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# ROUTINE KNOWLEDGE WORKER EFFICIENCY IN PHYSICAL WORKSPACES

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Abstract

The aim of the thesis was to investigate whether routine knowledge worker efficiency is affected by physical workspace layouts. This research was conducted for X-Index, a company selling, renting and designing workspaces. Though the majority of their workspaces are currently industrial and cater to the manual worker, the authors wanted to provide X-Index with answers on office workspace design and its connections to employee efficiency. This will consequently help X-Index develop their business towards also catering to companies employing knowledge workers.

The research was quantitative, involving an experimental method through which a real-life simulation of knowledge workers in different workspaces was conducted. Workspace designs were narrowed down to closed, open and team orientated spaces. Efficiency on an individual level was measured through quantity and quality of executed tasks as well as timeline. The simulations were conducted on 24.3.2014 in the JAMK Dynamo campus. A statistical analysis of the data was then conducted through SPSS and Excel.

The results of the research indicate that there is significant change in knowledge worker efficiency in the three different layouts and patterns emerged. While timeline was shortest (thus the best) in the closed office layout it was the worst in the team space. On the other hand, the results of quality improved in the team space when comparing to the other two layouts. Participants performed better in the closed office layout in terms of quantity.

Comparing the results to the theoretical background, the authors suggest that certain factors such as communication, concentration and the level of task interdependence can be attributed to the changes in efficiency in the different workspace layouts. The authors have thus compiled a series of statements/questions to aid companies and X-Index in designing workspaces or combinations of workspaces for possible clients in a new field.



Keywords

closed office, employee efficiency, knowledge work, open plan office, team space, workspace


Miscellaneous

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Tiivistelmä
Opinnäytetyön tarkoituksena oli tutkia vaikuttavatko fyysiset työtilaratkaisut tietotyöntekijän tehokkuuteen tämän suorittaessa rutiininomaisia työtehtäviä. Tutkimus toteutettiin X-Indexille, toimitilavälittäjälle joka myy, välittää sekä suunnittelee toimitiloja. Yrityksen pääpaino on tällä hetkellä teollisissa toimitiloissa ja täten se palvelee manuaalisen työn tekijöitä. Opinnäytetyö laadittiin tarjoamaan vastauksia toimitilasuunnitteluun ja sen yhteyksistä työntekijän tehokkuuteen. Vastausten avulla X-Index voi kehittää toimintaansa palvellakseen myös tietotyöntekijöitä työllistäviä yrityksiä.

Opinnäytetyön tutkimusosuus toteutettiin hyödyntäen kvantitatiivista menetelmää, sisällyttäen kokeellisen osuuden, jossa tietotyöntekijöiden tehokkuutta mitattiin erilaisissa työympäristöissä. Opinnäytetyötä sekä kokeellista osuutta varten toimitilat rajattiin kolmeen erilaiseen ratkaisuun: suljettuun työtilaan, avoimeen työtilaan sekä ryhmätilaan. Yksilön tehokkuutta kyseisissä toimitiloissa mitattiin määrän, laadun sekä aikajanan kautta.

Koe-tilanne toteutettiin 24.3.2014 Jyväskylän Ammattikorkeakoulun Dynamo-kampuksella, ja kerättyä tietoa analysoitiin tilastollisesti SPSS:n sekä Excelin avulla. Tutkimuksen tulokset osoittavat tietotyöntekijän tehokkuudessa merkittävän eron kolmen eri toimitilan välillä. Suljettu työtila oli ajankäytön kannalta paras kun taas ryhmätyötila osoittautui ajallisesti kuormittavimmaksi. Työn laadun kannalta ryhmätyötilassa saadut tulokset paranivat verrattaessa suljettuun tai avoimeen työtilaratkaisuun. Määrällisesti parhaimmat tulokset tulivat suljetussa työtilassa.

Verrattaessa opinnäytetyön teoreettista osuutta koe-tilanteesta saatuihin tuloksiin, voidaan tietyillä tekijöillä kuten kommunikaatiolla ja keskittymisellä olettaa olevan vaikutusta tehokkuuden muutoksiin eri työtilaratkaisuissa. Yrityksen kannalta oikeanlaisen työtilaratkaisun valintaprosessin ja -perusteiden tueksi kehitettiin kyselylomake-työkalu, joka helpottaa tehokkaimman työtilan (tai työtilayhdistelmän) valitsemista huomioiden yrityksen tarpeet.

Avainsanat (asiasanat)

avokonttori, henkilökohtainen työtila, ryhmätyötila, tietotyö, työtehokkuus, työtila

Muut tiedot

# Contents

# 1 Introduction

This thesis investigates whether workspace layouts have an effect on knowledge worker efficiency. It concentrates on the different types of workspaces where a knowledge worker generally works and on the different characteristics of different types of workspaces that aid or hinder knowledge worker efficiency. The way in which a knowledge worker works and the type of work executed are discussed and categorization of knowledge workers is presented at a theoretical level, while workspace layouts are narrowed down to three different layouts: closed office layout, open plan office layout and team space. The research is further narrowed down to only include the efficiency of executing routine tasks in the theoretical background. Different theories coined by researchers for measuring knowledge worker efficiency will be presented.

As the design of workplaces is affected by the needs of the employees and impacts the ways in which they work (Steiner 2005, 7) it is crucial to find out whether employees', in this case knowledge workers' performance in terms of efficiency is affected by the type of workspace layout. Knowledge workers are distinctive in that the use of knowledge and information are in a central role in their jobs (Ian Brinkley 2006, 13). The efficiency of knowledge workers is challenging to measure due to the lack of standard ways of working, production times or rigid tasks (Ramirez & Nembhard 2004, 603). Factors such as lighting, plants, colors and ergonomics of furniture are seen as contributors to the overall comfort of employees in a workspace (Vischer 2007, 69-71), thus also supporting them in their daily activities. It remains unclear as to which workspace is the most efficient, and there is no clear consensus on the matter.

A real-life simulation of knowledge workers who execute routine tasks in the three workspace layouts was conducted. A sample of students who can be regarded as future knowledge workers was used in the experiment.

The motivation for this thesis comes from the background of studying Facility Management, where the authors have had the chance to experience different innovative workspaces. Generally researchers believe that the knowledge

workers and the maximization of their efficiency is the next key asset for companies operating in the 21st century. A universally accepted tool to measure knowledge worker efficiency has not yet been created and the authors try to develop the situation by constructing a measuring tool on the basis of the theoretical background.

The need for the thesis arose from X-index, a real-estate company planning, building and selling facilities for client companies operating in different fields. At the moment, the company is conducting business with industrial companies and providing them with workspaces and storage facilities. Thus their workspaces cater more to the needs of manual workers. However, because the knowledge economy has grown, the authors aim to provide X-Index with an insight into office spaces in order help the company to expand their business operations to also provide office facilities often used by knowledge workers. The end product of the thesis can be utilized by the company to develop their operations and to understand the needs of the white-collar industry. Although this thesis was primarily conducted based on the needs of X-Index, the authors suggest that the results can be applied by any company trying to increase knowledge worker efficiency through workspace design. The thesis is structured not to include X-Index in the research design. The authors try to provide an outsider's point of view and suggest new possibilities for the company in the field of office facilities and whether the design of workspaces actually needs to be taken into account.

The research problem is that employers (or X-Index) do not know if they should take into account the workspace layout when aiming to maximize the efficiency of knowledge workers. The thesis explores if workspaces play a part in the efficiency of knowledge workers. Thus the objective is to help employers and real-estate companies such as X-Index (when planning and distributing workspaces) to decide whether to take into account workspaces when promoting employee efficiency. Consequently the research question is the following:

- Does routine knowledge worker efficiency vary in different workspace layouts?

The objectives of the thesis are to find out the following:

- What is a knowledge worker and what is knowledge work?
- What is knowledge worker efficiency?
- How can knowledge worker efficiency be measured?
- Do workspaces have an effect on knowledge worker efficiency?
- What factors in workspaces have an effect on knowledge worker efficiency?

The study was organized into three stages: data collection, data analysis and data interpretation, consequently connecting the empirical data to the initial research questions and reaching ultimately to the conclusions.

This thesis applies a quantitative research method, and the research strategy used is deductive. The research approach is experimental. The authors take on an objective role in the thesis. The implementation of the research involves statistical analysis through SPSS and Excel.

# 2 Knowledge work

To better understand the term knowledge worker, one should first familiarize themselves with the concept of "knowledge economy" as its workforce comprises of knowledge workers. The knowledge economy changes the means through which a company is able to create tangible and intangible values and at the core of it all is knowledge:

> *Essentially, it [the knowledge economy] refers to a transformed economy where investment in 'knowledge based' assets such as R&D, design, software, and human and organizational capital has become the dominant form of investment compared with investment in physical assets – machines, equipment, buildings and vehicles. Thus, the term 'knowledge economy' captures the subsequently changed industrial structure, ways of working, and the basis on which organisations compete and excel.* (Brinkley, Fauth, Mahdon, Theodoropoulou 2009, 9.)

The graph in Figure 1 below portrays the rise in percentage of different services in the EU15 (: the countries in the EU prior to the accession of 10 more countries in 2004 which include Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands,

Portugal, Spain, Sweden and the United Kingdom). OECD categorizes knowledge based services as including financial and business services, communications, health and education services (Brinkley 2009, 8).

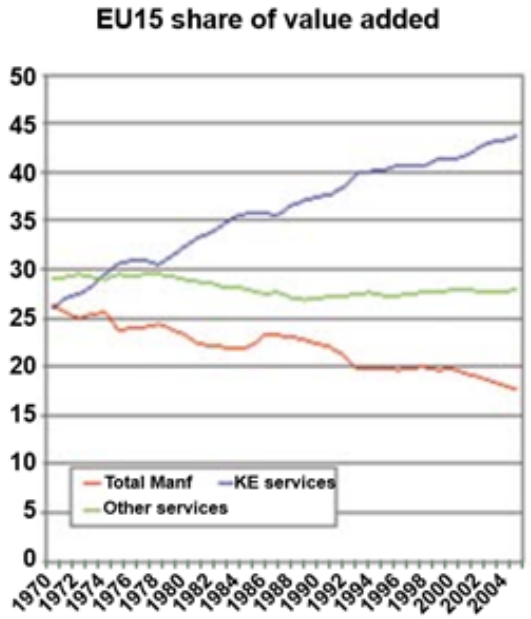



Figure 1. The rise of knowledge -based services 1970-2005 based on the OECD categorization of Knowledge Economy services (Brinkley 2009, 8)

As the knowledge economy has grown, the term knowledge worker has become more relevant. The term was first mentioned by Peter Drucker in 1959. Years later, after industrial developments, knowledge workers are seen as key assets in organizations. According to Dul, Ceylan and Jasper (2011, 715) Richard Florida (2005) regards knowledge workers as “the creative class”. Knowledge work differs from material-based manual work in that it is information-based and usually requires the processing of information from one form to another, thus often creating intangible results. A knowledge worker uses their mind as the means of production and the work being done is “invisible”. (Nickols 1999, 4-5.)

Prior to this, the process of work started from taking instructions and converting them into actions which then resulted in materials transforming

from one form to another. It has since changed to knowledge-based working where knowledge is transformed into actions, consequently altering the control over tasks being executed. The control has shifted to the worker conducting the tasks. Because of the nature of knowledge work, it is a challenge for managers to supervise and control the workforce as well as measure the efficiency of the work being done. (Nickols 1999, 5-8.) Knowledge workers have become crucial in the creation of innovation in organizations (Davenport, Thomas & Cantrell 2002, 23) and are consequently essential in helping companies compete in the 21st century.

Because a knowledge worker's main tool in the work process is knowledge, it is important to understand the term. Davenport and Prusak (2000, 4) offer the following "working definition" for knowledge:

> *Knowledge is a fluid mix of framed experience, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the mind of the knowers. In organizations it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices and norms.*

From this definition it can be concluded that knowledge can be articulated and recorded (Nickols n.d., 13) into for example documents or graphs. It can also exist in humans and can be used to produce an action (Davenport & Prusak, 2000, 5-6). Davenport and Prusak also state that "Knowledge derives from information as information derives from data." What knowledge workers do is find, create, distribute, package and apply knowledge so that it can be exploited for the benefit of the company. (ibid. 5.) Essentially knowledge work involves the use of various types of knowledge for problem-solving (Kidd 1994, 187), be it at an individual level or at an organizational level.

Companies nowadays have to deal with knowledge (Alavi & Leidner 2001, 113) that can be categorized into tacit, implicit and explicit knowledge (Nickols n.d., 13-14). Swan, Newell, Scarbrough and Hislop (1999, 264) mention that Levinthal and March (1993) state that companies have to aid the exploitation of knowledge (in different forms comprising of e.g. knowledge creation and knowledge sharing) inside the company through knowledge management i.e aid the knowledge workers' efficiency. Knowledge management is thus closely related to managing knowledge workers as well.

Tacit knowledge is knowledge which cannot, unlike explicit knowledge, be articulated into for example graphs, codes or texts. The essence of tacit knowledge is in knowing something but not being able to explain the essence of what one knows. Finally, implicit knowledge is the type which can be presented in a systematic way, but has not yet been articulated. (Nickols n.d., 14-15.) In other words, knowledge workers make use of knowledge in different forms to create both tangible and intangible results.

Because different types of knowledge workers use workspaces in differing ways (Greene, 2009) the exploitation of knowledge can be aided by the design of workspace layouts (Gensler 2013 U.S. workplace survey, 12-13). Consequently, knowledge workers need workspaces which support them in maximizing their work efficiency when centering the idea of increasing knowledge worker efficiency on conducting tasks.

## 2.1 Categorizing knowledge workers

In her speech "Design for thought: Designing for knowledge workers", Greene (2009) mentions that knowledge workers can be categorized into four different types according to how they move around the workspace or place. These types include: anchor, connector, gatherer and navigator. Each type of knowledge worker uses the workspace differently, especially in terms of mobility (Greene, 2009).

Greene states that anchors are the exemplary office workers. The term is further specified by Nenonen, Hyrkkänen, Rasila, Hongisto, Keränen, Koskela and Sandberg (2012, 14) as an employee who conducts most tasks in the office, often resorting to one's own workstation and only moving in between it and the functional facilities of the workplace. Because of their low mobility, they are central in maintaining the flow knowledge through workplaces. (ibid., 14.)

According to Greene, connectors spend their working hours in different premises around the workplace and interact with different departments. A practical example of this could be a product development manager, who not only needs to communicate with line managers, but also different departments (Nenonen et al. 2012, 14-15).

True to their name, gatherers acquire information from outside the workplace and bring it back to the office along with possible new contacts (15). Similarly the navigator works mostly away from the office according to Greene. In their publication, Nenonen et al. add that navigators are considered as visitors in their own offices and use a sales representative who spends most of his/her time with customers as an example. (15.)

Davenport (2005) provides a categorization of knowledge workers according to the type of work they do and how they exploit their knowledge to create value in an organization. The level of interdependence and complexity of work are used to distinguish the categories. The level of interdependence defines if the job is done alone or in a group and the complexity of work defines what type of work is being done and how knowledge should be used to execute work successfully. Knowledge workers can be divided into four categories as can be seen in Figure 2. (Davenport 2005, 26-28.)

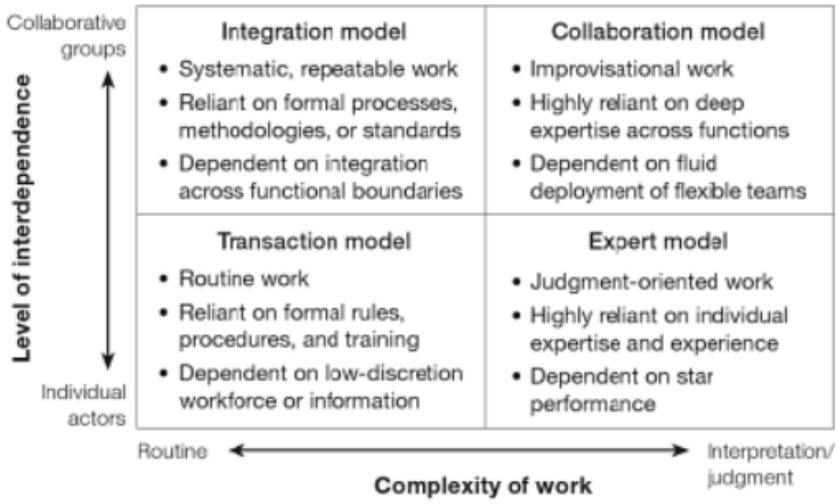



Figure 2. Knowledge worker categorization matrix (Davenport 2005, 27)

Employees included in the expert and collaboration -models in Davenport's categorization perform work which allows or needs creativity and a high level of expertise. While knowledge workers in the collaboration model work in teams employees pertaining to the expert -model prefer to work alone and

regard their own individual knowledge as the most important. (Davenport 2005, 27-28.)

This thesis however, focuses on Davenport's two categories of knowledge workers conducting routine tasks i.e. the integration and transaction –models. The thesis has been narrowed down to these two categories in order to simplify the implementation of the research. Because of the complexity of work being done by knowledge workers in the other two categories and the intangible nature of knowledge the efficiency of the tasks being conducted is easier to measure in routine knowledge work.

Employees categorized in the transaction model mostly conduct routine work that is tied to rules and procedures. This suggests that the job is linear and involves predictable actions. Davenport (2005) presents a call center worker as an example of the transaction category. Call center workers who follow precise guidelines set by the company or superior when engaging in tasks such as customer service can be regarded as executing routine work. (26.)

An integration worker is similar to that of the transaction model in that their work is routine-like. The difference however is that integration workers often reuse knowledge. They are encouraged to store explicit knowledge on for example computer databases so that an organization may benefit from it at a later point. These types of knowledge workers often work in groups and need to integrate with different departments inside a company. (Davenport 2005, 27.) It could be concluded that because the processes included in tasks are fairly similar for each knowledge worker in these two categories the process of executing tasks i.e. the input becomes irrelevant and emphasis and importance is on the output.

Aarons, Linger and Burstein (2006) present a counterview to Davenport's model. The table in Figure 2 assumes that all knowledge work can be categorized into four different models, ignoring types of knowledge work that stretch across boundaries. Aarons et al. argue that though the model works as a technique for classification, it does not take into account knowledge work contexts and their complex nature. (ibid., 2.) Davenport (2005, 28) also mentions that his categories in the matrix cannot cover the complex nature of the processes involved in knowledge work.

Burstein and Linger (n.d., 132) state that a knowledge worker may apply different “Bodies of Knowledge” when performing different tasks, thus categorizing the work being performed. A body of knowledge comprises of the experience and know-how of performing a task, but it is also important to take into account the way in which this experience and know-how is applied for different tasks. Four bodies of knowledge that are applied according to the activity being performed can be categorized: routine knowledge, creative knowledge, professional knowledge and craft-like knowledge. Whereas routine and craft-like knowledge are related to tasks of low variety, creative and professional knowledge are linked to tasks involving less predictability. (ibid.)

Burstein and Linger (n.d.) move on to represent a model of work focused on the task of knowledge workers. Though the model integrates the actual execution and outcome of the task i.e. the pragmatic layer to a conceptual layer where thinking, and processes and structure of the task are taken into account, this study only concentrates on the pragmatic layer, especially on the outcome of tasks. The outcome of the task can be regarded from an organization’s point of view or an individual’s point of view, thus changing the scope of the outcome. (138-139) This study focuses on the outcome of the tasks at an individual level when conducting routine work. Efficiency at an organizational level will not be included.

Knowledge workers are defined by the way in which they work, the nature of their task, their use of knowledge and their roles in companies. The problem is that the efficiency of knowledge workers is challenging to measure due to the nature of the work (Ramirez & Nembhard, 2004, 603). Before understanding how to measure knowledge worker efficiency, one must first understand efficiency as a term.

# 3 Defining efficiency

Heyne defines efficiency as follows: efficiency is the ability to produce something without wasting materials, time or energy (2008). In other words, efficiency is a measure of what can be achieved in comparison to what is actually being produced by utilizing the same amount of resources.

Another measurement of input in relation to output is productivity. The definitions of efficiency and productivity are much alike as they are both output based, but differ in the amounts of time consumed or resources. Whereas productivity is filling quotas and completing tasks within the given lines of conduct, efficiency is achieved by performing in a way which overcomes the expectations in terms of time and/or resources.

Productivity is defined as "the relation between output and input" (Tangen, 2002, 1; Bosch-Sijtsema, Ruohomäki & Vartiainen 2009, 536) suggesting that the difference between efficiency and productivity is quantity based. Whereas efficiency is linked to the consumption of materials in relation to time (the lesser amount of time spent and materials used, the higher the level of efficiency), productivity is based on numbers demonstrating that the more production delivered in a certain amount of time, the higher the level of productivity. (Tangen, 2002, 1-3.) In other words, a certain task can be performed in an X amount of time by utilizing a Y amount of materials but it does not necessarily have to be efficient in order to deliver the results. However, if the same process is completed utilizing a lesser amount of time and/or resources, the process has been delivered efficiently. For this research, materials are excluded from the definition of efficiency. Efficiency in this study is defined as the nature of the output (quality and quantity) and the output in relation to time. Efficiency is considered an important element when determining productivity and the two are dependent on environmental (workspace) effects on workers' ability to perform tasks.

# 4 Workspace

Bosch-Sijtsema et al. (2009, 541) mention that Vartiainen, Hakonen, Koivisto, Mannonen, Nieminen, Ruohomäki and Vartola (2007) state that workspaces are integrated into a workplace. Workspaces in which knowledge work is

conducted can be categorized into physical, mental, social and virtual spaces. An office is an example of a physical workspace. Virtual workspaces integrate information technology and involve collaboration in between employees through for example e-mails or intranets. Social workspaces are areas where people meet in and interact: coffee rooms or meeting rooms are examples of social spaces. Mental workspaces are individualistic and are internal. The mental workspace includes feelings and thoughts that help shape a knowledge worker's perceptions and interpretations of spaces. (Bosch-Sijtsema et al. 2009, 541.) This thesis focuses on physical workspace layouts as they are tangible and because the co-operating company designs and executes physical workspaces. Because of the tangibility of physical workspaces the results and effects on knowledge worker efficiency are empirically examined and analyzed.

A workspace design or layout is selected by the level of open space used in relation to closed space. The main factor dictating the type of a layout is the amount in which physical elements, the existence of walls and doors, as wells as movable elements such as furniture and space dividers, for example, create the characteristics of each of the layout styles. By adjusting the level in which physical elements are used to cut the space into smaller areas, the workspace layout changes. A space where numerous physical elements are used to cut a larger space into small private areas is called a closed office layout. On the other end of the spectrum is a space, where the usage of walls and doors, as well as space dividers is kept to the minimum, which is called an open plan layout. Team space, by name, is a space shared among more than two people. As the team space is a separate space for a team, the usage of physical elements to cut the area out of the existing larger space, is used in order to create separate areas for groups of people to conduct work in. In order for workers to perform tasks in an efficient manner, they need proper facilities and a suitable office layout structures that supports the actions required in conducting work (Gensler 2013 U.S. workplace survey, 12-13).

There are a number of different kinds of workspaces or working environments that are designed to support the actions required in performing certain tasks, some more physical or demanding than others, and to suit the needs of the employees in delivering those specific routine or non-routine tasks. Nevertheless, workspaces are an essential element in the process of delivering

work and in being efficient in the chain of actions required. Therefore, the workspaces need to be designed accordingly. The working environment needs to both facilitate and support the nature of the work performance by providing spaces with suitable office layouts that support the assigned task in terms of privacy, concentration and communication, to mention a few (Gensler 2013 U.S. workplace survey, 12-13).

In this study, the emphasis is on the various kinds of office settings within the corporate world as knowledge workers (also known as white collar workers) are associated with an office setting much due to the generalized job description. The thesis in question will further define and elaborate in more detail the various types of workspace designs in the business world. Therefore, as the purpose of the thesis is to study whether the efficiency of a knowledge worker is affected by the workspace design, the emphasis will be on the corporate setting. Educational workspace designs, and the effects those spaces have on employee efficiency, were left out of the study.

# 5 The source of efficiency in physical workspaces

Managers make constant decisions regarding workspaces by reflecting on environmental factors. Vischer (2007) suggests comfort as a key environmental factor that establishes efficiency in workspaces. (62.) Factors that to some extent – some more than others – are suggested to have an effect on the workers' ability to perform in an office setting, or in a working environment of any kind, can be divided into three categories according to Vischer. (2007, 68-72) The three categories are linked to Maslow's hierarchy of needs. Environmental factors affecting efficiency such as safety, lighting and control over the workspace can be seen as the basis of comfort, thus making comfort the basis for efficiency (Vischer 2007, 69-71).

According to Vischer's study (2007), over the years the building users' needs and satisfaction regarding the space in question has become an essential element in assessing and optimizing employee performance. Thus a need to analyze and measure employee satisfaction has risen and the three following categories of comfort have formulated: Physical Comfort, Functional Comfort

and Psychological Comfort. (62-76.) In her study, Vischer (2007) suggests that the first, physical comfort is the main key as it withholds elements such as the basic needs: the safety of the building and employees' sense of being safe working within the premises, for example need to be primarily addressed. It also stated that the buildings need to be easily accessible and other basic factors to ensure occupant's safety such as hygiene, for instance, must be taken care of in order to assure an operative environment. Without the basic needs being met, other levels of comfort can be pursued but in order to ensure better performance, the "fundamentals" need to be sorted first. (ibid.)

Functional comfort, suggested by Vischer's research, is the "environmental support for the activities" employees need in order to perform in the assigned tasks. Factors that help ensure functional comfort are, for instance, suitable ergonomic furniture, adequate lighting and the availability of an appropriate type of working environment (private office, open plan etc.) needed in performing the specific tasks in terms of concentration, communication and tools needed in the delivery process. (Vischer 2007, 68-69.)

Last, psychological comfort links the worker's satisfaction with the workspace. Employees' likes, dislikes, feelings and the sense of control and privacy, in addition to the solutions made in the interior design, such as indoor plants and wall colors and other decoration can have a psychological effect on the workers motivation and efficiency, as suggested by Vischer's study. (Vischer, 2007, 62-76.)

The relations of the three dimensions are displayed in Vischer's chart, in Figure 3 (2007, 69.) According to Vischer, the "Habitability Threshold" makes a division between the "minimally physically comfortable" space to work and the space where it is too uncomfortable to conduct any work. The well-being and comfort of (knowledge) workers can be linked to their efficiency. As the different levels of comfort are met, the efficiency of individuals increases. (69.) Workspaces include different attributes through which they support the efficiency of teams, groups and individuals (Vischer 2007, 70).


Figure 3. Ranges of comfort (Vischer 2007, 69)

# 6 Workspace layouts supporting efficiency

Worker comfort affects operational efficiency as well as productivity through for example job satisfaction and employee health according to Clements-Croome and Baizhan (2010, 633). This seems to suggest that comfortable workspaces are at the center of efficiency. Gibbs states in his article of "5 Highly Efficient Office Layouts" (2012) that in the planning process of office facilities, in addition to the style and appearance that effect on the overall image of a company, one needs to consider the layout of the particular premises in order to provide a space where the employees are able to perform at "optimum capacity". In order to provide an efficient workspace design, one must first understand the variable factors that can affect the worker's task performance depending on the office layout. The type of business often gives a direction to what kind of an office design would be optimal for a given company, considering the amount of information that needs to be shared in the office daily. According to Vischer (2007, 62) most companies nowadays combine more than one workspace layout and changes on the premises are frequently conducted in pursuing a more efficient workspace.

In his article, Gibbs claims that the five highly efficient workspace layouts are Modular Workstation Layout, Cluster Workstation Layout, Landscape Layout, Open Plan Layout and Traditional Closed Office Layout. (2012) In this study, emphasis will be on the open plan layout and closed office layout presented by Gibbs. A third layout is created by combining the characteristics of an open plan layout with the closed office, consequently creating a team space. The team space can be regarded as an open plan layout from the knowledge workers' point of view as they are able to communicate with each other in one shared space. On the other hand, it is a closed layout in terms of one single task being executed in a closed space.

A closed office layout is generally described as an enclosed room for a single person that allows the worker some privacy and the ability to concentrate regardless of the noise outside. The closed office setting also provides the worker with a space in which to conduct tasks that require confidentiality or in which to arrange meetings. (van Meel, Martens & van Ree 2010.) Gibbs (2012) argues that it is important to have at least some closed offices in the overall office setting of a company, in order to create employee hierarchy and a status structure. A partially closed office layout can also motivate workers to deliver better results in order to climb up the corporate ladder by obtaining a closed office of their own.

Although the physical existence of walls and doors can affect the flow of information and communication negatively, it also provides several benefits. "Knowledge workers prefer closed offices, but seem to communicate better in the open ones" (Davenport 2005, 167). According to Brand and Smith (2005, 819) closed offices allow for better concentration as the physical elements of the office layout block out any excess noise or other distractions and variables that could have a negative effect on the workers performance during task execution . According to Vischer (2007), McCusker (2002) states that the type of personality of the worker, in this case a knowledge worker, has an impact on how the worker reacts and responds to the changing workspace design. Unlike introverts, extroverts respond more positively to the open office concept and to the possibilities the particular office form provides. The level and ability to respond to a certain type of office setting together with the worker's

personality, affects the workers' efficiency, thus explaining why extrovert personalities seem to do well in the open plan office settings. (68.)

According to Davenport (2005, 166) a workspace design can encourage the way people behave and act, without never actually guaranteeing a chance in behavior. Nowadays, the common trend within the corporate world in terms of space is to adjust and re-design offices to support the open plan layout by decreasing the amount of closed private offices (Kim & de Dear, 18). The open plan layout enhances employee performance, providing workers more open space to facilitate collaboration and to increase the amount of interactions among colleagues (Kim & de Dear, 2013, 18; Brand & Smith, 2005, 818). However, the findings of the 2013 U.S Workplace Survey by Gensler state that 53% of the sample size of 2035 knowledge workers, struggle to focus due to being disturbed by others. (2013, 8.) Gensler's finding's provide a strong counter view to the common assumption at workplaces today that open plan layouts are superior when considering employee efficiency.

Due to the nature of the work, a knowledge worker is able to work regardless of the space (but not necessarily always in the most efficient manner) as the work is conducted using one's brain. The work a knowledge worker engages in could include creative tasks such as writing, thinking and designing which allows mobility in the work itself and thus enables the knowledge worker to work for example from home. However, according to Davenport (2005, 34) this is not an ideal setting for a knowledge worker, although flexibility is something every worker appreciates at some point. Davenport states that permanent or semi-permanent absence from "the real office environment", causes difficulties in the social aspects of the work as communication, the flow of information and building social capital are likely to suffer from telecommuting. (ibid.)Researchers seem to have differing views on what is an efficient layout for knowledge workers.

# 7 The three office layouts: from closed to open, to team orientated space

In the following thesis, the effects of a closed office layout, an open plan layout and a team space are analyzed and this section explains the various factors

affecting a knowledge worker's efficiency to perform tasks in the three particular workspace settings in more detail. In addition to the traditional closed office setting, shared offices and cubicles can also be categorized as closed office layouts. Van Meel et al. (2010) define a shared office as a closed workspace seating two to three people that allows employees to concentrate (not necessarily as well as in the private offices but still to some extent in comparison to open plan layout) due to the physical elements of blocking distractions. The shared office, i.e. the team space enables collaborative tasks as it provides better flow of information and the support of colleagues sitting close by thus facilitating communication and the exchange of knowledge. However, Banburry and Berry (2010, 26) mention that Langdon (1966) suggests that a downside to employees working in the same space is that constant collaboration and communication in between the people can create extensive noise, which in turn may result in annoyance between the workers. This could especially be negative if the dynamics of the individuals in the workgroup differ. Brennan, Chugh and Kline (2002, 285) point to confidentiality as a potential issue due to the sharing of the same office premises. The authors of this thesis consequently suggest that negative tensions between the co-workers can cause issues in communication and further result in lower levels of motivation and efficiency. The ability to concentrate on individual tasks can be dependent on the people sharing the office. This statement is supported by the results of Gensler's survey (2013, 8) which indicate that more than half of the participants included in the survey were disturbed by noise of others working in the same space. On the contrary, discussions with colleagues might bring forward creativity.

An open plan layout is defined by van Meel et al. (2010) as an open area for more than ten people to work in. It is described as an area that allows a constant flow of information and is thus suitable for tasks and activities that require little concentration, as routine tasks generally do. Despite the noise, distractions and the lack of privacy the particular model creates, it is perceived as a structure that enforces teamwork and collaboration (Gibbs, 2012). Gibbs (2012) also claims that the fact that the occupants of the space are not separated by walls or space dividers in individual sections or cubicles, and are therefore able to see others working, can be seen as an advantage and possibly

as a motivator towards efficiency. However, a counter view to this is provided by the findings of Gensler's Workplace Survey (2013), stating that the fact that employees are able to see each other working may not increase collaboration. This is due to the distractions, the visual pressure created by co-workers and the decrease in focus, issues that are increased because of the layout. In an open plan layout, more people are placed per square meter and thus the level of noise and other distractions increase eventually lowering the ability to focus and further affecting to the efficiency of the workers in that space. Gensler also compares the results of its surveys in 2008 and 2013 which shows that efficiency within workspaces has fallen by 6% since 2008, suggested to be the fault of open plan layouts. (8-9.)

In an open plan office layout, desks can be arranged according to the company's own liking but in his article Gibbs (2012) suggests that the landscape layout where the work stations are arranged in various angles diminishes a tight office structure and organization by creating a more relaxed atmosphere. According to Gibbs the landscape model is a mixture of two models: modular workstation layout and a cluster workstation layout. In the cluster office layout, based on his description, the desks are arranged to demonstrate the "spokes in a wheel", meaning that the desks are in lines connecting to "the central core". The modular office layout is formed when a set of movable furnishing and space dividers are used to cut a larger space into small individual work areas. Gibbs adds that a "hybrid approach" is popular among companies as it combines the two layouts creating a mixture of closed and open spaces bringing out the best of both layouts. (2012)

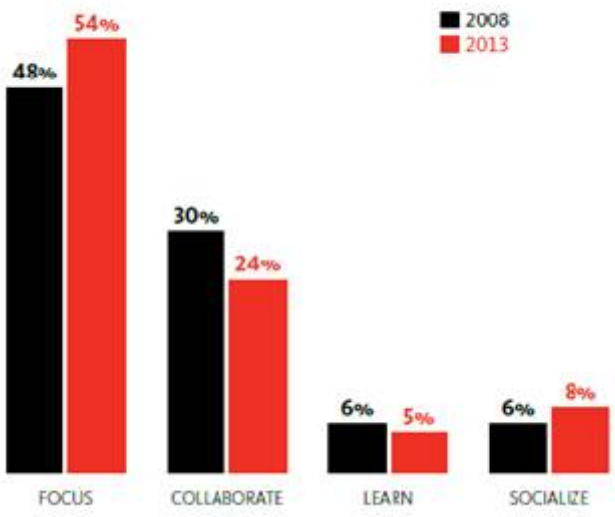
Further supporting the "hybrid approach" Davenport (2005, 170) claims that in order for knowledge workers to collaborate, facilities need to be strategically designed to include different types of spaces. This also ensures group communication and the movement of knowledge. "Particular designs can encourage certain types of behavior, although they will never guarantee it" (Davenport, 2005, 166) – a statement that according to Vischer (2007, 68) seems to support McCusker's findings (2002) that workers with extrovert personalities seem to perform significantly better than introverts in open plan offices. Therefore, spaces facilitating meetings and communication have an impact on the efficiency of introverts. The spaces also provide a separate area

out of the open space layout to concentrate on specific tasks. This and today's technology in mind, the availability of meeting facilities also play a significant role in video conferences and in other ways of telecommuting that are often addressed in firms today due to globalization. However, the "hybrid approach" presented by Gibbs (2012), where open plan layout is featured with private workspaces to provide privacy and the ability to concentrate with the creation of organizational structure and hierarchy, might prove more desired and optimal than one of the layouts alone in terms of employee efficiency.

The 2013 U. S. Workplace Survey was conducted to examine the factors that create an efficient workspace for knowledge workers. The results of the survey state that in efficient workplace, focus and collaboration are in balance (Gensler 2013 U.S. workplace survey, 8-11). In other words, suitable spaces to conduct work of a certain nature need to be available for the employee to choose from. According to Gensler (2013, 12-13) the fact that an employee is able to choose the right types of workspace keeping the nature of the work in mind results in higher job satisfaction, and further to high levels of performance and efficiency. This also supports the hybrid approach where a combination of both, open and private areas for working are utilized (Gibbs 2012.) This together with the findings of the 2013 U.S Workplace Survey suggests that the workspace layout does have an effect on the efficiency of a knowledge worker.

Gensler displays the ratio of focus and collaboration in the United States in Table 1 (2013, 9) suggesting that the main key in the workplaces is the ability to focus, and collaboration comes second. By ensuring the ability for employees to focus, other ways of working are supported as well and thus efficiency in employee performance increases. The survey found that collaboration and the time consumed in interacting with others has decreased while focus has increased since 2008, as displayed in the figure.

Table 1. A comparison of statistics on the percentage of focus and collaboration during an average workweek in the USA in 2008 and 2013 (Gensler 2013 Workplace Survey, 9)




# 8 Knowledge worker efficiency and how to measure it

According Heyne's definition of efficiency (2008), an efficient employee is one who creates results utilizing a lesser amount of time and/or resources. For this research, materials were excluded from the definition of efficiency. The factors constituting efficiency in this study are the essence of the output and the output in relation to time.

The share of knowledge workers has grown along with companies changing their ways of working. Knowledge workers are developing into the largest group of the workforce (Ramirez & Nembhard 2004, 602) and with this structural change employee efficiency is becoming harder to measure. While the efficiency of manual work has been measured by throughput, output or for example units produced in a certain time period (Huang, Dismukes, Shi, Su, Razzak, Bohdale & Robinson 2003, 513), the efficiency of knowledge workers is more challenging to measure due to them not always having a standard way of working, production times or rigid tasks (Ramirez & Nembhard 2004, 603). Much of the reviewed literature included examples of how difficult it is to measure knowledge worker efficiency and both Ramirez & Nembhard (2004,

602) and Drucker (1999, 86) state that though some methods have been created by researchers, none are universally accepted.

Because there is no clear way of measuring knowledge worker efficiency, it also becomes harder for companies to manage their people and processes. Precise models for measurement could aid companies in for example determining best management styles. They could also improve the productivity of new technological systems (such as Total Quality Management –systems) or the selection of potential employees. (Ramirez & Nembhard 2004, 606.)

Researchers have come up with different methods for measuring efficiency, though none are regarded as universally accepted. According to Ramirez et al. (2004, 607) Mundel (1975) coined a conceptual method for measuring knowledge worker efficiency in which he included a series of questions that should be answered in order to create a measurable tool:

- What is the objective of the task?
- What outputs are needed to complete the task?
- How can the needed outputs be measured?
- What type of resources and how much of it/them are needed to produce the output?
- What is a feasible operating plan for the next time period?
- Can the measures used be replicated and standardized

Six key principles have been identified that determine knowledge worker efficiency. In addition knowing what the task is, a knowledge worker must have autonomy and control over their efficiency. In knowledge work, quality is the essence of output and is as important, if not more important than quantity of the output. Innovation is a key principle that should be continuous and always at the heart of knowledge work. The creative class requires constant learning and teaching. Knowledge workers should, like any other employee, be regarded as assets in a company. (Peter Drucker 1999, 83-84.)

Gil Gordon (1997, 2) adds four measures that can be applied when measuring knowledge worker efficiency, (though he uses the broader term "effectiveness"):

- quantity (the number of tasks or outputs that are completed)
- quality (how well a task is completed)
- timeline (how long it takes to complete a task)
- multiple priorities (how many different tasks can be simultaneously executed)

These four measures of efficiency can be regarded as relating to both the nature of the process and the nature of the tasks being executed by knowledge workers. It is important not only to think of the process of the work, but also of the end result (Gordon 1997, 3).

Along with outcome based measurement methods such as solely measuring the outcome, or the outcome in relation to the ratio of input, there are also some methods that highlight the procedure of the tasks being executed by knowledge workers. Multi-minute measurement (MMM) is mentioned as a simple method for measurement. It entails measuring the employee's activities during a certain time interval through reporting procedures. The employee reports on the tasks executed during certain intervals. (Ramirez et al. 2004, 612-616.) This of course has its weakness in that an employee's efficiency is affected when writing reports during certain intervals.

Reporting on quality and activity has also been used as a measurement tool. The underlying idea of this method is that certain activities such as thinking or acquiring information could increase the quality of work, thus also increasing efficiency. The weakness in this is that it may be difficult to keep track of the acquisition of information as processes such as thinking are intangible. Other methods include for example the Achievement method where employees are evaluated on the amount of tasks finished in relation to the tasks that were assigned. Interviews, surveys and peer evaluation have also been used to assess knowledge worker efficiency. (Ramirez et al. 2004, 612-616.)

The quality of work is being regarded as the most important contributing factor that should be measured according to Ramirez et al. However, this is not evident as it is not used in most methodologies and conceptual methods related to knowledge worker efficiency. Most methods are still related to quantity. (Ramirez et al. 2004, 618) Perhaps this is because it is easier to measure. None of the methods cover all the dimensions that should be taken into account in knowledge worker efficiency.

Because routine work involves following rules and guidelines which make the processes of executing tasks linear, measurements regarding the processes leading to the result are less important than the actual result. It can consequently be concluded that result based measurements such as quality and quantity could be used. Thus this research concentrates on output based measurements when measuring routine knowledge worker efficiency.

# 9 The central role of workspaces

After studying Davenport's and Burstein and Linger's categorization models as well as studies on workspaces, three key connections arise that helped the authors form a model for the role of the workspace in the efficiency of individual knowledge workers conducting routine tasks. These factors are the body of knowledge, the task and the type of knowledge worker. The body of knowledge affects the type of task being conducted and vice versa, thus they are dependent on each other. The type of knowledge worker is defined by both the body of knowledge being used as well as the type of task being conducted (as specific tasks require specific bodies of knowledge). In the model the workspace is seen as supporting the task, the way in which the body of knowledge is applied and the type of knowledge worker. This of course means that different types of knowledge workers may need different types of workspaces. As an example, spaces can support a knowledge worker in conducting their tasks and their use of the body of knowledge by enhancing communication or providing a quiet place in which to concentrate better. Other factors such as ergonomics and lighting are also seen as having an effect. (Gensler 2013 workplace survey, 8, 11-13; Vischer 2007, 68-69)

Though spaces enabling face-to-face communication may hinder concentration, they support the sharing of knowledge (Swan et al. 1999, 262), thus efficiency of knowledge workers in these spaces could be altered as they are able to acquire information regarding a task from their peers. According to Perkin and Kloeckner (2013) the employees at Google offices are more efficient when they can communicate with each other, but when walls block face-to-face contact communication and collaboration is hindered. This is why Google have what the company calls “neighborhoods” where people work on their own tasks in one same space and are able to see each other, thus facilitating communication.

The model derived on the basis of the theoretical background represented in Figure 4 is meant to be applied to the individual knowledge worker as at an organizational level, different tasks are being conducted in a variety of spaces using different bodies of knowledge.

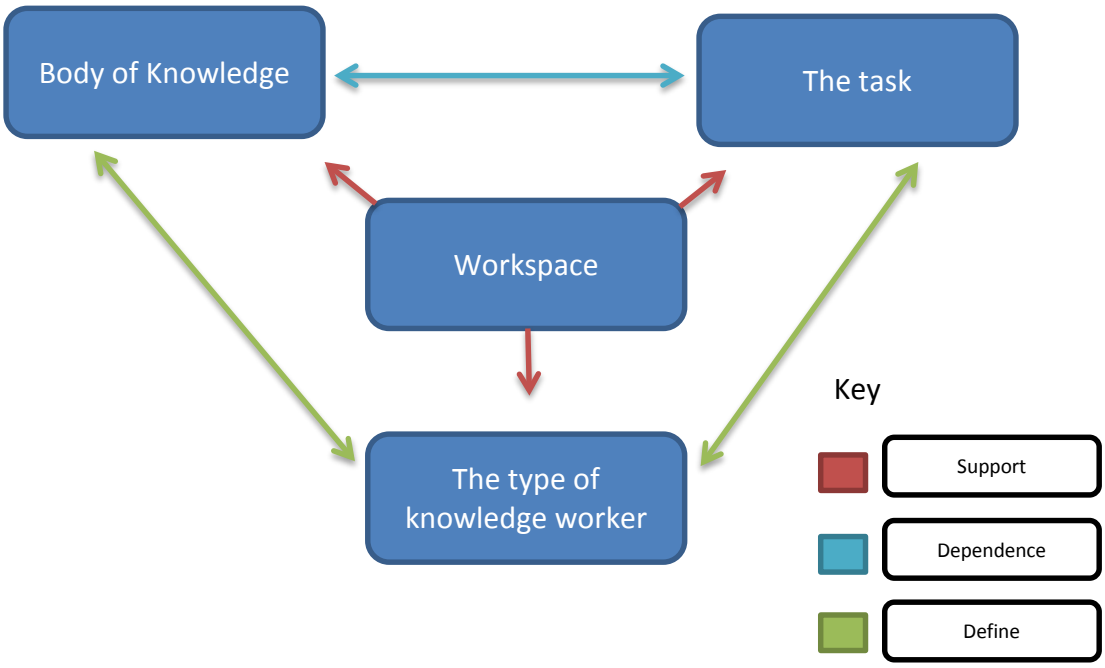



Figure 4. Workspace model: The central role of workspaces

# 10 Research implementation

The research question is to find out if knowledge worker efficiency varies in the three workspace layouts. The three categories were defined as closed office, team space and open plan office layouts. In order to help the authors answer the research question the following objectives were set:

- What is a knowledge worker and what is knowledge work?
- What is knowledge worker efficiency?
- How can knowledge worker efficiency be measured?
- Do workspaces have an effect on knowledge worker efficiency?
- What factors in workspaces have an effect on knowledge worker efficiency?

The research methods, strategy and approach have been narrowed down with the help of the "research process onion" seen in Figure 5. The research method is quantitative. The research method was chosen because through the quantitative research method, the authors are able to take on an objective, independent role, which prevents them from influencing, or being influenced by the phenomenon being studied (Sale, Lohfeld & Brazil 2002, 44) whereas qualitative research is more subjective according to McKereghan (1998, 1). As the research question is outcome-oriented and does not look to answer why a phenomenon is happening but rather whether there is a causal relationship in between two factors, quantitative data is more suitable than qualitative data (Anderson 2006, 2; Desphande 1983, 103). The authors' opinion is that gathering data representing actual measured results would best portray an answer to the research question.

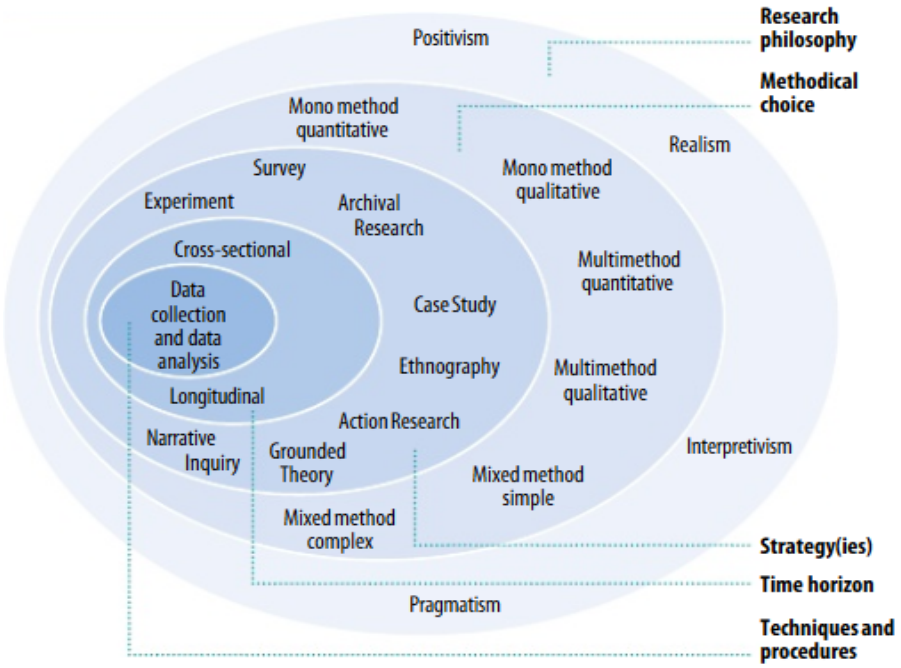



Figure 5. The Research Onion (Saunders & Tosey 2012, 59)

The chosen research strategy is a deductive strategy. The deductive research strategy has been chosen as it is often regarded as relating to quantitative research (Saunders et al. 2009, 125). The authors chose this method as it is a lower-risk strategy and it is also more suitable because it requires less time than most of the other strategies. (Saunders, Lewis, Thronhill 2009, 127.) The deductive approach to research is one in which the researcher explores earlier studies and existing theories of a phenomenon and then tests hypotheses that arise from the theoretical background. (Blackstone 2012) The researchers seek to prove or disprove a theory through the deductive approach (Saunders, Lewis & Thornhill 2009, 125).

The deductive research strategy is often compared to the inductive strategy as they are the opposite of each other (Denzin & Lincoln 2000, 100). The authors did not consider the inductive research strategy because according to Denzin and Lincoln (2000, 100-101) the inductive strategy starts by collecting data or observations and then analyzing it in order to make generalizations on a topic. The deductive strategy starts by deducing a theory, from which a research problem can be measured using quantitave methods (Saunders et al. 2009,

125), which is closer to the process the authors have undergone. The authors wanted quantitative, measurable data on an observed phenomenon.

The research approach used is experimental. The authors suggest that through the experimental approach statistical data of a real-life simulation on whether knowledge workers' efficiency in different office layouts changes while conducting a task can be collected instead of just acquiring assumptions and opinions through interviews or questionnaires. By using an experimental research approach, the authors are able to acquire actual measurement results of knowledge work efficiency. A statistical analysis of the acquired data was conducted because the intangibility of the work being conducted by knowledge workers may result in data on efficiency being harder to collect through for example action research or through questionnaires and interviews.

The results of each individual in the closed office, open plan office and team space are compared to their own results in the different spaces. Individuals' results are not compared to each other in order to exclude sources of error emerging from the differences in participants.

The research is conducted by acquiring a sample of 6 students who execute routine tasks in the three office layouts. Students have been chosen because they are unbiased towards working in a certain workspace. The students generally have no presumptions towards the nature of the tasks being conducted by knowledge workers and therefore have no standardized way of working in different spaces. It can also be deduced that they are future knowledge workers because of their line of education.

The sample size was small due to the lack of volunteers, but according to van Meel et al. (2010) the closed office layout is suitable for 1 person, the team space is suitable for 2-6 employees and the open plan office layout is suitable for more than 10 workers. Consequently, the sample size for the team space and closed layouts can be attributed to the actual amount of employees in the two spaces and the approximate sample size of 60% in the open plan layout.

## 10.1 Data collection

The experiment was conducted using six volunteers studying in fields that can be associated with future knowledge workers.  All participants were of the

same nationality, thus have the same educational background. In addition, the participants were near graduation. The task involved a sheet of paper in which there were relatively simple mathematical problems involving order of operations which required the use of mental arithmetic thus reflecting the type of tasks a routine knowledge worker engages in as there is a systematic linear way to solve the problem. For each of the workspace layouts, a different set of 15 questions was created which was solved by each individual. In other words, in each office layout the mathematical problems were of the same level of difficulty but were not the same questions. Every participant received a sheet with the same amount of problems. The math problems were standardized to include six digits. The problems were randomly selected from 60 overall problems for each layout. The simulation was executed in a classroom setting on 24.3.2014 at the JAMK Dynamo campus in Jyväskylä between the hours of 9 and 12. The simulation was conducted in the following order: open plan office layout, team space and closed office layout.

Three indicators were used to measure the efficiency of the tasks being executed: the amount of correct answers out of the total amount of problems, the amount of problems completed in a time interval of 5 minutes and the total amount of time it takes the participants to complete the entire sheet of mathematical problems. In other words, the experiment measures quality, quantity and timeline as factors of efficiency.

The test subjects solved different problems in each of the three workspace layouts. In each of the layouts the participants were the same. In the open plan office layout the questions were the same for each participant but the order in which the problems appear was randomized in order to create a more real-life simulation of an open plan office layout where employees often execute individual separate tasks, but communicate with each other about their respective tasks. Each participant had an individual workstation.

In the team space one sheet of calculations was conducted by two groups consisting of 3 participants so as to portray the collaborative nature of the work being executed in team spaces. Both groups were given the same problems and the simulation was conducted separately for the two groups.

In the closed office layout, every participant solved the problems individually in an enclosed space. When participants completed mathematical problems in the closed office layout they all had the same problems appearing in the same order as the task is conducted individually without consulting other participants.

Math problems were chosen as the task because the research question was narrowed down to knowledge workers executing routine work. Math problems include linear rules that should be followed in order to produce the correct answers thus portraying the nature of routine tasks executed by knowledge workers.

As there is no universally accepted tool to measure knowledge worker efficiency, a tool has been constructed on the basis of theoretical background for this research. The tool consists of three output based measurements utilizing methodology from Key Performance Indicators (KPI). The measuring tool includes quality as it is seen as the most important factor when measuring knowledge worker efficiency. Quantity is used an indicator because it is the most commonly used measurement as is suggested by the theoretical background. Timeline was chosen as a measurement due to the connection it has with efficiency.

Quality: the amount of correct answers out the total number of questions

Quantity: the amount of problems in 5 minutes.

Timeline: the amount of time it takes for the individual to complete the task

A pilot test was conducted so that a timeframe for the experiment could be set and the information was needed in order to reserve the classroom and inform the participants of the timing. The simulation was conducted in order to test the time it took for an individual to complete all the tasks. In addition, the amount of problems completed in 5 minutes (: quantity) as well as the amount of correct answers out of the total number of questions (: quality) was measured.

## 10.2 Data analysis

The efficiency of knowledge workers at an individual level in three different workspace layouts was compared using the IBM SPSS Statistics 2.1 and Microsoft Office Excel 2013 in order to derive a probability-value (P-value). SPSS was used to test the normality of the data. The homogeneity of the variances and the repeated measures ANOVA-statistical test were conducted using Microsoft Office Excel 2013. In order to conduct the parametric test (repeated measures ANOVA-test) the data had to be normally distributed and the variances homogenous. Because the assumptions required adhered for the data (see Table 12 & Table 13), no further modification was needed. Because the data was measurement based rather than frequency based and because the data analysis involves finding differences between one or more factors (measurements of efficiency) affected by one variable (workspace layout), a variance analysis had to be made. The test type was narrowed down to the repeated measures ANOVA-test due to the samples being dependent on each other, i.e. an individual's response to each of the conditions (workspace layouts) was compared. According to Ellis (1999, 556), Cohen (1988) states that the repeated measures ANOVA-tests are especially suitable for small sample sizes.

A statistical test was conducted because all knowledge workers in the world could not be taken into account. Thus with the help of a statistical test and a sample group, it was possible to find out whether the results are generalizable. The statistical test includes two hypotheses: the null hypotheses (H0) and alternative hypotheses (H1). H0 in P-value statistical tests is always "no affect" or "no change" whereas H1 is always "has an affect" or "there is change". The collective results of the three measurements (quality, quantity and timeline) in the three office layouts yielded three P-values when analyzed using a repeated measure design. The P-value represents the significance of the statistical difference of measurement results in the three office layouts and reveals whether the results can be generalized. The result appears as a decimal number which can be compared to the universally standardized P-value of 0.05 (5%) which is regarded as a reliable result. The closer the P-value is to 0, the more support the alternative hypothesis receives and the closer the P-value is to 1, the more support H0 receives.

The efficiency of an individual was measured through quality, quantity and timeline through the simulations of an open plan layout, team space and closed office layout. In order to acquire realistic results at an individual level in the team space setting, the quantity of tasks completed during the 5 minute interval was divided by the number of the group members. Following the same principle, the time in which the participants executed all tasks in the team space was multiplied by the number of the group members (3). The results had to be modified as SPSS does not detect that the results in the team space consist of a contribution made by three people.

## 10.3 Results

### 10.3.1 Quality

The results of quality measurements show that there is little variation in quality of individuals executing tasks in different spaces. The histogram (Table 2) supports the result.

Table 2. Measurement results of Quality

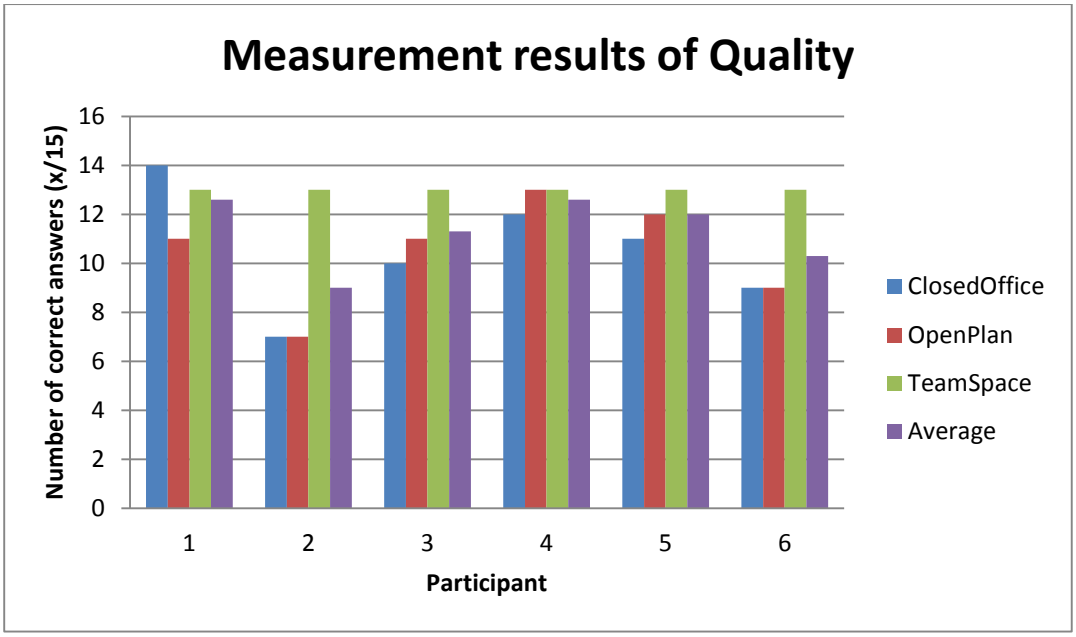



Table 3 displays the P-value of whether there is change in quality in different workspaces (: columns). Because P>0,05 (P=0,055126) the alternative

hypotheses (no change) is supported. Due to the P-value being extremely close to 0,05 a small stochastic change in the results could alter it towards P<0,05 making the results of quality statistically significant thus leading to the result that the efficiency when measured through quality of a knowledge worker is affected by workspace layout.

Table 3. P-vlaue representation of significant change of Quality in the 3 workspace layouts

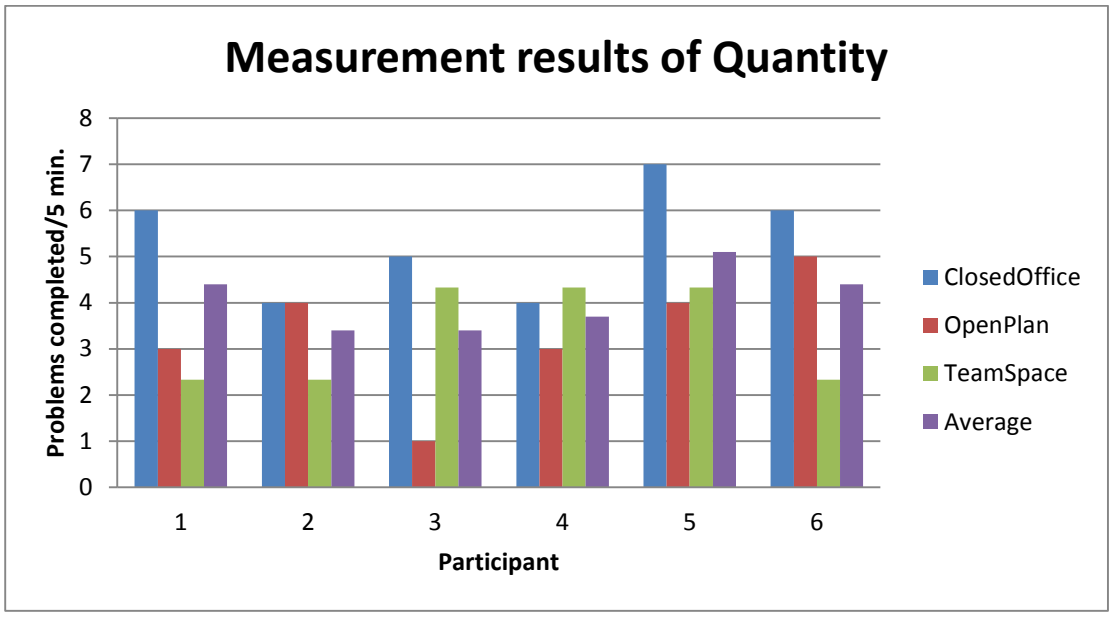
ANOVA

| *Sources of Variation* | *SS* | *Df* | *MS* | *F* | *P-Value* | *F-crit* |
|---|---|---|---|---|---|---|
| **Columns** | **25** | **2** | **12,5** | **3,537736** | **0,055126** | **3,68232** |

### 10.3.2 Quantity

The results of quantity show that there is significant variation between results in different workspaces. Table 4 displays the variation of quantity results.

Table 4. Measurement results of Quantity



The P-value represented in Table 5 shows that the change is significant because P<0,05 (P=0,018119). The P-value indicates that the null hypothesis (there is change) is strongly supported as the P-value is very close to zero.

Table 5. P-vlaue representation of significant change of Quantity in the 3 workspace layouts

ANOVA

| *Sources of Variation* | *SS* | *Df* | *MS* | *F* | *P-Value* | *F-crit* |
|---|---|---|---|---|---|---|
| **Columns** | **16,02671** | **2** | **8,013356** | **5,302956** | **0,018119** | **3,68232** |

### 10.3.3 Timeline

The results of timeline indicate that the work completed in the team space took a longer amount of time. The time used completing tasks in the open plan layout was higher in comparison to the time used in the closed office layout as can be seen in Table 6.

Table 6. Measurement results of Timeline

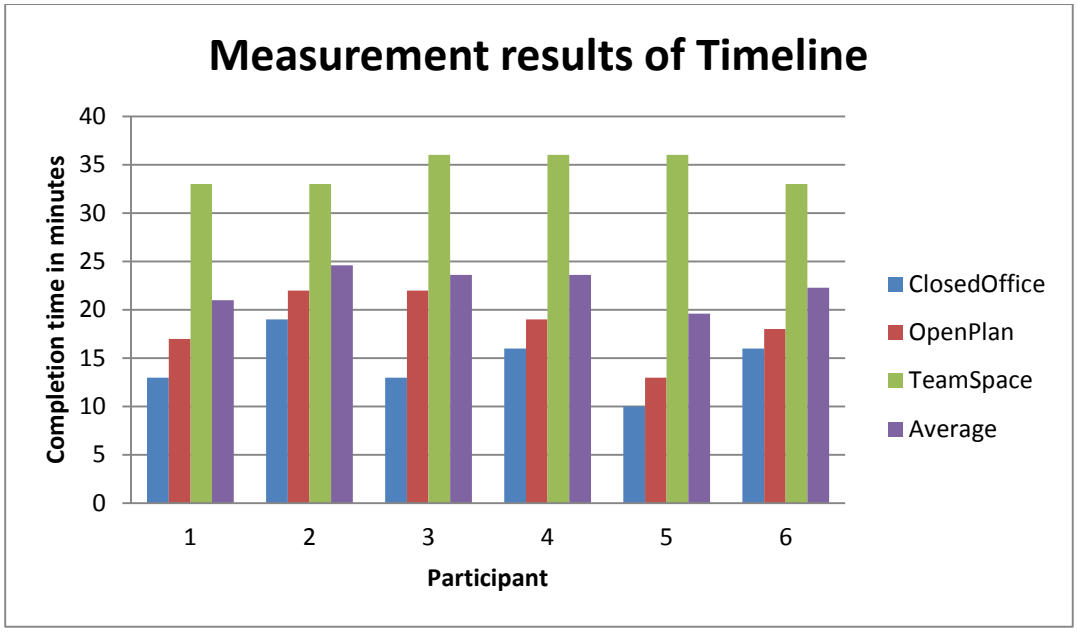


Table 7 displays the P-value as >0,0001. This supports that the change is significant when measuring knowledge worker efficiency through timeline.

Table 7. P-vlaue representation of significant change of Timeline in the 3 workspace layouts

ANOVA

| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-Value* | *F-crit* |
|---|---|---|---|---|---|---|
| **Columns** | **1344** | **2** | **672** | **83,65145** | **0,000** | **3,68232** |

# 11 Discussion

The aim of the research was to find out whether knowledge worker efficiency is affected by workspace design in order to help X-Index and other companies employing knowledge workers acquire information on whether to take into account certain types of workspace layouts in terms of employee efficiency. In order to do this, a theoretical background on workspaces, knowledge workers and workspaces effects on knowledge workers and their efficiency was built up through extensive sources. The research implementation was quantitative, as numerical data was deemed more appropriate to answer the research question. An experimental approach was taken which involved a KPI –based measurement tool measuring quality, quantity and timeline of the tasks executed.

The results showed that there was a significant change in task performance among workspace types in both quantity and timeline, and the results regarding quality were close to being significant.

Quality was generally highest in the team space (see Table 2). Only one participant had better results in terms of quality whilst working alone. Communication may have aided the sharing of knowledge in between the individuals, as has previously been suggested by van den Hooff and De Ridder (2004, 118). Oldham and Brass (1979, 268) mention that Bovard's (1951) study supports the fact that encouraged interaction between group members has

positive effects on the individuals in the group. These social interactions are essential to supporting task performance (Oldham & Brass 1979, 268). It can be deduced that communication was a key element in creating better performance in the team space.

Task interdependence indicates the degree of "task-driven interaction" among the members working in groups (Bosch-Sijtsema et al. 2006, 540). Task interdependence increases communication, cohesion and trust in a team according to Hertel, Geister and Konradt (2005, 77) referring to Kirkman Rosen, Tesluk and Gibson (2004). Because the team space allowed for better task-driven social interaction one could conclude that communication, trust and cohesion in the groups was increased, thus leading to better results in quality. One could also conclude that because individuals could consult each other and share their knowledge, the efficiency results regarding quality were generally higher.

Though the P-value indicates that changes in quality between workspaces were not statistically significant one could also argue that because of the small number of exercises, even a small difference in the results can be statistically significant. As can be seen in Table 2, Participant 2 can be seen as an outlier in the results because of the vast variation of results in the different workspaces which may be due to the researchers not having controlled e.g. personal skills. The results of Participant 2 draw the P-value closer to statistical significance. Thus if it were to be excluded from the results the P-value would be closer to the null hypothesis (no change).

The results of quantity were best in the closed office space as seen in Table 4. The results of quantity seem to support Davenport's (2005, 167) statement according to which knowledge workers prefer closed offices and Gensler's (2013, 8) findings which suggest that closed offices are better for employees as open plan layouts hinder concentration. Van der Voordt (2004, 145) concludes that privacy and distractions are factors affecting efficiency. When employees have a private space in which to work individually without being distracted, efficiency is altered. Concentration and the feeling of privacy probably aided in creating a more comfortable state and resulted in the participants achieving more in the 5 minute interval in the closed office layout.

Timeline was clearly the longest, thus the worst in the team space and the shortest, thus the best in the closed office layout setting. The open plan office layout situated in the middle for all participants. These results seem to suggest that in a space in which communication is enabled employees may distract each other, thus hindering concentration and making the completion time of tasks longer. This may have been the case in the open plan office layout as people conducted tasks individually. Instead of focusing their time on their own individual tasks, they used part of their time to help other participants, thus increasing their own completion time and distracting other participants' concentration in the process. The research conducted by Oldham et al. (2004, 278) supports this as they found out that open plan offices have a negative effect on concentration in relation to closed offices. Banburry and Berry (2005, 25) also state that noise is the most complained about factor in open-plan layouts and that interruptions and distractions are abundant in this type of space due to formal and informal communication.

Different levels of comfort may have also affected the participants' results in the different layouts. The authors suggest that psychological comfort may have played a part in achieving the best results of efficiency when measured through Timeline and Quantity in the closed office layout because as suggested by Vischer (2007, 62-76), privacy may have an effect on the feeling of comfort when performing the tasks.

When comparing the average results of each individual in the three dimensions of efficiency measured in each workspace to the overall averages in each workspace layout, no connections or trends arise. Participants have not repeatedly e.g. used more time to achieve better quality in results. However, when comparing the averages of quality quantity and timeline in each space connections do arise (see Table 8, Table 9 & Table 10). As mentioned before, the participants performed the fastest and completed the highest number of tasks in a certain interval in the closed office layout. Quality, i.e. the amount of right answers was highest in the team space. Quantity probably suffered in both the open plan layout and the team space as time was wasted by sharing knowledge on the tasks being executed.

Table 8. Averages of Quality

| Participant | ClosedOffice | OpenPlan | TeamSpace |
|---|---|---|---|
| 1 | 14 | 11 | 13 |
| 2 | 7 | 7 | 13 |
| 3 | 10 | 11 | 13 |
| 4 | 12 | 13 | 13 |
| 5 | 11 | 12 | 13 |
| 6 | 9 | 9 | 13 |
| Total | 63 | 63 | 78 |
| Average | 10.5 | 10.5 | 13 |

Table 9. Averages of Quantity

| Participant | ClosedOffice | OpenPlan | TeamSpace |
|---|---|---|---|
| 1 | 6 | 3 | 2.33 |
| 2 | 4 | 4 | 2.33 |
| 3 | 5 | 1 | 4.33 |
| 4 | 4 | 3 | 4.33 |
| 5 | 7 | 4 | 4.33 |
| 6 | 6 | 5 | 2.33 |
| Total | 32 | 20 | 19.98 |
| Average | 5.333333 | 3.333333 | 3.333333 |

Table 10. Avergaes of Timeline (where shortest Timeline is best)

| Participant | ClosedOffice | OpenPlan | TeamSpace |
|---|---|---|---|
| 1 | 13 | 17 | 33 |
| 2 | 19 | 22 | 33 |
| 3 | 13 | 22 | 36 |
| 4 | 16 | 19 | 36 |
| 5 | 10 | 13 | 36 |
| 6 | 16 | 18 | 33 |
| Total | 87 | 111 | 207 |
| Average | 14.5 | 18.5 | 34.5 |

From X-Index's, or an employer's, point of view, the choice of space (and thus the choice of how the work is conducted) is important as there seems to be significant change in both quantity and timeline. Because X-Index is a company designing, selling and renting workspaces, they or an employer could choose to use a team space where the quality of the work is the highest, but where it takes longer to conduct tasks in on an individual level. On the other hand, one could choose the closed office layout in which individuals are able to conduct more tasks in a less amount of time. This choice also reflects on the organizational level, where a company may have to choose from paying more to the employee(s) for the quality of work (due to the timeline), or paying less for faster work. It should be taken into account whether attaining results faster affect the work in negative ways. It is crucial to take into account the type of tasks conducted in X-Index's customer organizations when designing office layouts as well as the type of employees conducting the work. It is also as important to take into account what dimension of efficiency, in this case quality, quantity or timeline is the most important for a company. To conclude the research, the significance of the changes in two of the dimensions of efficiency seems to indicate that a company can influence the efficiency of individuals and how the work is conducted through the design of workspaces.

Future research on the topic could include exploring the assumptions and opinions of routine knowledge workers in terms of what workspace layout they prefer to work in when taking into account each dimension of efficiency. Those results could be compared to statistical results to find out if there are any connections in between the actual performance and the assumptions of the employees. The results of the research could also be tested in practice e.g. at a workplace where one of the dimensions of efficiency is preferred or needed to find out if the results can be applied to actual workspaces in working life.

As now one can only speculate why there was significant change in routine knowledge worker efficiency in the three workspaces, further research is needed to find out what caused the changes. In addition to studying the reasons for these results, one could also study the process of what happens to achieve results in the three dimensions of quality in different workspace layouts and perhaps find solutions to increase quality in terms of timeline, quantity and quality.

Future research could include other knowledge worker categories and explore whether different types of knowledge can work in the same spaces and co-exist. Could the efficiency of other types of knowledge workers be affected differently in the same spaces?

## 11.1 Workspace selection template

According to the theoretical background and the results of the research, companies should take into account workspace designs when planning workplaces to enhance employee efficiency. Workplace strategies, of which workspaces are crucial elements, can increase productivity and efficiency as well as the exploitation of knowledge. A workplace strategy is the alignment of work patterns in a company with the actual work environments i.e the workspaces. (Schriefer 2005, 223.) It can consequently be deduced that workspaces contribute to the overall business performance of a company through the workplace strategy as different workspaces are aligned in the right way to support employees working in different ways.

Consequently, on the basis of the research and results a series of guidelines has been formed to help X-Index (and other real estate agents) or any company employing knowledge workers in deciding the most suitable spaces or combination of spaces to suit their business needs.

The Workspace Selection Template in Figure 6 was created to provide guidance for X-Index or for any other company in the search of office premises for knowledge workers. The form guides the company by offering choices from which the suitable or accurate ones are then selected, keeping in mind the firm's nature of business. The guiding sentences will help the company define the types of knowledge workers they employ, their needs in terms of work and space. It also helps the company to identify what is needed from the working environment for workers to be able to conduct their work in an efficient manner. As Vischer (2007, 62) suggests, the comfort of the employees is connected to the working environment and to workplace performance. Therefore it can be deduced that a working environment which workers feel comfortable in encourages and supports better performance level and therefore has an effect on the efficiency of the workers. In addition to the statements in the form, X-Index or a company should thus take into account

the three aforementioned categories of comfort: physical, functional and psychological.

The categories of The Knowledge Worker, The Task and The Organization are derived from the model constructed earlier on the basis of the theoretical background and are shown in Figure 6. The Knowledge Worker category includes statements from the employees' point of view whereas The Task category includes statements based on the nature of the task in each layout and the needed environment for the completion of the tasks. The authors suggest that task nature and the needs of employees may vary between departments, but also in departments thus the answers could generate combinations of spaces. The Organization category includes statements on the needs of the employer which reflect the results efficiency acquired from the different spaces. As an example, costs can be regarded as being higher in the team space as a group of employees conducts one task together instead of conducting individual tasks, thus possibly executing more individually. On an individual level the results indicated that the time spent conducting the task in the team space was the longest. On the other hand, the quality of the work was the highest, consequently leading the employer to question what his emphasis in terms of employee efficiency should be on. On an individual level the results indicated that the time spent conducting the task in the team space was the longest.

By checking the boxes, the company acquires information regarding what kind of working environment would be the most appropriate workspace for them in terms of employee efficiency. Through the answers generated from the guiding sentences, a workspace layout or a combination of layouts is suggested for the company to use in maximizing routine knowledge worker efficiency.

The Workspace Selection Form in Figure 6 includes a color code for the different workspaces that were included in the research. The red colored statements represent the open plan office, the orange colored statements represent the closed office layout and the green colored statements represent the team space layout.

| Workspace Selection Template | |
|---|---|
| **The Knowledge Worker** | |
| My employees are extroverts and they find the constant communication as an positive factor in terms of job performance. | |
| In order for my employees to be able to conduct tasks, they need to be able to collaborate and communicate freely. | |
| High levels of interaction among colleagues create an inspiring and creative atmosphere for workers to conduct tasks in. | |
| My employees are working in small groups as a ratio of individual work together with collaboration and consultancy of other team members provides more efficient results, thus leading to a better overall job performance. | |
| High levels of interaction among colleagues create distractions and affect negatively on the efficiency of the workers. | |
| My employees value private, closed areas as they provide a better ability to focus and thus the workers perform better in their tasks. | |
| **The Task** | |
| The work in which my employees engage in requires medium privacy and confidentiality. | |
| The tasks my employees/department conduct requires low interdependence | |
| The tasks my employees/department conduct requires no interdependence | |
| The tasks are mainly conducted individually, without needing to consults peers. | |
| The work in which my employees engage in requires medium focus and collaboration with co-workers. | |
| The tasks my employees/department conduct require high interdependence | |
| **The Organization** | |
| As an employer I am willing to pay more for the quality of work. | |
| As an employer I value the time consumed in the process of delivering work and therefore I favor processes to be executed quickly with lesser money. | |
| As an employer I am willing to risk possibly decreasing the worker's ability to concentrate and focus as long as I save money in selecting the office premises. | |
| As an employer, I will take into account the nature of the work and the workers needs when selecting the office premises over the cost of it. | |
| As an employer I want to provide my workers a comfortable place to work in with functioning utilities. | |
| As an employer, I value communication and collaboration among staff members as I believe the factors support efficiency and deliver better results. | |
| As an employer, I prefer open spaces due to the flow of information and knowledge. | |

Figure 6. The Workspace Selection Form

## 11.2 Research reliability, validity and sources of error

According to Golafshani (2003, 598), Joppe (2000) defines reliability in quantitative research as the replicability or repeatability of the tests and the test results. Golafshani (2003) suggests that validity in quantitative research is concerned with two factors regarding the measurement tool: Are the measurements accurate and do they produce the results that are supposed to be measured?

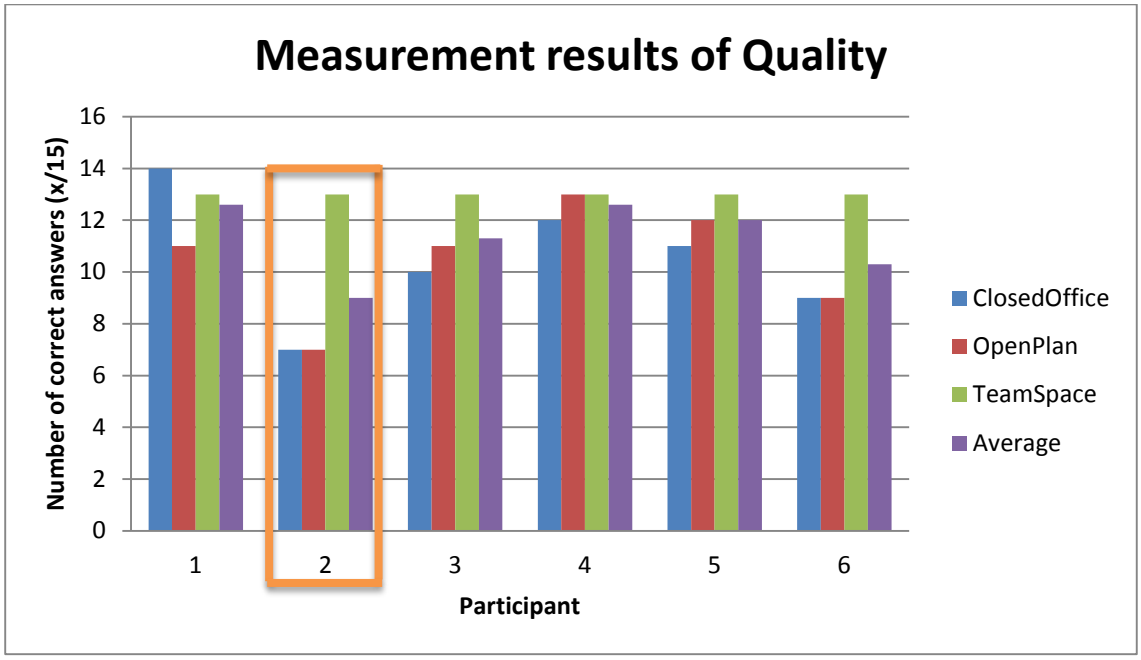
A number of factors could have attributed to the reliability of the real-life simulation and the results. For practical reasons the simulations had to be conducted in between the hours of 9 and 12 in the morning and at noon. Due to this, the participants' results of efficiency may have been affected by the time of the day as the simulations for each workspace were conducted at different times.

The advantage of the repeated measures experiment is that each test subject serves as their own control. However, the order in which the simulations were conducted i.e. multiple treatment interference may have affected the results. Because the individuals first participated in the open-plan layout where communication was permitted, knowledge sharing may have taken place. This may have helped the participants perform with better results in the other two simulations as the tasks were of the same nature in all simulations. The changes in the results may consequently not only be dependent on the space, but also on the prior simulations. This could affect reliability in terms of repetition of each layout simulation.

As there is no universally accepted measurement tool for knowledge worker efficiency, the authors were given the freedom to coin their own tool (Drucker 1999, 86; Ramirez et al. 2004, 602). Because there is no generally accepted tool and because of the number of measurements used the authors had to narrow down the measurements. The same measurements were applied to all layout simulations, but problems in terms of accuracy of the measurements i.e. validity did arise which is why the researchers had to manipulate the data. The manipulation of the data to suit the measurement of efficiency on an individual level may have caused errors.

Personalities and personal skills were not taken into account in the simulations. It was assumed that all the participants were equally efficient when analyzing the results regarding the team space which may have affected the validity of measurements. This possibly created error in the results gathered from the team space layout. An example of this can be seen in the results of Participant 2 in Table 11. Results in the team space were far higher than when executing the task individually. Without this outlier the results may have strongly shifted towards there being no change in efficiency when using quality as an indicator. With the results of Participant 2 included, the results indicated only a slight shift towards the alternative hypothesis.

Table 11. Measurement results of Quality depicting an outlier.




The assumption of normality adhered except in Quantity and Timeline in the case of the team space so the assumption of having to perform the repeated measures variance analysis partly failed. This is portrayed by the highlighted result in Table 12 and Table 13. The normality of the data is shown by a P-value and the data can be deemed as normally distributed if $P>0.5$.

The measurement data related to quantity and timeline was not normally distributed because the researchers needed to manipulate the data in order to acquire results on the individuals' efficiency i.e. multiply the results of timeline by the number of participants (3) and divide the quantity of tasks completed in 5 minutes by the number of participants (3). Thus, it was decided to ignore the data not being normally distributed. Because the measurements of quantity and timeline had to be manipulated, it also affected the validity of the measurements as these two dimensions did not display efficiency at an individual level before the manipulation of the data.

Table 12. Tests of Normality on Quantity results

**Tests of Normality**

| | WorkSpace | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|---|
| | | Statistic | Df | Sig. | Statistic | df | Sig. |
| Quantity | ClosedOffice | ,209 | 6 | ,200* | ,907 | 6 | ,415 |
| | OpenPlan | ,237 | 6 | ,200* | ,927 | 6 | ,554 |
| | TeamSpace | ,319 | 6 | ,056 | ,683 | 6 | ,004 |

*. This is a lower bound of the true significance.

Table 13. Tests of Normality on Timeline results

**Tests of Normality**

| | Workspace | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|---|
| | | Statistic | Df | Sig. | Statistic | df | Sig. |
| Time | ClosedOffice | ,183 | 6 | ,200* | ,960 | 6 | ,820 |
| | OpenPlan | ,182 | 6 | ,200* | ,921 | 6 | ,515 |
| | TeamSpace | ,319 | 6 | ,056 | ,683 | 6 | ,004 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

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