Participants and Site

Selection of participants and site have to include knowledge workers in their working environment. Due to time and resource limitations in this research, the focus was set on a small group of workers that have the same characteristics as knowledge workers and work in the same organization, but with different professions. The goal was to find workers that were willing to participate in the study for mutual interest. The mentor had access to a key person at Landspítali University Hospital, hence the sample was convenient. Handout was written to introduce the project, author and research purpose to a key person at the hospital. The key person suggested workers to contact and to introduce the project and to ask them if they were willing to participate in the study. The author contacted those workers that all agreed to participate.

## Software Application

Software application was designed for systematic data recordings in the shadowing phase in figure 2.5. The shadowing phase is where the author observes the participants by following them and recording data. The author uses the application on a tablet computer to record tasks performed by participants when they are working. The application returns a text-file with data set from recordings with appropriate information to be able to process the data to find the answers to the research questions.

The application is developed for systematic recordings in the field. The function of the application is as follows. Tasks names are added to the interface as buttons. The tasks added are pre-specified. Unthought of tasks that occur in the field can be added as the observation goes along. When a worker performs a task, the corresponding button is tapped to file informations of start time. The button is tapped again when the worker has finished the task, and the duration time is filed. Note that more than one task can be measured at once. The data generated from the recordings is a sequence list of the tasks. Informations for each task are documented to one data row. Those informations are start time and duration of each task, worker ID and the date of recordings.

## 2. Methodology

## Data Processing Algorithm

Algorithm is developed for analyzing the systematic data recorded with the software application. The algorithm is coded in the R statistical program. The functions of the algorithm are in two steps; first to refine the data set, and second, to perform calculations from the informations in the data set. The algorithm should also generate descriptive figures of the data.

The refinement of the data refers to dealing with overlaps, because two tasks can be measured at once in the software application. In this manner, time is one dimensional line because humans can't perform more than one task at a time. The algorithm function is that when a task overlaps another task, a piece correspondent to the overlapping task is cut from the predominant task. The terms overlapping task and predominant task described in following list, along with independent task. Note that a task can be both overlapping and predominant.

- Overlapping task: A task which overlaps another task by starting before the other (predominant) task ends
- Predominant task: A task where other task(s) overlaps it
- Independent task: not predominant nor overlapping

Iteration is needed to perform the data refinements where the predominant tasks are refined in respect of the first overlapping task. If there are more than one overlapping task, then the task is refined again. Execution of the data refinement is covered in verification of method in section 5.1 where illustrative figure is drawn.

Part two of the data processing algorithm was written to generate results from the three time use techniques introduced in chapter 1. The three techniques are developed from the literature review and covered in chapter 4. All figures that represent the data in chapters 5 and 6 are created with the algorithm.

## Interview Schedule

The interview schedule purpose is to maintain questions that the author thinks of and be able to compare separate answers from all participants. Answers to the questions are sought to gain deeper information and understanding of the subject matter. The questions in the schedule are drawn from the research scope and the research questions. If the author thinks of questions when conducting the research for example in the data gathering part it's noted and, if evaluated so, added to the interview schedule.

By introducing the research matter to the participants, the participant can come up with comments about their work and job design and processes in contrast with their understanding of the research description. The questions on the interview schedule are either asked parallel to shadowing recordings or on a meeting where results from data processing are introduced.

Interview schedule was developed by drawing questions from the research scope and research questions. Questions identified when shadowing the participants were added to the schedule.

Questions drawn up from research questions

- Q1: What is your education?
- Q2: What is included in your job?
- Q3: How busy is your job?

Question to contextualize the specific workday when the participant was shadowed

- Q4: how busy or unusual was this day in contrast with other workdays?


### 2.4.3. Data Gathering

As identified in the previous step, data sources are from literature review, observation and semi-structured interviews. Following paragraphs feature how the data is to be gathered. First, information and understanding of the research matter is gained from books and peer reviewed articles. From the writings found and selected in the search execution, notes and summaries are made to collect data. This is done to gain understanding and conceptual thinking that can be used for strategic advantage in the next steps.

The in the field data gathering process is the three steps outlined in figure 2.5. The author performs data gathering for each participant. The three phases are (1) short session with the participant, (2) shadowing, and (3) meeting. The purpose of the first step is to introduce the research to the participant and prepare data gathering software application. The short session can take place in the beginning of the day and is informal. The second step, shadowing, is when the author follows participants in their work environment and collects data with the software application on a tablet computer and notes information. Answers to the interview questions were gathered in the shadowing phase. The last step involves reviewing results from data analyzes.

## 2. Methodology



Figure 2.5: Data gathering process.

Data was collected systematically and descriptively. Systematic recording was done with the software application on a tablet computer as covered in previous step (section 2.4.2) by recording the tasks performed by the participants. Descriptive data gathering are participants answers to questions asked and additional notes written by the author. The additional notes purpose is for remembering, deeper description for task contents, ideas etc. To be able to record the data, card was used to fasten the tablet computer on one half of it, and glue the note block to the other half. Answers to the semi-structured interview questions are gathered at all steps in the data gathering process.

### 2.4.4. Ethical Issues

The participants participated voluntarily and gave permission for the observations. All information about participants are confidential and doesn't show in this research. Confidential paper was provided by the hospital, that the author signed. No information about patients were gathered and the author was not always present at patient meetings or direct care. The author was not present inside of patients rooms at the emergency department, and patients were not aware of the author.

### 2.4.5. Data Analyzes

Data analyzes consists of defining concepts and developing time use techniques from the literature review. The time use techniques consists of evaluating the tasks, and calculate time use. Theoretical background is covered in chapter 3 and the analyzes from the theoretical background is introduced in chapter 4.

When the systematic data have been gathered, it is prepared for the data processing algorithm. The preparation of data includes fixing errors or wrong evaluation tasks in the field. The errors are noted so the data can be fixed afterwards. Data preparation also consists of evaluating the tasks by the evaluation strategies developed from the literature review. The prepared data is processed with the algorithm to refine
the overlaps and make one dimensional time line of tasks. The algorithm generates the outcomes for the three time use techniques.

The descriptive data, gathered from field notes and semi-structured interviews, is analyzed by conceptual thinking by the author.

### 2.4.6. Disseminate and Research Findings

The final step is to answer the research questions from data analysis. The research findings is disseminated in this thesis submitted in partial fulfillment of a M.Sc. degree in Industrial Engineering. Poster is created and an article is written.

## 3. Theoretical Background

The theoretical background consists of summary from the literature review of knowledge workers and knowledge work, task and task dimensions, and time allocation in knowledge work. The research is inspired by Hopp et al.'s (2009) definition of white-collar work and Ramirez and Steudel's (2008) knowledge work quantification framework and eight knowledge work dimensions. From the theoretical background, concepts are defined to prepare the research execution and time use techniques developed to use as a protocols in data analyzes.

The search terms used to find the data were; knowledge work, knowledge worker, manual work, management, efficiency, time allocation, effectiveness, task, activity, productivity, routine, repetitive, complexity, difficulty, cognitive, knowledge, performance, profession and quality.

Following subchapters explore the concepts; knowledge workers and knowledge work, task and the eight task dimensions and previous findings and literature of time allocation in knowledge work.

### 3.1. Knowledge Workers and Knowledge work

Researchers define the term knowledge worker either at the individual level, or at the task level, i.e. from their characteristics of the worker; traits, skills, experience, education etc., or from the types of task they perform. Drucker and Maciariello (2008) first used the term knowledge worker and defined them as individuals with considerable theoretical background earned from formal education and the workers own the means of production. Óskarsdóttir (2014) combines the two aspects and defines knowledge worker as "A worker with high degrees of expertise, education or experience, with the main purpose of creating, sharing or applying knowledge in his job, where the nature of his work is non-routine, creative and intellectual".

Drucker (1999) implies that knowledge workers should be treated as an asset rather than a cost in the organization. Drucker (1999) defined technologists as those who perform manual work and knowledge work. Technologists fall under knowledge
workers and should be treated in the same way as them (Drucker, 1999). If knowledge workers have the ability, motivation and opportunity, they are more likely to engage in work (Kelloway and Barling, 2000). Autonomy is also an important factor for knowledge worker productivity (Drucker, 1999; Nair and Vohra, 2010) and job satisfaction (Nair and Vohra, 2010).

Work is the processes and sub-processes that workers perform to change input to output (Thomas and Baron, 1994). The real substance in knowledge work are the processes, not the product (Pyöriä, 2005) which require knowledge from internal and external sources to generate a product that is worthwhile (Thomas and Baron, 1994) and are contingent (Pyöriä, 2005). Researchers often seek to distinguish knowledge work from manual work by concepts that are opposite. According to Nickols (2012) the main difference is, that knowledge work is based on information and manual work is based on materials. Similar to that, Drucker and Maciariello (2008) state that knowledge work is performed in the head of the workers, but manual work in their hands. Thomas and Baron's (1994) components of work state that knowledge work scores high in knowledge use, decision making and complexity, while components of structure, skilled activity, volume and repetitive is low. Knowledge work is nonroutine in nature with low level of standardization (Pyöriä, 2005) and continuous learning and continuous teaching must be a part of knowledge work (Drucker, 1999). Kelloway and Barling (2000) proposed definition of knowledge work in organizations is built on the knowledge worker's discretionary behavior focusing on the use of knowledge. Discretionary task completion requires the judgement of the worker to decide when the work is complete (Hopp et al., 2007). In knowledge work, the knowledge is created, applied, transmitted and acquiesced (Kelloway and Barling, 2000).

Hopp et al. (2009) believe that there remains a fundamental distinction between knowledge worker and manual workers, that lies in classification of the tasks they perform. Hopp et al. (2009) defines blue and white-collar work along two dimensions; physical vs. intellectual and routine vs. creative. White collar work is creative and/or intelligence and blue collar work is physical and routine. Knowledge workers are a subset of white-collar workers in Hopp et al. (2009) definition.

Ramirez and Steudel (2008) also define knowledge workers from the tasks that they perform. The eight knowledge work dimensions defined by Ramirez and Steudel (2008) are;

- Autonomy
- Structure
- Tangibility
- Knowledge
- Creativity \& Innovation
- Complexity

Knowledge work is a set of tasks so these knowledge work dimensions refer to the tasks that the work consists of. The dimensions dictate the knowledge-intensity of each task performed by a worker, and hence the level of knowledge work in the knowledge worker job (Ramirez and Steudel, 2008).

Knowledge work is never pure manual or pure knowledge work, in most work there is a combination of blue and white collar tasks (Ramírez and Nembhard, 2004) which the work consist of (Hopp et al., 2007). It differs to what proportion of the task that the knowledge worker performs are knowledge intensive. Ramírez and Nembhard (2004) introduced the knowledge work continuum, where work and workers can be placed on correspondent to the knowledge intensity of the combinations of tasks that they perform.

### 3.2. Task Dimensions

Work process is a series of tasks (Hopp and Van Oyen, 2004). Hopp and Van Oyen (2004) define task as an activity where labor and/or resources are applied to an entity over time. Tasks are completed by workers through events (Reder and Schwab, 1990) and represent everything that needs to be done to accomplish specific objective (Hopp and Van Oyen, 2004). Reder and Schwab (1990) define task as discrete work objectives. Ramirez and Steudel (2008) define work task as "a set, subset or individual action that needs to be done to accomplish a job. Usually, a discrete unit that describes a part of job".

Taylor first studied work at a task level to improve manual worker productivity (Drucker, 1999). To measure knowledge work, a model building at the task level is preferable (Gleeson and Hargaden, 2014; Hopp et al., 2009; Ramirez and Steudel, 2008). Time can be considered as input to the work process (Thomas and Baron, 1994). This research uses the same approach, where time efficiency techniques developed are at the task level with evaluation of time as an input to the system.

The eight task dimensions are reviewed in following subchapters. The dimensions are; (1) Structure, (2) Tangibility, (3) Routine and repetitiveness, (4) Autonomy, (5) Knowledge, (6) Complexity, (7) Creativity and innovation, and (8) Physical effort (Ramirez and Steudel, 2008). Each of the dimensions can be evaluated for a specific task and hence the work placed on the knowledge work continuum (Ramirez and Steudel, 2008). Each dimension is reviewed on higher levels, such as work or organizational level, followed by definitions of the dimension at a task level.

### 3.2.1. Autonomy

One of the six factors that determine knowledge worker productivity is autonomy (Drucker, 1999). Drucker (1999) points out the importance of knowledge workers autonomy because they are responsible for their own productivity. This is supported by Hackman and Oldham (1976), that "job characteristics predicted to prompt employee feelings of personal responsibility for the work outcomes is autonomy". The worker decides when to release a task, therefore the worker has discretion over the value added to the outcome (Hopp et al., 2007). In addition, researches have shown that autonomy leads to job satisfaction (Hackman and Oldham, 1976; Nair and Vohra, 2010; Saragih, 2012).

Ramirez and Steudel (2008) define autonomy as the control of the worker regarding how a task is done. More control indicates more autonomy. Autonomy can be defined as the degree of discretion regarding procedures and timing of tasks and criteria modified to evaluate their performance (Breaugh, 1985). Hackman and Oldham (1976) define autonomy as how much freedom, independence and discretion included in the job and in determining the procedures used to perform the tasks. Therefore, the worker's judgment is required and the worker's approaches to solve a task may vary from one worker to another (Thomas and Baron, 1994).

### 3.2.2. Structure

Because of the task is given in manual work, i.e. it is always known what needs to be done, it is preferable to structure the task in the easiest, suitable way regarding sequence and time (Drucker, 1999). In manual work, known methods can be applied to structure tasks to increase productivity. However, in knowledge work, it should be a part of the worker's job to decide what tasks to perform (Drucker, 1999). The worker's judgment is important in decision-making and problem solving, and the task can be completed in many ways (Hopp et al., 2007; Thomas and Baron, 1994).

According to Ramirez and Steudel (2008) structure refers to established rules, policies, or procedures that the worker should apply to complete a task. Thomas and Baron (1994) defines structure from other aspect, as the constraints of how, when, where a task is done, and what is done. With higher degree of structure of a task, the performance time becomes more standardized and can be determined in advance (Hopp et al., 2007).

### 3.2.3. Tangibility

Visibility in manual work is high, while visibility in knowledge work is low (Nickols, 2012). Knowledge work involves abstract knowledge and symbols, and manual work involves working with physical matter (Pyöriä, 2005). The major issue in measuring knowledge worker productivity it's often the case that the work processes and products are intangible (Drucker, 1999; Nickols, 2012; Ramírez and Nembhard, 2004; Thomas and Baron, 1994). Drucker (1967) points out that when watching knowledge workers, it is impossible to know what they're thinking. Ramirez and Steudel (2008) refer to tangibility as how difficultly a task is perceived, especially by sense of touch and sight.

### 3.2.4. Knowledge

Blackler (1995) points out that every organization is knowledgeable. In manual work the knowledge is concentrated, while the knowledge is distributed in knowledge work (Nickols, 2012). Knowledge is applied to manual work in how to perform task, or series of tasks, by known methods (Drucker, 1999). With the shift to knowledge work, the location of knowledge in organizations is moving from bodies and routines, and to be located in brains, dialogue and symbols (Blackler, 1995). The knowledge is inside of worker's brains, and therefore it's owned by the workers in the organization, and is portable (Drucker, 1999). Knowledge is created, applied, transmitted and acquiesced in knowledge work (Kelloway and Barling, 2000). Continuous learning should be a part of knowledge worker's job (Drucker, 1999) and it is important stake to the worker to perform a task which he or she will learn from (Hackman and Oldham, 1976).

Ramirez and Steudel (2008) define knowledge at a task level as having previous knowledge and executing cognitive actions and processes to perform the task. Thomas and Baron (1994) refers knowledge as "relational information about objects or groups of objects" and points out that the worker uses data to perform a task, so the knowledge use per task is the amount and complexity of information applied by the worker (Thomas and Baron, 1994). Thus, the knowledge dimension of a task refers to the knowledge that is applied to complete it, that knowledge can have various sources.

### 3.2.5. Creativity and Innovation

Creativity is not the same as intelligence or knowledge (Amabile, 1996; Hopp et al., 2009). Creativity is an important factor in definition of knowledge worker produc-
tivity (Drucker, 1999). Creativity is the generation of any kind of useful or novel ideas (Amabile, 1996). As workers move from using cognitive knowledge to creativity the value of the intellect assess increases (Quinn et al., 1996). Factors that influence creativity in organizations are expertise, individual creativity skills and task motivation, task motivation encourages the worker to do more than just he or she can do (Amabile, 1996). Mumford et al. (2006) introduce biases that hinder creativity in organizations, which include knowledge, capacity, information use and process execution. It's important that knowledge workers have the opportunity to perform (Kelloway and Barling, 2000) and creativity should be supported by the organization by high level of empowerment and autonomy (Paton, 2013). Innovation is when the ideas from creative work are successfully implemented (Amabile, 1996).

Ramirez and Steudel (2008) define creativity and innovation as cognitive processes leading to an outcome that is original and worthwhile. In knowledge work the tasks are often different from one to another, therefore creativity is important in solving tasks by finding a solution to the problem and combining previous ideas and/or solutions (Hopp et al., 2009).

### 3.2.6. Complexity

Bainbridge et al. (1993) measurement of task complexity is related to the time it takes for an individual, with specific education, to master the task. Another measure of task complexity is probability of task success (Locke and Latham, 2002). The wanted outcome of a complex task is to obtain the knowledge learned when performing the task (Locke and Latham, 2002). With self-efficacy, complex tasks motivate knowledge workers and lead to better performance in work (Bainbridge et al., 1993; Bolt et al., 2001; Chen et al., 2001; Nair and Vohra, 2010).

Ramirez and Steudel (2008) definition of complexity of a task is the difficulty in understanding and/or degree of confusing sub tasks. Thomas and Baron (1994) defines complexity as the difficulty of the task in terms of the amount of decisionmaking and the amount of knowledge needed. Task complexity can differ, from the worker aspect, with lack of resources, such as tools and time (Campbell, 1988). Prietula et al. (2000) propose that four factors influencing effort of the worker in complex tasks, they are materials, strategies, knowledge characteristics and goals. Task complexity can be looked at from technical, goals, requirements and environmental aspects (Bainbridge et al., 1993). Another view is the level of paths to perform the task, multiple outcomes, conflict and links among ways and multiple outcomes (Campbell, 1988). So, complexity of a task can differ from one worker to another perspective.

### 3.2.7. Routine and Repetitiveness

Tasks that require specific amount of knowledge to be completed but are repeatable, leads to that the worker doesn't need to think to get the task done (Paton, 2013). This is often the case in knowledge work, where the worker has mastered how to perform the task, and knowledge intensive tasks become routine to the worker (Quinn et al., 1996). Another aspect of the repetitive dimension is Hackman and Oldham's (1976) definition of task identity, i.e. the worker is performing a task that is a part of a bigger work, or the worker is performing a series of tasks, from beginning to an end with an outcome. The repetitiveness is where the identity is high.

If the task is a part of regular or established procedure and the performance is characterized by habitual or mechanical, then the task is routine and repetitive (Ramirez and Steudel, 2008). If the procedures are known in advance, then the task is routine (Hopp et al., 2009). Marschak (1967) describes routine tasks as tasks with low level of uncertainty and the worker has been given all the information needed to perform the task. The task can be routine, but require a specific amount of knowledge (Hopp et al., 2009). Thomas and Baron (1994) defines repetitiveness as a function that is, and will always be, done in the same way each time. Manual work often consists of known methods used to perform a task repetitively (Hopp et al., 2009). Thus, the repetitive dimension of tasks refer to that the same or similar tasks are performed again and again and they are always performed in the same or similar way. The routine is where the task has become habitual to the worker.

### 3.2.8. Physical effort

Ramirez and Steudel (2008) define physical effort in work as the use of physical power to perform the tasks. Thomas and Baron (1994) defines skilled activity as "the physical difficulty of performing the work". Thus, if the worker have to apply physical strength to perform a task, then the task is considered physical. Manual work requires physical power and knowledge work doesn't (Ramirez and Steudel, 2008).

### 3.3. Time Allocation

Ways of finding and previous findings from examining time allocation in knowledge work are reviewed in this section. Various grouping of tasks in relation to time use are reviewed. Specific amount of the literature includes interruptions in one form or another. Some include multitasking and task switching and how these concepts
impact the workers and the worker that they are doing. If the knowledge work is viewed as a process with input and output, time is considered as input (Thomas and Baron, 1994).

In knowledge work, workers tend to have more discretion over the time spent on each task than in manual work (Hopp et al., 2009). But case studies and researches have shown that knowledge workers use a specific amount of their time doing unnecessary tasks and restrictions make it difficult to concentrate on a specific task at a time. Donnelly (2006) studied autonomy among knowledge workers in a consultants firm and listed the constraints that restrict their autonomy, which are: needs of the workers clients and employers, professionalism, network relations and career ambitions. Three years of studying knowledge workers, Birkinshaw and Cohen (2013) determine that knowledge workers spend $41 \%$ of their time doing tasks that are unnecessary or can easily be delegated. Staats and Upton (2011) refer to knowledge workers time spent on unimportant tasks as a waste. Birkinshaw and Cohen (2013) suggest that workers can identify low value tasks and decide whether to drop, delegate or redesign the tasks. The time saved from this can be used on tasks that are valuable. This causes increase in time efficiency, but it's also important to use the time gained effectively (Birkinshaw and Cohen, 2013). Perlow (1999) findings suggest that the workers are evaluated by managers for the visible work and working long hours. Donnelly (2006) also refers to workers as their work is valued more if they seem busy, though the work they were doing was not valuable. Long hour culture does appear from competition and workers desire for promotion or move up the ladder (Donnelly, 2006). O'Carroll (2008) argues that "while participants [workers] often adopts rationalist discourse of industrial working time, their work practice remains located in another, less visible time."

Perlow (1999) examined how workers use their time and why they use it that way by dividing tasks into four activities: individual, interactive, social, personal affairs. Perlow (1999) results showed that $60 \%$ of the time on individual activities, workers didn't focus on a task for more than a half hour due to interactive activities. It's unavoidable to consider the impact that workers have on each other. Interruptions are breaks in a task that the worker is performing to perform a another task (Hopp et al., 2005). Interruptions can be from other sources than interactions with other workers, such as from internal sources for example when the worker suddenly remembers some task that needs to be done (Biron et al., 2009; Murray and Khan, 2014), and from secondary task (Biron et al., 2009) or external sources such as audio and visual (Murray and Khan, 2014). Murray and Khan (2014) state that interruptions cause time loss in white collar work and have negative impact of workers performance. Biron et al. (2009) results from studying nurses revealed that they seldom completed a task without being interrupted. Claessens et al. (2010) results were that the main reasons for that workers couldn't complete scheduled tasks were due to; lack of time time, unplanned tasks that came up, and interacting with other workers.

Often multiple projects need to be done, and multitasking is a part of the job followed by switches between tasks. Multitasking refers to that the worker is working on too many projects at the same time (Coviello et al., 2014). Decrease in output for given effort and ability are the results of multitasking and increase in duration and completion time of the task (Coviello et al., 2014). Due to multiple projects and multitasking, workers have to switch between tasks. Leroy (2009) findings were that if workers had not finished prior tasks before starting to perform the next task it led to a decrease in performance doing the present task and the attention was still on the previous task. Arman et al. (2009) studied health care managers, where the day consisted of short activities and circa one half of their time was spent in meetings. Arman et al. (2009) applied Mintzberg's model studying health care managers. Duration and frequency of different work types and purpose were considered. Arman et al. (2009) results were that variation in time use patterns between individuals were considerable.

Dahooie et al. (2012) propose a framework to determine knowledge intensity and communication intensity of tasks, which can be used to identify groups of knowledge work. Dahooie et al. (2012) found the knowledge intensity and communication intensity scores for 118 jobs and identified four clusters in the data. Dahooie (2013) proposed a framework to evaluate knowledge work intensive score of jobs. Importance weight and time weight were determined to generate the KWIS and the framework applied for two workers which jobs were; deputy of finance and support and laboratory technician, the knowledge work intensity score for the jobs were $62 \%$ and $52 \%$ respectively. Ramirez and Steudel (2008) applied the knowledge work quantification framework to two job types; welding and information technology consultant. The KWSs were $36 \%$ and $82 \%$ respectively.

## 4. Time Use Techniques

The purpose of this research is to answer two research questions How do knowledge workers use their time at work? and What kinds of tasks are knowledge workers performing? The author shadowed knowledge workers and recorded the tasks performed. The tasks recorded were listed in a data set to be evaluated for each participant. To answer the research questions, three techniques were developed to analyze the data sets. The techniques were drawn from the theoretical background.

The three techniques consist of evaluating the tasks in the data sets and calculation of time use which can be determined as time efficiency. Two of the techniques generate knowledge work time efficiency (KWTE) and the third generates work time efficiency (WTE). The dimension technique is from Ramirez and Steudel's (2008) quantification framework where eight dimensions are determined on the scale 1 to 5 , and knowledge work score (KWS) is calculated. The group technique is drawn from Hopp et al.'s (2009) definition of white collar work and assigns tasks to six groups, and task based knowledge intensity score (TKIS) is calculated. The work time efficiency technique calculates the overall time use on work related tasks. Figure 4.1 features the techniques.


Figure 4.1: Time use techniques.

## 4. Time Use Techniques

Before the three techniques are discussed further, definitions of knowledge workers, knowledge work and task are reviewed. The definitions are drawn from theoretical background and listed in table 4.1. The definitions are fundamental to outline the concepts before research execution. Note that as found out in theoretical background, work is a subset of tasks, i.e. work is a series of tasks performed. Job is the workers occupation or profession, and therefore work and tasks performed by a worker belongs to the workers job.

Table 4.1: Knowledge worker, knowledge work and task definitions.

| Dimension | Definition |
| :--- | :--- |
| Knowledge Worker | "A worker with high degrees of expertise, education or expe- <br> rience, with the main purpose of creating, sharing or applying <br> knowledge in his job, where the nature of his work is non-routine, <br> creative and intellectual" (Óskarsdóttir, 2014) |
| Knowledge Work | "A process that requires knowledge from both internal and ex- <br> ternal sources to generate a product which is distinguished by <br> its specific information content" (Thomas and Baron, 1994) |
| Task | "an activity that applies labor and/or resources to an entity over <br> time" (Hopp and Van Oyen, 2004) or "A set, subset or individual <br> action that needs to be done to accomplish a job. Usually, a <br> discrete unit that describes a part of job." (Ramirez and Steudel, <br> 2008) |

### 4.1. Dimension Technique

The dimension technique consists of a dimension evaluation strategy and dimension time use technique are covered in this section. The dimension evaluation method is a determination of Ramirez and Steudel (2008) procedures of evaluated eight dimensions. The dimensions are (1) autonomy, (2) structure, (3) tangibility, (4) knowledge, (5) creativity and innovation, (6) complexity, (7) routine and repetitiveness, and (8) physical effort. The dimensions are evaluated for each task on the scale from 1 to 5 . The scale is from very low intensity (1) to very high intensity (5). The four dimensions (2) structure, (3) tangibility, (7) routine and repetitiveness, and (8) physical effort are irregular. That a dimension is irregular implies that a higher intensity relates to less knowledge work characteristics, counter to the others. Table 4.2 features definitions of the eight knowledge work dimensions.

Table 4.2: Eight tasks dimensions (Ramirez and Steudel, 2008).

| Dimension | Definition |
| :--- | :--- |
| Autonomy | Degree of control of the worker on how a task is done. |
| Structure | Degree of established rules, policies, or procedures on <br> how a task is done. |
| Tangibility | Degree to which a task is capable of being easily per- <br> ceived using the five senses; especially by the sense of <br> touch and sight. |
| Knowledge | Degree to which having previous knowledge, executing <br> cognitive actions and executing cognitive processes are <br> part of the task. |
| Creativity and Innovation | Degree to which cognitive processes are used to lead <br> to the production or creation of something that is both <br> original and worthwile. |
| Complexity | Degree to which a task offers great difficulty in under- <br> standing or has confusing interrelated sub-tasks. |
| Routine and Repetitiveness | Degree to which a task is part of regular or established <br> procedure characterized by habitual or mechanical per- <br> formance of tasks. |
| Physical Effort | Degree to which a task requires body strength, coordi- <br> nation, and skill in order to be performed; the use of <br> physical power. |

Guidelines for assigning scores from very low intensity (1) to very high intensity (5) are outlined in table 4.3. The guidelines are based on the dimensions definitions in table 4.2. The third dimension, tangibility, was made binary where participants were either working with material or not. It was decided to only use "the touch and sight" in previous definition. The eight dimension, physical effort, was evaluated in threefold scale rather than five as illustrated in the table, by whether the task require no physical effort, for example interacting, working in the computer etc., specific amount of physical effort, for example working in hands with material, or physical power, like walking, moving bigger objects etc. When evaluating the tasks, consistency between tasks was kept.
Table 4.3: Eight tasks dimensions evaluation guidelines.

|  | Autonomy | Structure | Tangibility | Knowledge | Creativity \& Innovation | Complexity | Routine \& Repetitiveness | Physical Effort |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Worker has no control on how the task is done | There are no rules, policies or procedures on how the task is done | The task is very hard to perceive, the worker is not working with material | There is no need for previous knowledge or execution of cognitive actions or processes to perform the task | No cognitive processes are used to perform the task | The task is very easy to understand | The task is not a part of regular and habitual performance | The task requires no physical effort |
| 2 | Worker has little control on how the task is done | There are little rules, polices or procedures on how the task is done |  | There is little need for previous knowledge or execution of cognitive actions or processes for performing a part of the task | Little cognitive processes are used to perform the task | The task is easy to understand | Part of the task performance follows regular and habitual procedures |  |
| 3 | Worker has control on how the task is done | There are rules, polices or procedures on how the task is done |  | There is need for previous knowledge or execution of cognitive actions or processes to perform the task | Need for cognitive process use to perform the task | It is difficult to understand the task | Task performance follows regular and habitual procedures | The task requires physical effort to the amount of working in hands |
| 4 | Worker has much control over how the task is done | There are tight rules, polices and procedures on how the task is done |  | There is need for previous knowledge or execution of cognitive actions or processes for large part of the task | Cognitive processes are used to product or create original results | The task is hard to understand and has confusing interrelated sub-tasks | Regular and established procedures with habitual and mechanical performance describe a part of the task |  |
| 5 | Worker has total control on how the task is done | There are very tight rules, polices and procedures on how the task is done | The task is very easily perceived, the worker is working with material | The task requires previous knowledge and execution of cognitive actions or processes altogether to be performed by the worker | Cognitive processes are used to product or create something that is original and worthwhile | The task is very hard to understand and has many confusing interrelated sub-tasks | High degree of regular and established procedures with habitual and mechanical performance describe the task | The task requires physical power by the worker |



After determination of each dimension for all the tasks in a data set, the level of knowledge work for the data set is to be found. Ramirez and Steudel (2008) knowledge work quantification framework uses the eight dimensions to create a mathematical methodology to generate a score of knowledge work in a knowledge workers job, hence the knowledge work intensity score for the worker. In this research, a part of Ramirez and Steudel's (2008) framework is used to calculate task based knowledge intensity score from the data sets.

Ramirez and Steudel (2008) use time frame cycles on a year basis in the calculation. That is, time frame cycles were identified and their yearly percentage time found. In this research, the time frame cycles are skipped. Percentage of time is found for each task in a data set, as the recorded time duration of the specific task divided by the total time of recordings. Weighted average knowledge work score is found for the whole data set, by using the determination of the eight dimensions and percentage of time. Following transcript and equations were used to calculate knowledge work score.

The first step is to reverse the irregular dimensions. Then knowledge work task score $(K W T S)$ is found for each task in the data set that represent the intensity of knowledge work for the specific task. KWTS are calculated by the following equation as the average of the eight dimensions $\left(d_{i}\right)$ determined for task $x$.

$$
\begin{equation*}
K W T S_{x}=\sum_{i=1}^{8} \frac{d_{i}}{8} \tag{4.1}
\end{equation*}
$$

The percentage time $(P T)$ is found for each task $(x)$ as the time duration per task $x\left(T_{x}\right)$ as a proportion of total time $(T T)$.

$$
\begin{equation*}
P T_{x}=\frac{T_{x}}{T T} \tag{4.2}
\end{equation*}
$$

The total time is the cumulative time of all tasks $(n)$ in the data set, $T T=\sum_{x=1}^{n} T_{x}$, so $\sum_{x=1}^{n} P T_{x}=100 \%$. The final knowledge work score from $1-5$ for the total of $n$ tasks performed the day recorded is calculated from time percentage and knowledge work task score for all tasks recorded by following equation.

$$
\begin{equation*}
K W S=\sum_{x=1}^{n} P T_{x} \cdot K W T S_{x} \tag{4.3}
\end{equation*}
$$

To convert the $(K W S)$ from the scale $1-5$ to the percentage scale $0-100 \%$ following

## 4. Time Use Techniques

equation is used.

$$
\begin{equation*}
K W S(\% T)=\frac{K W S-1}{5-1} \tag{4.4}
\end{equation*}
$$

The $K W S(\% T)$ represent the percentage of time used in knowledge intensive tasks, thus the time use is evaluated from the types of tasks performed by the worker. Table 4.4 illustrates how the KWS is calculated for $n$ tasks, where $T_{x}$ is time duration for task $x$ and $T T$ is the total time, or $\sum_{x=1}^{n} T_{x}$.

Table 4.4: Illustrative example for calculating KWS.


The purpose of Ramirez and Steudel (2008) quantification framework was to place the work, and hence the worker, on the knowledge work continuum. The dimension technique is to evaluate the time used in knowledge work on the basis of recordings for one work day. The previous technique is therefore inspired by Ramirez and Steudel (2008).

### 4.2. Group Technique

The group evaluation strategy and group technique were developed by the author and based on Hopp et al. (2009) definition of white collar work. Hopp et al. (2009) definition of white collar work is based on the tasks that knowledge workers perform. Tasks can be described by two dimensions, routine vs creative, and, physical vs intelligence. Blue collar work is physical and routine, while white collar work is intelligence and creative as illustrated in figure 4.2. Knowledge work is then a subset of white collar work in the definition (Hopp et al., 2009).


Figure 4.2: White collar vs. blue collar work (Hopp et al., 2009).

Hopp et al.'s (2009) definition was adjusted for task evaluation. A matrix was drawn to assign the tasks in data sets to six groups as illustrated in figure 4.3. The determination for assigning tasks to groups is based on two dimensions. The dimensions differ from the original definition in the way that the horizontal axis was called knowledge instead of intelligence and formal education was considered as a division of tasks into the three columns. The vertical axis is unchanged and binary where the tasks were either evaluated routine or creative.


Manual vs Knowledge

Figure 4.3: Six task groups matrix.

## 4. Time Use Techniques

Guidelines for the divisions along the horizontal axis were; (1) before college, (2) during college, and (3) after college. Tasks in the first column of the matrix represent tasks that the worker could perform before he or she started college, or does not require previous knowledge of the worker. The second column of the matrix represents tasks that the worker learned in collage, or tasks that require specific amount on previous knowledge. The third and last column were the tasks that the worker learned after college, from work experience.

Vertical axis of the matrix is binary and calles for developing a rule of thumb to evaluate when the task is creative and when it is not. Hopp et al. (2009) refer to whether procedures for performing the tasks are specified in advance or not. If procedures can not be pre specified, the task is creative and the worker has to develop the procedures as the performance of the task goes along. So, if the worker knows in advance what to do and how to do it, the task is routine, otherwise it's creative.

The authors opinion regarding the vertical axis were that more formed guidelines had to be set to determine whether the task is creative or routine. Three considerations were examined; procedures as Hopp et al. (2009) refer to, repetitiveness, and expertise. Expertise is achieved from learning (Gleeson and Hargaden, 2014). These three concepts are listed in table 4.5. When assigning the tasks to groups, the rule of thumb was that two of the three concepts have to apply for the task to be evaluated creative.

Table 4.5: Concepts determining whether a task is routine vs. creative.

| Concept | Definition |
| :--- | :--- |
| Procedures | "If procedures can be clearly specified in advance, then the task is <br> routine. If procedures cannot be pre-specified, so that it falls to the <br> worker to develop them, then the task is creative." (Hopp et al., 2009) |
| Repetitivness | "A function done in the same way every time, and will always be <br> done in the same way. If the job changes each time, then it is not <br> repetitive." (Thomas and Baron, 1994) |
| Expertise | "includes memory for factual knowledge, technical proficiency, and <br> special talents in the target work domain" (Amabile, 1996) |

After all the tasks in the data set have been divided into the six groups, task based knowledge intensity score is set to be found. The group technique is developed to generate the time use from cumulative time duration of the tasks assigned to each group. To attach the groups to knowledge work, Hopp et al. (2009) definition of white collar work and the knowledge work definition in table 4.1 were considered.

Apparently, it was decided to include groups 5 and 6 in knowledge work and exclude
groups 1 and 2. Tasks in groups 5 and 6 require much knowledge from the worker but tasks in groups 1 and 2 require no, or very little knowledge to be done. But there were speculations about groups 3 and 4 . Some of the tasks in those groups could be considered as knowledge work and some not. The weight of these groups were therefore determined by drawing a straight line between upper left corner of group 4 to lower right corner of group 3 as illustrated in figure 4.4. The area on the right of the line drawn was set to be knowledge work. Also, figure 4.2 helped making this decision, where the dotted line represent the division of blue collar and white collar work. Knowledge work is a subset of white collar work in Hopp et al.'s (2009) definition where physical and creative work is not considered as knowledge work.


Manual vs Knowledge

Figure 4.4: Knowledge work group matrix.

From figure 4.4 the weights of groups 3 and 4 are determined as $1 / 4$ and $3 / 4$, respectively. Thus the following equation was made to calculate the cumulative time used performing knowledge intensive tasks, the task based knowledge intensity score (TKIS)

$$
\begin{equation*}
\text { TKIS }=\frac{1}{4} \sum_{x=1}^{n} T_{3, x}+\frac{3}{4} \sum_{x=1}^{n} T_{4, x}+\sum_{x=1}^{n} T_{5, x}+\sum_{x=1}^{n} T_{6, x} \tag{4.5}
\end{equation*}
$$

## 4. Time Use Techniques

Where $T_{g, x}$ stand for the duration time of task $x$ in group $g$ and the total number of tasks were $n$. The following equation was used to calculate the TKIS as a percentage of the total time $(T T)$. $T T$ is cumulative time for all tasks in the data set, $T T=$ $\sum_{g=1}^{6} \sum_{x=1}^{n} T_{g, x}$.

$$
\begin{equation*}
T K I S(\% T)=\frac{T K I S}{T T} \tag{4.6}
\end{equation*}
$$

Execution of the group task evaluation method and group time use technique for each participant are covered in chapter 5 .

### 4.3. Work Time Efficiency

The third technique, called work time efficiency (WTE), was considered as a percentage of the total time where worker is performing work related tasks. Tasks that are not work related are breaks and personal time. All other tasks are considered work related. Tasks that are not work related could of course be necessary and are union rights for the worker such as breaks, but the worker is not working in the meantime. As reviewed in theoretical background chapter, some of the tasks performed by knowledge workers could be delegated, automatic, or even skipped. Those tasks, that are in most cases manual and routine are considered work related, because it is necessary to perform those tasks in work despite for them not being knowledge work. Those tasks could have $K W T S$ as 1 or assigned to group 1 in the strategies in previous sections. The WTE technique was foremost developed to compare the results from $W T E$ to the results from the other two techniques, $K W S(\% T)$ and TKIS $(\% T)$ introduced previously.

The following equation was proposed to receive an outcome as a percentage of time use similar to the other two methods. The cumulative time of work related tasks are divided by the total time where $m$ tasks are considered related to work. If total of $m$ tasks are found as not work related $(m \in n)$, the following equation was developed:

$$
\begin{equation*}
W T E=\frac{T T-\sum_{x=1}^{m} T_{x}}{T T} \tag{4.7}
\end{equation*}
$$

The total time is the same as in previous techniques; $T T=\sum_{x=1}^{n} T_{x}$.

## 5. Time Use Results

This chapter features results for each participant. The results review the data gathered and evaluation of tasks in data sets. Dimensions are determined for each task and each task assigned to one of the six groups as covered in chapter 4. Outcomes from the three techniques; group method, dimension method and work time efficiency are found. The three methods are covered in chapter 4. Answers to the interview questions are to be reviewed and additional notes that were noted during the observations.

Before reviewing the results, the participant selection is described. From the awareness of quality management work at Landspítali University Hospital, it was decided to meet with one of the team member, a project manager, to introduce the research. The following handout was delivered before the first meetings took place to introduce and explain the purpose of the research. The handout was sent via e-mail and can be found in appendix A .

The sample is convenient, but replicates to the research purpose and has mutual interest for the researcher and the workplaces improvement goals. The workers were willing to participate in the study. It was decided to perform one initial test run and shadow a medical specialist for one workday. A total of four participants were shadowed, each for approximately one work day during the period from March to April. The participants shadowed are listed in table 5.1, their education and time duration of recordings.

Table 5.1: Participants schedule.

| Participant | Education | Duration |
| :--- | :--- | ---: |
| medical specialist | medicine M.D. | $7: 07: 08$ |
| medical specialist | medicine M.D. | $6: 04: 48$ |
| project manager | nursing B.Sc., project management M.Sc. | $5: 04: 32$ |
| shift supervisor | nursing B.Sc. | $7: 42: 42$ |
| nurse | nursing B.Sc. | $7: 40: 26$ |

In following subsections data gathering and data analyzes were executed as outlined in research design in sections 2.4 .3 and 2.4.5. Subsection 5.1 is a verification of the method outlined in section 2.4 where the data set is analyzed and described in more
detail than in the sections afterwards where the same method was applied to other data sets. In subchapters 5.2 to 5.5 results from shadowing the participants in table 5.1 medical specialist, project manager, nurse shift supervisor and nurse on regular shift are covered. Each of the subsections covers results from the three techniques.

### 5.1. Verification of Method

In this section, processes for data gathering and data analyzes, covered in section 2.4.2, are executed for verification. The verification was done by the author who shadowed a knowledge worker for one work day. The purpose is to identify practical problems and improve the instruments introduced in section 2.4 .2 before the next data gatherings were performed. The instruments are the software application, data processing algorithm and interview schedule. The processes execution are covered here below.

The first participant shadowed was medical specialist. The work day consisted of meetings with coworkers, video meeting with a mathematician, two meetings with patients (direct care) and conduction of two job interviews. According to the participant, it was rather unusual day in the way that there were more meetings and the job interviews were for summer-jobs. Most of the meetings with coworkers were for organizational planning purposes. The author was present in all meetings, but not in the job interviews.

The author used a tablet computer with the previously described software application to record the tasks performed by the participant. As described in section 2.4.2, task names were added to the application before the shadowing took place. Dummy tasks were also added to the application use when unthought-of tasks were performed. In this case, the job interviews were for example a type of unthought-of task. Sometimes two task buttons were used to record one task, for example the content of interacting with coworker was coordination, then interact and coordination task buttons were used. Sometimes task buttons were pressed accidentally, then it was noted in the note block and fixed afterwards in the data. Notes were written when there was time. Interview questions were asked when shadowing took place, for example while transporting. The notes written include participants comments and answers to questions, authors ideas and descriptions of task contents.

The software application generates a data set in a text file with informations of tasks recorded as described in section 2.4.2. The data set was prepared for algorithm run in three ways. First by fixing errors noted in the note block, and second, by combining two or more task data lines to one task as described previously. Data preparation also consisted of manually evaluating the tasks with the strategies where each task
in the data set is assigned to one of the six groups and the eight task dimensions are determined as covered chapter 4. Tasks were considered work related or not by the author to find the time efficiency. A total of 124 task data lines were recorded. After data preparation, the data set reduced to 65 tasks performed by the participant. The prepared data set is listed in table B. 1 in appendix.

Tasks evaluation strategies were used to determine the eight task dimensions and assign tasks to one of the six groups. The task dimensions were evaluated from very low intensity (1) to very high intensity (5). The evaluation strategies are covered in chapter 4 which are both drawn from theoretical background. Table 5.2 lists tasks from the prepared data set with informations about determination of groups and dimensions. Calculated knowledge work task score (KWTS) for each task is also included in the table, $K W T S$ is calculated by using equation 4.1. Task dimensions are symbolized with capital letters, A: autonomy, S: structure, T: tangibility, K: knowledge, CI: creativity and innovation, C: complexity, R: routine and repetitiveness, and P: physical effort. Note that four of the dimensions are irregular, those are structure ( S ), tangibility $(\mathrm{T})$, routine and repetitiveness ( R ), and physical effort (P).

Table 5.2: Tasks evaluation for chosen tasks from prepared data set.

| TASK | GROUP | DIMENSIONS |  |  |  |  |  |  |  | KWTS |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | A | S | T | K | Cl | C | R | P |  |
| Meeting - scientific | 6 | 4 | 2 | 1 | 5 | 5 | 5 | 1 | 1 | 4.75 |
| Direct care | 6 | 4 | 2 | 1 | 5 | 5 | 5 | 2 | 1 | 4.63 |
| Computer - patient record | 6 | 5 | 2 | 1 | 5 | 5 | 5 | 3 | 1 | 4.63 |
| Job interview | 6 | 3 | 3 | 1 | 5 | 5 | 5 | 1 | 1 | 4.50 |
| Meeting - about patients | 6 | 3 | 3 | 1 | 5 | 5 | 5 | 2 | 1 | 4.38 |
| Interacting - patient related | 6 | 4 | 2 | 1 | 5 | 4 | 3 | 2 | 1 | 4.25 |
| Meeting - strategic planning | 4 | 3 | 2 | 1 | 3 | 4 | 2 | 2 | 1 | 3.75 |
| Interacting | 3 | 4 | 2 | 1 | 3 | 3 | 3 | 3 | 1 | 3.75 |
| Take notes | 4 | 5 | 2 | 5 | 5 | 5 | 4 | 2 | 3 | 3.63 |
| Answering emails | 3 | 5 | 3 | 1 | 3 | 3 | 3 | 4 | 1 | 3.63 |
| Interacting - coordination | 1 | 2 | 2 | 1 | 1 | 2 | 1 | 4 | 1 | 2.75 |
| Transport | 1 | 1 | 5 | 5 | 1 | 1 | 1 | 5 | 5 | 1.00 |

A: autonomy, S: structure, T: tangibility, K: knowledge, CI: creativity \& Innovation, C: complexity $R$ : routine \& repetitiveness, $P$ : physical effort

Figure 5.1 features tasks from the prepared data set in a Gantt chart. The figure reveals overlaps that occur when two tasks are recorded at once. This can easily be seen for tasks number 12 and 60 in the figure. Task is said to be predominant task if there is another task that overlaps it. The task that overlaps another task (the predominant task) is called the overlapping task. If a task is not predominant or
overlapping, it is independent. The six colors assigned to the tasks stand for the six groups illustrated in figure 4.3.


Figure 5.1: Gantt chart of tasks before data processing.

The prepared data set was processed with the data processing algorithm introduced in section 2.4.2. The algorithm refined the data by dealing with overlaps. The algorithm also calculates the knowledge work score (KWS), generates cumulative time segmentation of tasks into the six groups in figure 4.3 and calculates the task based knowledge intensity score (TKIS) all covered in chapter 4 . The data analyzes are covered here below.

Figure 5.2 (a) features a closer look at tasks from 10:00 to 10:30 in the data in figure 5.1. The participant was answering emails in the computer (task 10) until around 10 o'clock when there was video meeting scheduled. Then the participant waited for the video call (task 11). During the waiting, the participant used the time looking at emails (task 12) until the participant decided to call five minutes later. Task 13 stands for the video meeting with mathematician where the participant noted information from the meeting (tasks 14,15 and 17-21) and tried to fix settings in the computer system because the video didn't work as supposed to (task 16). Figure 5.2 (b) illustrates the same tasks after data processing where pieces from the
predominant tasks have been "cut" out where the overlapping tasks occur.


Figure 5.2: Example of overlaps before and after data processing.

Figure 5.3 illustrates the tasks in figure 5.2 in one dimensional time line. Overlaps cannot be identified, but switches between tasks are clear.


Figure 5.3: One dimensional timeline of the tasks in example.

Figure 5.4 features the tasks in the processed data set, all 65 tasks, in a Gantt chart. Data refinements due to overlaps can be identified in the figure.


Figure 5.4: Gantt chart of tasks after data processing.

Figure 5.5 features all the tasks in the data set in one dimensional timeline after data processing. Those tasks are the same as the tasks in figure 5.4. From the figure, task switches pattens can be identified as vertical lines. As before in the Gantt charts, the colors represent the six groups as illustrated in figure 4.3.


Figure 5.5: One dimensional time line of tasks after data processing.

The task types recorded and logged in the data set are listed in table 5.3. Cumulative time duration for those task types before and after data processing and the difference, i.e. the overlapping time. The overlapping time is the time cut from predominant tasks that correspond to the overlapping task time, as illustrated in figure 5.2 (b). Data processing results in shorter time duration for predominant tasks. Data processing is done to refine the data for further calculations where the total time is used, i.e. prevent double counting time duration for parallel tasks as in figure 5.2 (a). Humans perform serial procedures and time is a line, in other words one dimensional. Note that the tasks in the table can have different contents, interaction with coworkers can be patient related, planning related etc.

Table 5.3: Total appearances and cumulative time for chosen tasks before and after data processing.

| Task | Occurrences | Cumulative time |  | Difference |
| :---: | :---: | :---: | :---: | :---: |
|  |  | Before processing | After processing |  |
| Meetings | 9 | 3:34:02 | 3:23:56 | 10:06 |
| Transport | 13 | 1:06:47 | 43:55 | 22:52 |
| Interactions | 15 | 1:01:12 | 57:10 | 4:02 |
| Computer | 9 | 56:53 | 31:47 | 25:06 |
| Job interview | 2 | 48:24 | 48:24 | 0:00 |
| Telephone | 6 | 10:06 | 10:06 | 0:00 |
| Other | 11 | 25:40 | 25:38 | 0:02 |
| Total | 65 | 8:03:04 | 7:00:56 | 1:02:08 |
| Idle | 24 | - | 6:12 | - |
| Total | 89 | 8:03:04 | 7:07:08 | 55:56 |

It was decided to refer to the video meeting in figure 5.2 as a meeting and not as a computer work in table 5.3 which explains the difference of $22: 52$ for computer work. Total time of 22:52 while transporting was used for performing other tasks, for example on telephone calls. Therefore total time of $43: 55$ was not used on anything else than transport. Overlapping tasks for the meetings were for example waiting and note information. The author was not present during the job interviews. Telephone calls were always independent or overlapping task. Total time was found to be 7:00:56 that corresponds to cumulative time duration for all tasks in the processed data set. The fixed time, from beginning to the end of recordings is 7:07:08. Idle time stands for time when there were no tasks recorded in data gathering. Idle time instances for this case were 24 with cumulative time of $6: 12$ and is illustrated in figure 5.6.


Figure 5.6: One dimensional time line of idle time gaps data processing.

The total time used in further calculations of the three techniques does not include the idle time. As the figure shows the idle time are short gaps in the recordings that appear between tasks. The idle time was considered as inaccuracy in data gathering and therefore not to be evaluated in the same way as the tasks. Therefore, idle time was not included in calculations.

Next step in data processing was to calculate the knowledge work score (KWS) with the dimension technique covered in section 4.1. The data processing algorithm was formatted to calculate the KWS. Table 5.4 features the calculation of KWS for the data set. The pieces of data from the processed data set are shown and are the same tasks as in table 5.2. Knowledge work task score $\left(\mathrm{KWTS}_{x}\right)$ for each task was calculated using equation 4.1. Percentage time $\left(\mathrm{PT}_{x}\right)$ was calculated using equation 4.2. Knowledge work score (KWS) for the data set was found by using equation 4.3. The total time $T T$ was 7:00:56.

- Reverse irregular task dimensions
- Calculate knowledge work task score $\left(\mathrm{KWTS}_{x}\right)$ for each task $x$ using equation 4.1
- Calculate percentage time $\left(\mathrm{PT}_{x}\right)$ for each task $x$ using equation 4.2
- Calculate knowledge work score (KWS) for the whole data set with total time (TT) using equation 4.3
- Calculate knowledge work percentage score (KWS \%T) using equation 4.4

Table 5.4: Illustrative example for calculating KWS.


A: autonomy, S: structure, T: tangibility, K: knowledge, CI: creativity \& innovation, C: complexity
$R$ : routine \& repetitiveness, $P$ : physical effort

The results from the task dimension evaluation strategy applied to the data set are illustrated in figure 5.7. Cumulative time for tasks on the intervals determined on the horizontal axis was calculated. Most of the tasks have calculated KWTS between 4 and 4.5. Knowledge work score (KWS) and knowledge work score as a percentage of time (KWS (\%T)) for the whole data set, generated by data processing algorithm, were found by using equations 4.3 and 4.4 and the results were

$$
K W S=3.77 \text { or } \quad K W S(\% T)=69 \%
$$



Figure 5.7: Cumulative time per KWTS intervals.

Next step was to calculate the task based knowledge intensity score (TKIS) by the group technique covered in section 4.2. The data processing algorithm was formatted to summarize time duration for all tasks assigned to the same group separately. Table 5.5 features the division of tasks and cumulative time duration of tasks assigned to each of the six groups. Occurrences stand for the number of tasks in each group, cumulative time is the sum of time duration for the tasks occurred and percentage is found by dividing cumulative time for each group by the total time ( $T T$ ). The six groups are illustrated in figure 4.3

Table 5.5: Group segmentation and cumulative time for tasks in the data set.

| Group | Occurrences | Cumulative time | Percentage |
| ---: | :--- | :--- | :--- |
| 1 | 25 | $1: 23: 29$ | $20 \%$ |
| 2 | 0 | 0 | $0 \%$ |
| 3 | 15 | $32: 11$ | $8 \%$ |
| 4 | 10 | $44: 09$ | $10 \%$ |
| 5 | 3 | $8: 00$ | $2 \%$ |
| 6 | 12 | $4: 13: 07$ | $60 \%$ |
| Total | 65 | $7: 00: 56$ | $100 \%$ |
| Idle | 24 | $6: 12$ | - |
| Total | 89 | $7: 07: 08$ | - |

Most tasks (25) were assigned to group 1, defined as manual and routine work. The cumulative time for group 1 was 1:23:29. Although, highest cumulative time was for tasks in group 6, defined as knowledge and creative work, or $60 \%$ of the total time. Groups 3 and 4 fall under technologists. Fifteen tasks were assigned to group 3 and ten to group 4, the cumulative times for groups 3 and 4 were $32: 11$ and 44:09 respectively. No tasks were assigned to group 2 which representes manual and creative tasks.

The task based knowledge intensity score was calculated using equations 4.5 and 4.6. Following are calculations where values are substituted in the equations

$$
\begin{gathered}
\text { TKIS }=\frac{1}{4} \cdot 32: 11+\frac{3}{4} \cdot 44: 09+8: 00+4: 13: 07=5: 02: 17 \\
\text { TKIS }(\% T)=\frac{5: 02: 17}{7: 00: 56}=72 \%
\end{gathered}
$$

So, according to the group technique, $72 \%$ of the total time, $T T$, was used performing knowledge work.

Finally, the work time efficiency (WTE) introduced in section 4.3 was found. Work time efficiency was described as the portion of total time when the worker is performing work related tasks. All the tasks in the data set were reviewed manually by the author and either included as work related, or excluded. Breaks, waiting and personal tasks were excluded. Cumulative time for the work related tasks was found 6:36:19 or $94 \%$ of the total time $(T T)$ as following calculations show.

$$
W T E=\frac{7: 00: 56-24: 37}{7: 00: 56}=94 \%
$$

The interview schedule includes four questions which are:

- What is your education? (Q1)
- What is included in your job? (Q2)
- How busy is your job? (Q3)
- How busy or unusual was this day in contrast with other workdays? (Q4)

Table 5.6: Interview questions answers.

## Answers to interview questions

Q1: M.D. degree in medicine.
Q2: Included in the participants job is direct care in the form of meetings with patients, diagnosing and deciding further treatment for patients, file information in patient record computer system, etc. Other work is organizational and strategic planning, teaching and research.
Q3: The participant described the work as busy, days are scheduled and if there is time that is not planned there are always projects that need to be completed. The day shadowed was very busy related to other work days. The meetings about patients in the beginning of the day, the meeting with mathematician and meeting with two patients were scheduled, but the job interviews were not.
Q4: Making plans for the summer was a large part of the day which is unusual on a year basis. Making plans for the summer included the job interviews and discussing them.

The author noticed that specific amount of interacting with coworker was spent on finding time for meetings and reschedule meetings. The participant mentioned that much time spent in transporting to another building, often followed by difficulty in finding a parking spot. This causes that there have to be enough time before and after scheduled work. That results in less capacity for meetings and direct care due to the possibility of them being delayed.

### 5.2. Results From Observing Medical Specialist

The methods verified in the previous section (5.1) are now executed on another data set. After the verification was done, the same participant was shadowed again for one work day. The data set recorded with the software application was manually prepared by the author and then processed with the data processing algorithm. Knowledge work score (KWS), task based knowledge intensity score (TKIS) and work time efficiency (WTE) were found. The work day recorded consisted of finalizing patient records from the day before, preparing for patient meetings on an outpatient department, meeting with two patients on the outpatient department, a meeting or student presentation that included giving feedback as a part of teaching and computer work. The author was not present during the direct care meetings with the two patients.

Total of 271 task data lines were recorded. After data preparation the data set reduced to 106 tasks. The prepared data is listed in table B. 2 and Gantt charts
of the tasks, correspondent to the ones in previous section, can be found in figures B. 3 and B. 4 in appendix B.2. Figure 5.8 features the tasks in the data set in one dimensional timeline after processing algorithm run. As previously, colors were assigned to tasks in terms of the six group evaluation strategy as illustrated in figure 4.3.


Figure 5.8: One dimensional timeline of tasks after data processing.

Common tasks in the data set are listed in table 5.7. Total of occurrences, cumulative time duration before and after data processing and the difference, i.e. the overlapping time. Total time working on the computer was 1:55:02 but after overlapping tasks were cut from the computer tasks the time reduced to 1:44:52. The number of computer tasks recorded were 44.

The participant met with two patients where the author was not present. Total time in direct care was 1:31:31. Interactions with coworkers were 23 instances with cumulative time 53:10, but after data processing 49:18. The participant had to move to another building to attend a meeting. Total transport time was $48: 15$, but 10.38 minutes while transporting were used on other tasks, for example telephone calls and interacting with coworkers. The meeting was evaluated in two parts, one part was listening to students presentation and the other part teaching the students and audiences, assigned to group 5 and 6 respectively. Total time of the meeting was $43: 45$. Time spent on telephone was $21: 17$ that reduced to $20: 20$ after data processing. Time spent on other tasks cumulates to $7: 48$. The fixed total time duration of recordings was $6: 04: 48$, and the idle time was $9: 22$. Total cumulative time for tasks was $T T=5: 55: 26$ which was used in all three technique calculations covered in chapter 4.

Table 5.7: Total appearances and cumulative time for chosen tasks before and after data processing.

| Task | Occurrences | Cumulative time |  | Before processing |
| :--- | :--- | :---: | :---: | :--- | After processing Difference

Instances were no tasks were recorded, i.e. idle time, are illustrated in a one dimensional time line in figure 5.9. Total of 32 idle gaps with cumulative time of 9:22. As previously, these gaps were considered as inaccuracy and the correspondent time was not included in further calculations.


Figure 5.9: One dimensional time line of idle time gaps data processing.

Figure 5.10 illustrates the results from dimension task evaluation where cumulative time of tasks on each interval are represented with a bar. The highest cumulative time were for tasks with KWTS between 4.5 and 5 . Knowledge work score (KWS) was calculated. The data processing algorithm performed the calculations and generated the outcomes which are as followes

$$
K W S=3.83 \quad \text { or } \quad K W S(\% T)=71 \%
$$



Figure 5.10: Cumulative time per KWTS intervals.

Table 5.8 features the division of tasks and time each of the six groups in figure 4.3. Total occurrences for each group are listed in the table and percentage of time for every group calculated. Most time was spent on performing tasks evaluated in group 6 , or $41 \%$. Number of occurrences was highest in group 1 with cumulative time of $23 \%$ of the total time. 29 and 14 tasks were assigned to groups 3 and 4 respectively, each with cumulative time of $12 \%$ of the total time. One task was assigned to group 2 , that was social surprise event planning for 3.6 minutes, or $1 \%$ of the total time. One task was assigned to group 5, that was listening to the student presentation, for $11 \%$ of the total time.

Table 5.8: Total appearances and cumulative time for chosen tasks before and after data processing.

| Group | Occurrences | Cumulative time | Percentage |
| ---: | :--- | :--- | :--- |
| 1 | 43 | $1: 22: 32$ | $23 \%$ |
| 2 | 1 | $3: 36$ | $1 \%$ |
| 3 | 29 | $42: 39$ | $12 \%$ |
| 4 | 14 | $41: 23$ | $12 \%$ |
| 5 | 1 | $38: 28$ | $11 \%$ |
| 6 | 18 | $2: 26: 48$ | $41 \%$ |
| Total | 106 | $5: 55: 26$ | $100 \%$ |
| Idle | 32 | $9: 22$ | - |
| Total | 138 | $6: 04: 48$ | - |

The TKIS was found by using equations 4.5 and 4.6. Following calculations show values from table 5.8 substituded into the equation to find the KWTD and TKIS.

$$
\begin{gathered}
\text { TKIS }=\frac{1}{4} \cdot 42: 39+\frac{3}{4} \cdot 41: 23+38: 28+2: 26: 48=3: 46: 58 \\
\text { TKIS }(\% T)=\frac{3: 46: 58}{5: 55: 26}=64 \%
\end{gathered}
$$

So, according to the group technique the percentage of time used in knowledge work was $64 \%$ for the recorded data set.

The third method, work time efficiency (WTE), was used to find percentage of time used in work related tasks. The cumulative time for those tasks was $5: 41: 21$ which is $96 \%$ of the total time, $T T=5: 55: 26$.

$$
W T E=\frac{5: 55: 26-14: 05}{5: 55: 26}=96 \%
$$

The tasks that were excluded, i.e. not considered work related, were breaks, waiting and personal time in the computer and one personal telephone call. The only break was buying food. The cumulative time for those tasks were 14 minutes and 5 seconds.

Table 5.9: Interview questions answers.

## Answers to interview questions

Q3: In contrast to other work days, this day was going to be rather easygoing according to the participant and a coworker. One meeting with patient was scheduled and a student presentation, but it came along that another patient was scheduled. The participant had time at the end of the day to organize the email inbox and answer piled up emails.
Q4: A cooperation project with another hospital was unusual according to the worker, that included legal paperwork and finalizing the cooperation contract.

The first two interview questions, Q1 and Q2, were answered in previous section. The author noticed the same issue on finding time to meet with coworker. In this case, workers were trying to decide the time with text message. Also, the author noticed that schedules do change where tasks are skipped or delayed and other tasks appears.

### 5.3. Results From Observing Project Manager

Results and data analyzing from shadowing project manager are covered in this section. The data was prepared and processed with the data processing algorithm. The algorithm refines the data by dealing with overlaps and generates the results from the three techniques covered in chapter 4.

The project manager at the hospital was shadowed for one work day in April 2016. The participant's education is a B.Sc. degree in nursing and M.Sc. degree in project management. The day consisted of three meetings and the making of an emergency plan. The participant was preparing a gel pad for teaching new techniques in angiocath at a conference in the evening. The gel pad was supposed to be used as a fake human body to practice a new technique related to angiocath. The three meetings were about making of new emergency plan, daily status meeting, and new hospital building project. The author was not present during the emergency plan meeting. Table 5.10 features group and dimension evaluation for essential tasks in the data set.

Table 5.10: Tasks evaluation for chosen tasks from prepared data set.

| TASK | GROUP | DIMENSIONS |  |  |  |  |  | KWTS |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 5 | 2 | 1 | 5 | 5 | 5 |  | 1 | 4.88 |
| Making of emergency plan | 6 | 5 | 2 | 1 | 5 | 5 | 5 | 1 | 1 | 4.88 |
| Meeting preparation in computer | 6 | 5 | 2 | 1 | 5 | 5 | 5 | 2 | 1 | 4.75 |
| Answering emails | 3 | 5 | 2 | 1 | 5 | 5 | 5 | 3 | 1 | 4.63 |
| Meeting - emergency plan | 6 | 3 | 2 | 1 | 5 | 5 | 5 | 1 | 1 | 4.63 |
| Meeting - new hospital building | 6 | 3 | 2 | 1 | 5 | 5 | 5 | 2 | 1 | 4.50 |
| Meeting - status meeting | 5 | 3 | 3 | 1 | 5 | 5 | 5 | 2 | 1 | 4.38 |
| Interacting | 3 | 4 | 2 | 1 | 3 | 3 | 3 | 3 | 1 | 3.75 |
| Making gel pad | 4 | 5 | 4 | 5 | 3 | 5 | 3 | 1 | 3 | 3.38 |
| Getting supplies | 3 | 4 | 4 | 5 | 5 | 2 | 2 | 3 | 3 | 2.75 |
| Transport | 1 | 1 | 5 | 5 | 1 | 1 | 1 | 5 | 5 | 1.00 |

A: autonomy, S: structure, T: tangibility, K: knowledge, CI: creativity \& Innovation, C: complexity $R$ : routine \& repetitiveness, P: physical effort

A total of 133 task data lines were recorded during the shadowing. After data preparation the task data lines reduced to 90 task performed by the participant. The data set was then processed to deal with overlaps and generate outcomes for the three techniques. Figure 5.12 features the tasks performed in one dimensional time line. Gantt charts of the data before and after data processing and the data set can be found in appendix B.3.


Figure 5.11: One dimensional time line of tasks after data processing.

Table 5.11 features common tasks performed by the participant, total occurrences and their cumulative times before and after data processing. Most time was spent on meetings. Three meetings were attended, first about emergency plan, second was daily status meeting, and third about the new hospital project. The duration of the meetings were 19:35, 7:46 and 1:05:30 respectively. A total time of 1:18:51 was spent on computer work which reduced to 1:00:35 after data processing were overlapping tasks are cut out, such as telephone calls, interacting with coworker etc. As in the results from the first and second observations, the participant had to transport to another building to attend a meeting. The total time in transport was 59:23 which reduced to 53:03 after data processing. The gel pad project introduced previously was unusual for the participant everyday work. A total time of $37: 16$ was spent on the gel pad project. Total time of interactions was 23:28 and telephone 13:40. Time on other tasks cumulates to $25: 59$, or $25: 23$ after processing, which include breaks and getting supplies for the gel pad project.

Table 5.11: Total appearances and cumulative time for chosen tasks before and after data processing.

| Task | Occurrences | Cumulative time |  | Difference |
| :---: | :---: | :---: | :---: | :---: |
|  |  | Before processing | After processing |  |
| Meetings | 3 | 1:32:51 | 1:32:51 | 0:00 |
| Computer | 12 | 1:18:51 | 1:00:35 | 18:16 |
| Transport | 23 | 59:23 | 53:03 | 6:20 |
| Gel Pad | 9 | 37:16 | 33:39 | 3:37 |
| Interactions | 25 | 23:28 | 17:31 | 5:57 |
| Telephone | 10 | 13:40 | 13:38 | 0:02 |
| Other | 8 | 25:59 | 25:23 | 0:36 |
| Total | 90 | 5:31:28 | 4:56:40 | 34:48 |
| Idle | 36 | - | 7:52 | - |
| Total | 126 | 5:31:28 | 5:04:32 | 26:56 |

Figure 5.12 features idle time gaps in the processed data set. There were 36 instances of idle time gaps which were considered as inaccuracy and not included in further calculations. Thus, the total time used was $T T=4: 56: 40$.


Figure 5.12: One dimensional timeline of idle gaps in data set.

The KWTS for the tasks in the data set are illustrated in figure 5.13. Knowledge work score (KWS) was received from data processing algorithm run, calculated using equations 4.1 to 4.4. Following results were received.

$$
K W S=3.50 \quad \text { or } \quad K W S(\% T)=62 \%
$$



Figure 5.13: Cumulative time per KWTS intervals.

Table 5.12 features division of tasks and total time into the six groups in figure 4.3. Most time was used in performing tasks in group 6, or $52 \%$ of the total time. Highest number of tasks were assigned to group 1, or 35 all told, and $29 \%$ of the total time. The proportion of time used on groups 1 and 6 altogether was $81 \%$. The other $19 \%$ of the total time partitioned between to groups 3,4 and 5 where the percentage was found $7 \%, 9 \%$ and $3 \%$ respectively.

Table 5.12: Group segmentation and cumulative time for tasks in the data set.

| Group | Occurrences | Cumulative time | Percentage |
| ---: | :--- | :--- | :--- |
| 1 | 35 | $1: 26: 04$ | $29 \%$ |
| 2 | 0 | $0: 00$ | $0 \%$ |
| 3 | 32 | $22: 24$ | $7 \%$ |
| 4 | 8 | $27: 11$ | $9 \%$ |
| 5 | 1 | $7: 46$ | $3 \%$ |
| 6 | 14 | $2: 33: 15$ | $52 \%$ |
| Total | 90 | $4: 56: 40$ | $100 \%$ |
| Idle | 36 | $7: 52$ | - |
| Total | 126 | $5: 04: 32$ | - |

The TKIS was calculated from the cumulative time information in table 5.12. Following calculations give the results for TKIS and TKIS (\%T)

$$
\begin{gathered}
\text { TKIS }=\frac{1}{4} \cdot 22: 24+\frac{3}{4} \cdot 27: 11+7: 46+2: 33: 15=3: 07: 00 \\
\operatorname{TKIS}(\% T)=\frac{3: 07: 00}{4: 56: 40}=63 \%
\end{gathered}
$$

Calculated TKIS (\%T) was found $63 \%$ using the group technique for project manager data. Work time efficiency (WTE) was used to calculate the time use of performing work related tasks. The cumulative time for those tasks was $4: 25: 19$ or $93 \%$ of the total time.

$$
W T E=\frac{4: 56: 40-21: 21}{4: 56: 40}=93 \%
$$

Breaks and personal time were excluded from the data, with cumulative time of 21:21.

Table 5.13: Interview questions answers.

## Answers to interview questions

Q1: B.Sc. degree in nursing and M.Sc. degree in project management
Q2: The participant is a project manager at the emergency department and is included in about twenty projects.
Q3: The participant stated that the work is busy and always something to work on. The participant had a big pile of projects that were unfinished.
Q4: The days are very different from one another, some days just include report and paper work at the office, while some are scheduled. The participant compared the job to being a student.

As appears in previous results, much of the time was spent on meetings. According to the participant, transporting and work related to meetings "decrease productivity by one third". Also, the participant finds that many interactions with coworkers have negative impact on the work performance. The duration of one of the meetings was more than one hour, as noted previously, which was beyond scheduled time. Some of that time was a discussion about identifying the problems that needs to be solved and how to identify the problems.

### 5.4. Results From Observing Shift Supervisor

This section covers the results from shadowing shift supervisor at the emergency department for one work day. Data was prepared and then processed with data processing algorithm run. The algorithm refines the data due to overlaps and generates the results from the three techniques covered in chapter 4.

Shift supervisor at the emergency department was shadowed for one work day in April 2016. The participants education is a B.Sc. degree in nursing. The work day consisted of interacting with coworkers, taking in and arranging patients to rooms and be responsible for that every patient is assigned a nurse and doctor. The shift supervisor interacts with coworkers about patients, arrangements and shift system and does not have one fixed workstation. On shift changes, meetings are held with all workers and after the meeting, pairs of workers share informations about the patients assigned to them. The shift supervisor attended the daily status meeting at the hospital. The shift supervisors have to count medicine supplies on shift changes, with one another. Table 5.14 features group and dimension evaluation for essential tasks in the data set.

Table 5.14: Tasks evaluation for chosen tasks from prepared data set.

| TASK | GROUP | DIMENSIONS |  |  |  |  |  | KWTS |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 5 | 2 | 1 | 5 | 4 | 5 |  | 1 | 4.63 |
| Interacting - Patient condition | 6 | 4 | 2 | 1 | 5 | 5 | 5 | 2 | 1 | 4.63 |
| Transceiver | 5 | 2 | 3 | 1 | 5 | 5 | 5 | 2 | 1 | 4.25 |
| Interacting - Room system | 3 | 4 | 2 | 1 | 3 | 4 | 4 | 3 | 1 | 4.00 |
| Room system | 4 | 4 | 4 | 1 | 3 | 4 | 5 | 3 | 1 | 3.88 |
| Interacting - coordination | 1 | 2 | 3 | 1 | 2 | 4 | 3 | 3 | 1 | 3.38 |
| Arrangements for plumber | 1 | 4 | 4 | 5 | 1 | 2 | 1 | 1 | 5 | 2.13 |
| Get new patient files | 1 | 2 | 5 | 5 | 1 | 1 | 1 | 5 | 3 | 1.38 |
| Counting supplies | 1 | 1 | 5 | 5 | 1 | 1 | 2 | 4 | 4 | 1.38 |
| Transport | 1 | 1 | 5 | 5 | 1 | 1 | 1 | 5 | 5 | 1.00 |

A: autonomy, S: structure, T: tangibility, K: knowledge, CI: creativity \& Innovation, C: complexity
R: routine \& repetitiveness, P: physical effort

A total of 850 data lines were recorded during the shadowing, 19 of them was an error from accidental tabbing by the author on the tablet computer. Some of the tasks were combined in one and the final result was 521 tasks data lines listed in table B. 4 in appendix B.4. The prepared data set was processed with the data processing algorithm. Gantt chart of the tasks in the data set before and after data processing can be found i figures B. 7 and B.8, respectively. Figure 5.14 features the
processed tasks in a one dimensional timeline. As noticed by looking at the timeline figure, high frequency of task switches describe the work day. Note that the author did not gather data from approximately 12:00 to 13:00.


Figure 5.14: One dimensional time line of tasks after data processing.

Table 5.15 features common tasks in the data set, total occurrences of those tasks and cumulative time before and after data processing. The cumulative time reduces due to overlaps in the data, where pieces corresponding to overlapping tasks are cut from the predominant tasks. The participant used most of the time on interactions, or 2:46:40 interacting 240 times with coworkers. These coworkers were mainly nurses and doctors. Second most time was spent on looking at and organizing in the room computer system, or 1:10:37 reduced to $44: 42$. Often the participant was multitasking, such as organizing in the room computer system and interacting with coworkers followed by frequent task switches. The worker spent 58:09 minutes in transport inside the hospital, that time reduced to 40:50 after data processing. The overlaps for transport time were for example interacting with coworkers, get new patient files etc. Cumulative time for counting and getting supplies were 26:21 and 21:58, before and after data processing respectively.

The room system task corresponds to viewing and assigning patients to rooms in the room computer system. Computer work, other than working in the room system, was 12:45 after data processing, but the participant was interacting to coworkers while working in the computer. Get new files task refer to that the participant has to transport to the secretary area to get new files about patients in the waiting room. Direct care in this case, unlike for the other participant (medical specialist and nurse), were calling in patients, interacting with patients and/or relatives, and checking on patient. The participant had to make arrangements for plumber work at the hospital, where the time cumulates to 2:41 without related transport. The high idle time was explained part time by no observation time which was 1:06:25.

Table 5.15: Total appearances and cumulative time for chosen tasks before and after data processing.

| Task | Occurrences | Cumulative time |  | Difference |
| :--- | :--- | :---: | :---: | :--- |
|  |  | $2: 46: 40$ | $2: 24: 17$ |  |
| Room system | 49 | $1: 10: 37$ | $44: 42$ | $25: 55$ |
| Transport | 118 | $58: 09$ | $40: 50$ | $17: 19$ |
| Supplies | 13 | $26: 21$ | $21: 58$ | $4: 23$ |
| Computer | 8 | $22: 26$ | $12: 45$ | $9: 41$ |
| Telephone | 28 | $31: 47$ | $29: 26$ | $2: 21$ |
| Get new files | 13 | $7: 32$ | $6: 41$ | $0: 51$ |
| Direct care | 11 | $6: 57$ | $6: 55$ | $0: 02$ |
| Meetings | 3 | $5: 09$ | $4: 51$ | $0: 18$ |
| Transceiver | 11 | $4: 55$ | $4: 49$ | $0: 06$ |
| Plumber project | 8 | $2: 41$ | $2: 41$ | $0: 00$ |
| Other | 19 | $42: 53$ | $40: 36$ | $2: 17$ |
| Total | 521 | $7: 26: 07$ | $6: 00: 31$ | $1: 25: 36$ |
| No observation | 1 | - | $1: 06: 25$ | - |
| Idle | 305 | - | $35: 46$ | - |
| Total | 827 | $7: 26: 07$ | $7: 42: 42$ | $0: 16: 35$ |

The idle time was $35: 46$ if the no observation time is set aside. Figure 5.15 features the idle time gaps in one dimensional time line. The idle time increases from previous results due to more frequency in task switches.


Figure 5.15: One dimensional time line of idle time gaps.

Results from the three techniques are covered here below. First, results from dimen-
sion technique where knowledge work score (KWS) and knowledge work score as a percentage of time (KWS (\%T)) were calculated. Following are the results from dimension technique were

$$
K W S=3.17 \text { or } \quad K W S(\% T)=54 \%
$$

Figure 5.16 features the KWTS of the tasks in the data set.


Figure 5.16: Cumulative time per KWTS intervals.

Next, the TKIS was found by using the group technique. Table 5.16 features division of the tasks and total time to the six groups in figure 4.3, number of tasks and cumulative time for the tasks assigned to each group. Most time was spent on performing tasks assigned to group 1 , or $36 \%$ of the total time ( $T T$ ), $T T=6: 00: 31$ in this case. Second most time was spent on performing tasks in group 6, or $21 \%$ of the total time. One task was assigned to group 2, when the participant used massage aid. Groups 3 and 4 account for $17 \%$ of the total time each and $7 \%$ of the total time was spent on performing tasks in group 5 .

## 5. Time Use Results

Table 5.16: Group segmentation and cumulative time for tasks in the data set.

| Group | Occurrences | Cumulative time | Percentage |
| ---: | :--- | :--- | :--- |
| 1 | 201 | $2: 10: 02$ | $36 \%$ |
| 2 | 1 | $8: 13$ | $2 \%$ |
| 3 | 119 | $1: 01: 48$ | $17 \%$ |
| 4 | 68 | $1: 01: 27$ | $17 \%$ |
| 5 | 32 | $25: 05$ | $7 \%$ |
| 6 | 100 | $1: 13: 56$ | $21 \%$ |
| Total | 521 | $6: 00: 31$ | $100 \%$ |
| Idle | 306 | $1: 42: 11$ | - |
| Total | 827 | $7: 42: 42$ | - |

The TKIS was calculated from the cumulative times in table 5.16 as follows

$$
\begin{gathered}
\text { TKIS }=\frac{1}{4} \cdot 1: 01: 48+\frac{3}{4} \cdot 1: 01: 27+25: 05+1: 13: 56=2: 40: 33 \\
\text { TKIS }(\% T)=\frac{2: 40: 33}{6: 00: 31}=44.53 \%
\end{gathered}
$$

Work time efficiency (WTE) was found by using equation 4.7. Tasks that were not work related were breaks and personal time with cumulative time of 29:07.

$$
W T E=\frac{6: 00: 31-29: 07}{6: 00: 31}=92 \%
$$

Answers to the questions on the interview schedule are listed in table 5.17.

Table 5.17: Interview questions answers.

## Answers to interview questions

Q1: B.Sc. in nursing
Q2: Included in shift supervisor job is to be responsible for that every patient is assigned a nurse and a doctor, arrange patients to rooms by prioritizing cases and to notify other departments about patients, this requires interacting with coworkers to assign projects and gather informations. Shift supervisor performs work related to supplies, i.e. counting, ordering and dispatching supplies, this refers to medicine and other supplies.
Q3: Participant described the job is busy and there is little breathing space to perform because there are always projects waiting to be done. Being a shift supervisor requires solving problems from various sources and be responsible for that everything functions.
Q4: The work day shadowed was busy, but not as busy as previous days according to the participant. Around 11 AM the rooms were full, and participants were moved to lie on hallways, but in previous days the rooms were full 24 hours. The shift supervisor does not usually attend the daily status meeting as the participant did in this case.

The author noticed much interacting with other workers, and finds the transfer time high related that the participant was just transferring inside the building. It's worth noting that included in the transfer time could be checking status, i.e. gathering information to make decisions, but it was not evaluated in that way because the author couldn't notice that. The time spent on supplies related tasks have to be considered, the author evaluated those tasks as not knowledge intensive. The author noticed that there were always some tasks that were on hold and the participant was looking for a coworker to share or gather information with. So the focus is not at a one task at a time.

### 5.5. Results From Observing Nurse

This section covers the results from shadowing nurse on a regular shift at the emergency department. Data was prepared and then processed with processing algorithm run where the data is refined and calculations performed. The data processing algorithm generates results from the three techniques in chapter 4 .

Nurse at the emergency department was shadowed for one work day in April. Participants education is B.Sc. in nursing. The day consisted of two shift change meetings on shift changes, interacting with coworkers, direct care, getting and preparing
supplies and medicine, and computer work. The participant had to document information in three computer systems; room system, medicine system and patient record system.

Table 5.18: Tasks evaluation for chosen tasks from prepared data set.

| TASK | GROUP | A | DIMENSIONS | KWTS |  |  |  |  |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 6 | 5 |  | 1 | 5 | 5 | 5 | 2 | 1 |
| Interacting - advising with | 6 | 4 | 2 | 1 | 5 | 5 | 5 | 2 | 1 | 4.75 |
| coworker |  |  |  |  |  |  |  |  |  |  |
| Interacting - inform coworker | 6 | 4 | 2 | 1 | 5 | 5 | 4 | 2 | 1 | 4.50 |
| Interacting - answer question | 6 | 4 | 2 | 1 | 5 | 5 | 4 | 2 | 1 | 4.50 |
| Direct care | 6 | 4 | 2 | 1 | 5 | 4 | 4 | 3 | 1 | 4.25 |
| Computer - medicine system | 3 | 4 | 3 | 1 | 5 | 4 | 2 | 3 | 1 | 3.88 |
| Computer - room system | 3 | 4 | 4 | 1 | 3 | 4 | 5 | 3 | 1 | 3.88 |
| Interacting | 3 | 4 | 2 | 1 | 3 | 3 | 3 | 3 | 1 | 3.75 |
| Direct care - give medicine | 5 | 4 | 4 | 5 | 5 | 3 | 4 | 3 | 3 | 3.13 |
| Supplies - Preparation | 5 | 4 | 4 | 5 | 5 | 3 | 2 | 3 | 3 | 2.88 |
| Direct care - angiocath | 5 | 3 | 4 | 5 | 5 | 3 | 4 | 4 | 3 | 2.88 |
| Get supplies | 3 | 4 | 4 | 5 | 5 | 2 | 2 | 3 | 3 | 2.75 |
| Supplies - dispatch | 3 | 2 | 4 | 5 | 1 | 1 | 1 | 4 | 3 | 1.63 |
| Transport | 1 | 1 | 5 | 5 | 1 | 1 | 1 | 5 | 5 | 1.00 |

A: autonomy, S: structure, T: tangibility, K: knowledge, CI: creativity \& Innovation, C: complexity
$R$ : routine \& repetitiveness, $P$ : physical effort

Total of 530 tasks were recorded on the software application, twelve of them were accidental tabbing. After combination of task data lines and preparation, total of 380 tasks data lines were processed with the data processing algorithm. The prepared data set is listed in table B. 5 and Gantt charts of the data before and after algorithm processing can be found in figures B. 9 and B. 10 in appendix B.5. Figure 5.17 features one dimensional timeline of tasks performed by the participant.


Figure 5.17: One dimensional time line of tasks after data processing.

Table 5.19 features common tasks performed by the participant during the shadowing, total occurrences of those tasks and cumulative time before and after data processing. The cumulative time reduces due to overlaps in the data. Most time was used in direct care or 2:24:06 and 2:20:07, before and after data processing. The reduction of time was explained by supply gathering or preparation during the direct care. Second most time was used in computer work documenting informations about patients in three computer systems. Interactions occurred most often in the data set and had the third most cumulative time. The task supplies refer to getting, preparing, and dispatching supplies, medicine and test samples. Breaks were approximately one hour of other tasks in the table.

Table 5.19: Total appearances and cumulative time for chosen tasks before and after data processing.

| Task | Occurrences | Cumulative time |  | Difference |
| :---: | :---: | :---: | :---: | :---: |
|  |  | Before processing | After processing |  |
| Direct Care | 48 | 2:24:06 | 2:20:07 | 3:59 |
| Computer | 54 | 1:29:52 | 1:15:57 | 13:55 |
| Interactions | 113 | 1:20:41 | 1:16:40 | 4:01 |
| Supplies | 43 | 42:21 | 30:18 | 12:03 |
| Transport | 90 | 32:54 | 27:51 | 5:03 |
| Telephone | 8 | 14:31 | 10:22 | 4:09 |
| Meetings | 2 | 3:46 | 3:11 | 0:35 |
| Other | 22 | 1:12:07 | 1:09:13 | 2:54 |
| Total | 380 | 8:00:18 | 7:13:39 | 46:39 |
| Idle | 239 | - | 26:47 | - |
| Total | 619 | 8:00:18 | 7:40:26 | 19:52 |

## 5. Time Use Results

Total idle time was 26:47 and figure 5.18 illustrates the idle time gaps in one dimensional time line. As noted in previous section, the idle time increases with number of tasks and is considered as inaccuracy in data gathering.


Figure 5.18: One dimensional time line of idle time gaps data processing.

Results from the three techniques covered in chapter 4 are covered in following steps, the KWS (\%T), TKIS and WTE outcomes are found. Following are outcomes from dimension technique generated from the data processing algorithm

$$
K W S=3.21 \quad \text { or } \quad K W S(\% T)=55 \%
$$

Figure 5.19 features KWTS of the tasks in the data set.


Figure 5.19: Cumulative time per KWTS intervals.

Hence, time use in knowledge intensive tasks for the data set are found to be $55 \%$ of the total time. Next, the group technique was executed on the data set. Table 5.20 features division of tasks and total time between the six groups. Most time was used by performing tasks in group 6, or $30 \%$ of the total time. Second most time was spent on performing tasks in group 1, or $26 \%$. No task was assigned to group 2.

Table 5.20: Group segmentation and cumulative time for tasks in the data set.

| Group | Occurrences | Cumulative time | Percentage |
| ---: | :--- | :--- | :--- |
| 1 | 124 | $1: 54: 05$ | $26 \%$ |
| 2 | 0 | $0: 00$ | $0 \%$ |
| 3 | 106 | $1: 12: 16$ | $17 \%$ |
| 4 | 20 | $38: 02$ | $9 \%$ |
| 5 | 53 | $1: 19: 46$ | $18 \%$ |
| 6 | 77 | $2: 09: 30$ | $30 \%$ |
| Total | 380 | $7: 13: 39$ | $100 \%$ |
| Idle | 239 | $26: 47$ | - |
| Total | 619 | $7: 40: 26$ | - |

The TKIS was calculated from cumulative time information in table 5.20. Calcula-
tions and outcomes were as follows

$$
\begin{gathered}
T K I S=\frac{1}{4} \cdot 1: 12: 16+\frac{3}{4} \cdot 38: 02+1: 19: 46+2: 09: 30=4: 15: 52 \\
\text { TKIS }(\% T)=\frac{4: 15: 52}{7: 13: 39}=59 \%
\end{gathered}
$$

According to the group technique, $59 \%$ of the total time was used in knowledge work. The third technique, work time efficiency (WTE), represent percentage of time performing work related tasks. Tasks not considered as work related were breaks and personal time. Following are results for that technique

$$
W T E=\frac{7: 13: 39-1: 02: 14}{7: 13: 39}=86 \%
$$

The interview questions are listed in table 5.21.

Table 5.21: Interview questions answers.

## Answers to interview questions

Q1: B.Sc. in nursing
Q2: Included in nurse's job is nursing, the participant is assigned and responsible for about four patients at a time. Interactions with doctors and the shift supervisor about patient condition and decide patient continuation are essential.
Q3: The job is very busy at the emergency department. The department is full most of the time so nurses have maximum number of patients assigned to them.
Q4: The day shadowed was not as busy as previous days according to the participant and other workers. At the end of the day, it became very busy with patients coming in.

It's noted that much of the tasks recorded were routine, though it required specific amount of knowledge where part of direct care tasks were routine, such as take blood, set up angiocath and give medicine. When difficulties occurred, the task was evaluated creative because the procedures do not hold completely, the task completion changes and the worker has to use special talents obtained from previous work to perform the task. Example is difficulties in setting up angiocath because of patient condition. It was noted by the author that the participant once had to transport to the next floor to get supplies that were not available at the main warehouse.

## 6. Summary and Comparison

In previous steps in the research process, three time use techniques were developed and executed to generate time efficiency for the data sets. Two of the techniques generate knowledge work time efficiency (KWTE) and the third generates work time efficiency (WTE). The techniques consist of two activities; first, evaluating tasks, and second, calculate time efficiency. The time use techniques are covered in chapter 4. Results from the four participants and five observations are summarized and compared in this chapter.

The results from the three techniques are compared within and between the five observations to answer the first research question: How do knowledge workers use their time at work? The techniques are; dimension technique resulted in knowledge work score (KWS), group technique resulted in task based knowledge intensity score (TKIS), and work time efficiency (WTE) technique. Table 6.1 features the outcomes for each participant, which can all be described in percentage time efficiency of the total time.

Table 6.1: Three methods results summary for the participants.

| Participant | Group technique <br> TKIS $(\% T)$ <br> (by author) | Dimension technique <br> $K W S(\% T)$ <br> (Ramirez and Steudel, 2008) | Work Time <br> Efficiency <br> $W T E$ |
| :--- | :---: | :---: | :---: |
| Medical specialist | $72 \%$ | $69 \%$ | $94 \%$ |
| Medical specialist | $64 \%$ | $71 \%$ | $96 \%$ |
| Project manager | $63 \%$ | $62 \%$ | $93 \%$ |
| Shift supervisor | $45 \%$ | $54 \%$ | $92 \%$ |
| Nurse | $59 \%$ | $55 \%$ | $86 \%$ |

For every of the five observations, work time efficiency (WTE) was the highest value of the three methods as expected. The difference between the other two methods was considered. It differs whether the outcome from one is higher or lower. The most difference was between outcomes for shift supervisor and the least difference for the project manager, $9 \%$ and $1 \%$ respectively. The rank of TKIS and KWS for the participants was the same, except it differed which technique resulted in higher time use for medical specialist. In summary, medical specialist used most time in

## 6. Summary and Comparison

knowledge intensive tasks, followed by project manager, nurse and shift supervisor.
Results from the group technique are on a higher interval than results from the dimension technique. But the group technique is evaluated by two dimensions, while the dimension technique is evaluated by eight dimension, which can be a reason for more stability in the KWSs. Also, the dimensions; tangibility and physical effort was not considered directly when evaluating tasks in the group technique. Those two dimensions can either cause increase or decrease in the KWTS. Especially when considering technologists, who work with their hands as well as with their head (Drucker, 1999), then tangibility and physical effort can cause decrease in knowledge intensity.

Results from task evaluations strategies were considered to answer the second research question: What types of tasks are knowledge workers performing?

Knowledge work task score (KWTS) sorted to eight intervals for each participant is represented in figure 6.1. This figure summarizes figures $5.7,5.10,5.13,5.16$ and 5.19 in previous result chapter. The KWS from table 6.1 are noted at the top of each bar in the figure. Most spread in KWTS are with shift supervisor and nurse and more knowledge intensive tasks occur at medical specialist and project manager. This difference can be related to the technologist working in their hands with physical matter as well as in the KWS.


Figure 6.1: KWTS results for each participant.

Table 6.2 features a closer view at the results from group task evaluation. The cumulative time of the tasks assigned to the six groups for each participant is listed as a percentage of the total time. By comparing these results between the participants, most of the time was used in performing tasks in group 6 and group 1. In the case of the shift supervisor, cumulative time of tasks in group 1 was higher than the cumulative time of tasks in group 6 .

Table 6.2: Group segmentation for each participant.

| Participant | Group [percentage of total time] |  |  |  |  |  | TKIS |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
|  | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ |  |
| Medical Specialist | $20 \%$ | $0 \%$ | $8 \%$ | $10 \%$ | $2 \%$ | $60 \%$ | $72 \%$ |
| Medical Specialist | $23 \%$ | $1 \%$ | $12 \%$ | $12 \%$ | $11 \%$ | $41 \%$ | $64 \%$ |
| Project Manager | $29 \%$ | $0 \%$ | $7 \%$ | $9 \%$ | $3 \%$ | $52 \%$ | $63 \%$ |
| Shift Supervisor | $36 \%$ | $2 \%$ | $17 \%$ | $17 \%$ | $7 \%$ | $21 \%$ | $45 \%$ |
| Nurse | $26 \%$ | $0 \%$ | $17 \%$ | $9 \%$ | $18 \%$ | $30 \%$ | $59 \%$ |
| Average | $27 \%$ | $1 \%$ | $12 \%$ | $11 \%$ | $8 \%$ | $41 \%$ | $61 \%$ |

Extraction from table 6.2 where percentage of time along the two dimensions are listed in table 6.3. The two dimensions are; routine vs. creative and degree of formal

## 6. Summary and Comparison

education as covered in chapter 4. As noticed in figure 6.1, difference between results from nurse and shift supervisor, on one hand, and medical specialist and project manager on the other, is recognized. While more time is used on creative tasks with medical specialist, more time is spent on routine tasks with shift supervisor and nurse. More balance between workers is among degree of formal education dimensions, but the shift supervisor stands out with higher time spent on tasks that does not require formal education to be performed, and lower time on tasks that require formal education.

Table 6.3: Group segmentation along two dimensions

| Participant | Routine | Creative | Before <br> collage | During <br> collage | After <br> collage |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Medical Specialist | $30 \%$ | $70 \%$ | $20 \%$ | $18 \%$ | $62 \%$ |
| Medical Specialist | $46 \%$ | $54 \%$ | $24 \%$ | $24 \%$ | $52 \%$ |
| Project Manager | $39 \%$ | $61 \%$ | $29 \%$ | $16 \%$ | $55 \%$ |
| Shift Supervisor | $60 \%$ | $40 \%$ | $38 \%$ | $34 \%$ | $28 \%$ |
| Nurse | $61 \%$ | $39 \%$ | $26 \%$ | $26 \%$ | $48 \%$ |

The participants described their work as busy. The medical specialist and project manager have not time to complete their projects, and had many projects waiting to be done. They agreed that much of their time was spent on meetings, the project manager stated that "everything related to attending meetings decreased the productivity of one third". Also, answering questions from coworkers can affect the concentration to a specific task and makes it harder to complete it. The medical specialist mentioned that transporting between buildings, sometimes just for one meeting, is very time consuming and sometimes it can take a few minutes to find a parking spot. The lunch time is often used for work, where workers meet over lunch.

The working environment at the emergency department is more dynamic and require the workers to perform tasks that needs to be done by schedule and priority. Information flow between workers was found important. The shift supervisor was responsible for the department to function, involved in the work was to assign patients to other departments. To do that, a nurse with the specific patient and the shift supervisor had to notify the patient. The nurse mentioned that three computer systems were used to file informations about the patients. The nurse and another worker had a discussion in the lunch break that the workers had to work amongst a common goal, by increasing information flow between workers about sample results and patient conditions to provide a better care. So workers are aware of what might be done better, and talk about it.

The research questions identified were:

- How do knowledge workers use their time at work?
- What types of tasks are the workers performing?

Answer to the first research question can be drawn from table 6.1. Three types of time use efficiency were found, two of them were related to knowledge intensity of the tasks performed by the participants, or knowledge time efficiency. The knowledge work time efficiency ranged from $45 \%$ to $72 \%$ for the cases, while the time used on work related tasks varied between $86 \%$ to $96 \%$. From this, at least $20 \%$ of the time working is spent on non knowledge intensive tasks.

Answer to the second research question is that the task types varies with working environment and worker's profession. The medical specialist and project manager use more of their time on tasks that are on the high-end of the task evaluation in both dimension technique, and more than $50 \%$ of the time is used on creative tasks. However, the shift supervisor and nurse use less time on the tasks at the high-end of the knowledge intensity evaluation, and with more spread of task types and tasks are rather routine than creative. The answer can be addressed from figure 6.1 and tables 6.2 and 6.3.

In conclusion, workers use specific amount of working time (WTE) on tasks that are not knowledge intensive and the time used on knowledge intensive tasks can be less than $50 \%$. Highest values generated from two knowledge time efficiency techniques, TKIS and KWS, were $72 \%$ and $71 \%$. Also, there appears to be a difference between workers time use in terms of either profession and work environment, or both.

## 7. Discussion

This chapter features discussion of authors perspective and the results in relation to other findings reviewed in literature on time allocation in section 3.3. Limitations of the research include issues in research design and suggestions of further research is introduced.

This work shows results of time efficiency in knowledge work and segmentation of tasks performed by knowledge workers. The segmentation of tasks are based on the knowledge intensity of the tasks. Higher time efficiency does not necessarily lead to better effectiveness or outcome. Workers are performing tasks that could be delegated or tasks that could be dropped. Some of those tasks might be evaluated as knowledge intensive but are not necessary. Some of the tasks might be evaluated non-knowledge intensive but are necessary for the process of work being performed. Some tasks might be restructured to increase time efficiency and maybe effectiveness. Whereas knowledge work is unstructured and workers perform the tasks in various ways so the time duration can vary from one worker to another. It could take shorter time for one worker to complete the task more effectively than other worker. Hence, more time spent on knowledge intensive task does not necessarily lead to better outcome.

Whether tasks can by dropped or delegated to subordinates was not evaluated in this research. Some of the tasks evaluated as knowledge intensive in this work could be delegated and some of the tasks evaluated non-knowledge intensive could not be delegated. That is, it is not given that unnecessary tasks, that reduce time efficiency, are not knowledge intensive. Another aspect is tasks such as transporting which are in many cases necessary but not knowledge intensive. Reengineering of tasks could though affect some of those non-knowledge intensive tasks.

The quality of an outcome in knowledge work is difficult to evaluate and measure, but in knowledge work is quality of the outcome as much important as quantity (Drucker, 1999). The quality of the work outcome was not considered in this research. Latent value is difficult to identify in advance and measure. Workers time effectiveness is also difficult to access, whereas workers perform the tasks in various ways so the time duration can vary between workers. Some researchers argue that with more time duration per task, the outcome or results of the work is better (Hopp et al., 2007).

## 7. Discussion

Interactions and communications are a big part of the work, in the form of informal or formal meetings, telephone calls, transceiver or interruptions. Though this work is on individual level the impact of coworkers have to be considered from the perspective of the participant. In every of the cases studied, interactions accounted for a specific amount of the total time. In this study, distinction was not made between interacting tasks, though some of them might be from other interrupting the participant and the participant interrupting others. But the interactions are necessary for information flow for workers to make decisions, identify a new task, etc. However, the impact of interactions and task switches are considered negative on time use and performance of the worker according to the literature. Tasks that occur from interruptions can be evaluated knowledge intensive, and in this work interruptions were not specified in the data. Therefore, time duration of tasks, both knowledge intensive and not, can be increased and take longer time due to the interruptions and task switches. Interruptions due to technical errors were though evaluated non-knowledge intensive. Apparently these interruptions decrease time efficiency. Also, interruptions due to suddenly remembering a task that had to be done was recognized by the author in all the cases.

From the above, productivity in knowledge work cannot be determined straight from time efficiency. The time effectiveness, output quality and task sources should be further considered. Also, worker's personal productivity and organizational environment are factors that need to be taken into consideration.

### 7.1. Limitations

Limitation to this work include issues in research design, foremost in instrument development; sample and site selection, data gathering and data analyzes. The sample selection was convenient with low number of participants and therefore not representative so the results from the study are not generalizable. The participants had different professions but all worked in the health care industry at Landspítali University Hospital. The workers were shadowed for one work day, but workdays can vary in knowledge work so the duration of the shadowings was short. Apparently, it affects the participants that they were being shadowed, and that can predict unusual work patterns. Other workers at the workplace noticed the author, and questioned it. The participants sometimes had to explain to others that the author was shadowing, or the author explained it.

In data gathering, idle time increased with number of tasks recorded, that is due to reaction time of the author and difficulty in deciding what task was to be performed
until it was started. The data could have been refined by changing the starting time of a task to be the end time of previous tasks. Also, milliseconds between tasks can round to one second of an idle gap in the data. This could also be a clue of decrease in time efficiency due to task switches.

When evaluating tasks, it was done from the author knowledge and understanding of the literature. The guidelines developed from the literature were followed with authors best knowledge with consistency in mind. But, a task can be evaluated in multiple ways with different reasonings so the task evaluation is not accurate.

### 7.2. Further Research

Future research could be to examine larger sample of workers and for a longer time. The data collection could be done by the workers themselves by using the software application on a tablet computer. Future research could be to concatenate a time efficiency technique by considering the two time efficiency techniques developed and executed in this work. Tasks that are considered non-knowledge intensity might be done effectively while high knowledge intensive tasks are not performed effectively. Considerations for time effectiveness to be added to the technique, by the evaluation of the worker of his/her work effectiveness and outcome. This could be done with a questionnaire sent to participants to evaluate the task's effectiveness. Also, an interruption index can be found by accounting the task switches related to interruption tasks.

Further research may also consider automatization of tasks, i.e. when tasks that are performed manually become automatic. This could be considered from the group evaluation, where tasks move from being manual to being automatic, or down the columns in the group matrix. That links to time efficiency and effectiveness for individuals and higher levels where worker's time is not spent on those tasks anymore. This refers to more emphasis on the task side of the research and higher level such as organizational and team level in knowledge work, where delegation of tasks is considered. Tasks are performed by workers or they are performed automatically.

To evaluate knowledge worker productivity there is need to develop techniques to measure and identify the factors that impact the knowledge worker productivity. Time efficiency is included in many conceptual models and frameworks in the literature.

## References

Amabile, T. M. (1996). Creativity and innovation in organizations. Harvard Business Review Background Note, 396-239.

Arman, R., Dellve, L., Wikstrom, E., and Tornstrom, L. (2009). What health care managers do: applying mintzberg's structured observation method. Journal of Nursing Management, 17(6), 718-729.

Bainbridge, L., Lenior, T. M. J., and Vanderschaaf, T. W. (1993). Cognitiveprocesses in complex tasks - introduction and discussion. Ergonomics, 36(11), 1273-1279.

Birkinshaw, J. and Cohen, J. (2013). Make time for the work that matters. Harvard Business Review, 91(9), 115-+.

Biron, A. D., Lavoie-Tremblay, M., and Loiselle, C. G. (2009). Characteristics of work interruptions during medication administration. Journal of Nursing Scholarship, 41(4), 330-336.

Blackler, F. (1995). Knowledge, knowledge work and organizations: An overview and interpretation. Organization Studies, 16(6), 1021-1046.

Bolt, M. A., Killough, L. N., and Koh, H. C. (2001). Testing the interaction effects of task complexity in computer training using the social cognitive model. Decision Sciences, 32(1), 1-20.

Breaugh, J. A. (1985). The measurement of work autonomy. Human Relations, 38(6), 551-570.

Campbell, D. J. (1988). Task complexity - a review and analysis. Academy of Management Review, 13(1), 40-52.

Chen, G., Casper, W. J., and Cortina, J. M. (2001). The roles of self-efficacy and task complexity in the relationships among cognitive ability, conscientiousness, and work-related performance: A meta-analytic examination. Human Performance, 14(3), 209-230.

Claessens, B. J. C., van Eerde, W., Rutte, C. G., and Roe, R. A. (2010). Things to do today ... : A daily diary study on task completion at work. Applied Psychology-an International Review-Psychologie Appliquee-Revue Internationale, 59(2), 273-295.

## REFERENCES

Cooper, D. R. and Schindler, P. S. (2013). Business Research Methods (12th ed.). New York: McGraw-Hill Higher Education.

Coviello, D., Ichino, A., and Persico, N. (2014). Time allocation and task juggling. American Economic Review, 104(2), 609-623.

Dahooie, J. H., Afrazeh, A., Hosseini, S. M. M., and Arsalan, M. R. G. (2012). Knowledge work difficulty factors: An empirical study based on different groups of knowledge workers. South African Journal of Economic and Management Sciences, 15(1), 1-15.

Dahooie, J and Arsalan, M. (2013). Applying fuzzy integral for evaluating intensity of knowledge work in jobs. International Journal of Industrial Engineering Computations, 4(4), 517-534.

Donnelly, R. (2006). How "free" is the free worker? an investigation into the working arrangements available to knowledge workers. Personnel Review, 35(1), 78-97.

Drever, E. (1995). Using semi-structured interviews in small-scale research: a teacher's guide. Edinburgh: SCRE.

Drucker, P. F. (1967). The Effective Executive. New York: Harper \& Row.
Drucker, P. F. (1999). Knowledge-worker productivity: The biggest challenge. California Management Review, 41(2), 79-+.

Drucker, P. F. and Maciariello, J. A. (2008). Management. Collins, New York, NY, rev. edition.

Eisenhardt, K. M. (1989). Building theories from case-study research. Academy of Management Review, 14(4), 532-550.

Marschak, Thomas A., and Gennan, Thomas K. and Summers, Robert. (1967). Strategy for $R$ \& D; studies in the microeconomics of development. New York: Springer-Verlag.

Hackman, J. R. and Oldham, G. R. (1976). Motivation through design of work - test of a theory. Organizational Behavior and Human Performance, 16(2), 250-279.

Handfield, R. B. and Melnyk, S. A. (1998). The scientific theory-building process: a primer using the case of tqm. Journal of Operations Management, 16(4), 321-339.

Gleeson, F. and Hargaden, V. (2014). A task based framework to improve knowledge work efficiency. School of Engineering, University College Dublin.

Hopp, P. J., Smith, C. A. R., Clegg, B. A., and Heggestad, E. D. (2005). Interruption management: The use of attention-directing tactile cues. Human Factors, 47(1), $1-11$.

Hopp, W. J., Iravani, S. M. R., and Liu, F. (2009). Managing white-collar work: An operations-oriented survey. Production and Operations Management, 18(1), 1-32.

Hopp, W. J., Iravani, S. M. R., and Yuen, G. Y. (2007). Operations systems with discretionary task completion. Management Science, 53(1), 61-77.

Hopp, W. J. and Van Oyen, M. P. (2004). Agile workforce evaluation: a framework for cross-training and coordination. Iie Transactions, 36(10), 919-940.

Kelloway, E. and Barling, J. (2000). Knowledge work as organizational behavior. International Journal of Management Reviews, 2(3), 287-304.

Leroy, S. (2009). Why is it so hard to do my work? the challenge of attention residue when switching between work tasks. Organizational Behavior and Human Decision Processes, 109(2), 168-181.

Locke, E. A. and Latham, G. P. (2002). Building a practically useful theory of goal setting and task motivation - a 35-year odyssey. American Psychologist, 57(9), 705-717.

Mumford, M. D., Blair, C., Dailey, L., Leritz, L. E., and Osburn, H. K. (2006). Errors in creative thought? cognitive biases in a complex processing activity. Journal of Creative Behavior, 40(2), 75-109.

Murray, S. L. and Khan, Z. (2014). Impact of interruptions on white collar workers. Emj-Engineering Management Journal, 26(4), 23-28.

Nair, N. and Vohra, N. (2010). An exploration of factors predicting work alienation of knowledge workers. Management Decision, 48(4), 600-615.

Nickols, F. (2012). The shift from manual work to knowledge work. Retrived January, 2016, from http://www.nickols.us/shift_to_KW.htm.

O'Carroll, A. (2008). Fuzzy holes and intangible time: Time in a knowledge industry. Time \& Society, 17(2-3), 179-193.

Paton, S. (2013). Introducing taylor to the knowledge economy. Employee Relations, 35(1), 20-38.

Perlow, L. A. (1999). The time famine: Toward a sociology of work time. Administrative Science Quarterly, 44(1), 57-81.

Prietula, M. J., Feltovich, P. J., and Marchak, F. (2000). Factors influencing analysis of complex cognitive tasks: A framework and example from industrial process control. Human Factors, 42(1), 56-74.

Pyöriä, P. (2005). The concept of knowledge work revisited. Journal of Knowledge Management, 9(3), 116-127.

## REFERENCES

Quinn, J. B., Anderson, P., and Finkelstein, S. (1996). Managing professional intellect: Making the most of the best. Harvard Business Review, 74(2), 71-+.

Ramirez, Y. W. and Steudel, H. J. (2008). Measuring knowledge work: the knowledge work quantification framework. Journal of Intellectual Capital, 9(4), 564-584.

Ramírez, Y. W. and Nembhard, D. A. (2004). Measuring knowledge worker productivity. Journal of Intellectual Capital, 5(4), 602-628.

Reder, S. and Schwab, R. G. (1990). The temporal structure of cooperative activity. Paper presented at ACM conference: Computer-supported cooperative work. Los Angeles, California, United States. doi: 10.1145/99332.99363.

Saragih, S. (2012). The effects of job autonomy on work outcomes: self efficacy as an intervening variable. International Research Journal of Business Studies, 4(3).

Simpson, M. and Tuson, J. (1995). Using Observations in Small-scale Research: A Beginner's Guide. Edinburgh: SCRE.

Staats, B. R. and Upton, D. M. (2011). Lean knowledge work. Harvard Business Review, 89(10), 100-+.

Stuart, I., McCutcheon, D., Handfield, R., McLachlin, R., and Samson, D. (2002). Effective case research in operations management: a process perspective. Journal of Operations Management, 20(5), 419-433.

Su, N. M., Brdiczka, O., and Begole, B. (2013). The routineness of routines: Measuring rhythms of media interaction. Human-Computer Interaction, 28(4), 287-334.

Thomas, B. E. and Baron, J. P. (1994). Evaluating knowledge worker productivity: literature review. Interim Report, No. FF-94/27, USACERL, pp. 1-27.

Tucker, A. L. and Spear, S. J. (2006). Operational failures and interruptions in hospital nursing. Health Services Research, 41(3), 643-662.

Voss, C., Tsikriktsis, N., and Frohlich, M. (2002). Case research in operations management. International Journal of Operations \& Production Management, 22(2), 195-219.

Yin, R. K. (1994). Case study research: Design and methods. Thousand Oaks: Sage Publications.

Óskarsdóttir, H. G. (2014). A Mapping of an Agile Software Development Method to the Personal Productivity of the Knowledge Worker a Systematic Review of SelfHelp Books. Thesis. Faculty of Industrial Engineering, Mechanical Engineering and Computer Science, University of Iceland, pp. 158.

