Rethinking refurbishment projects for improved users' working environment

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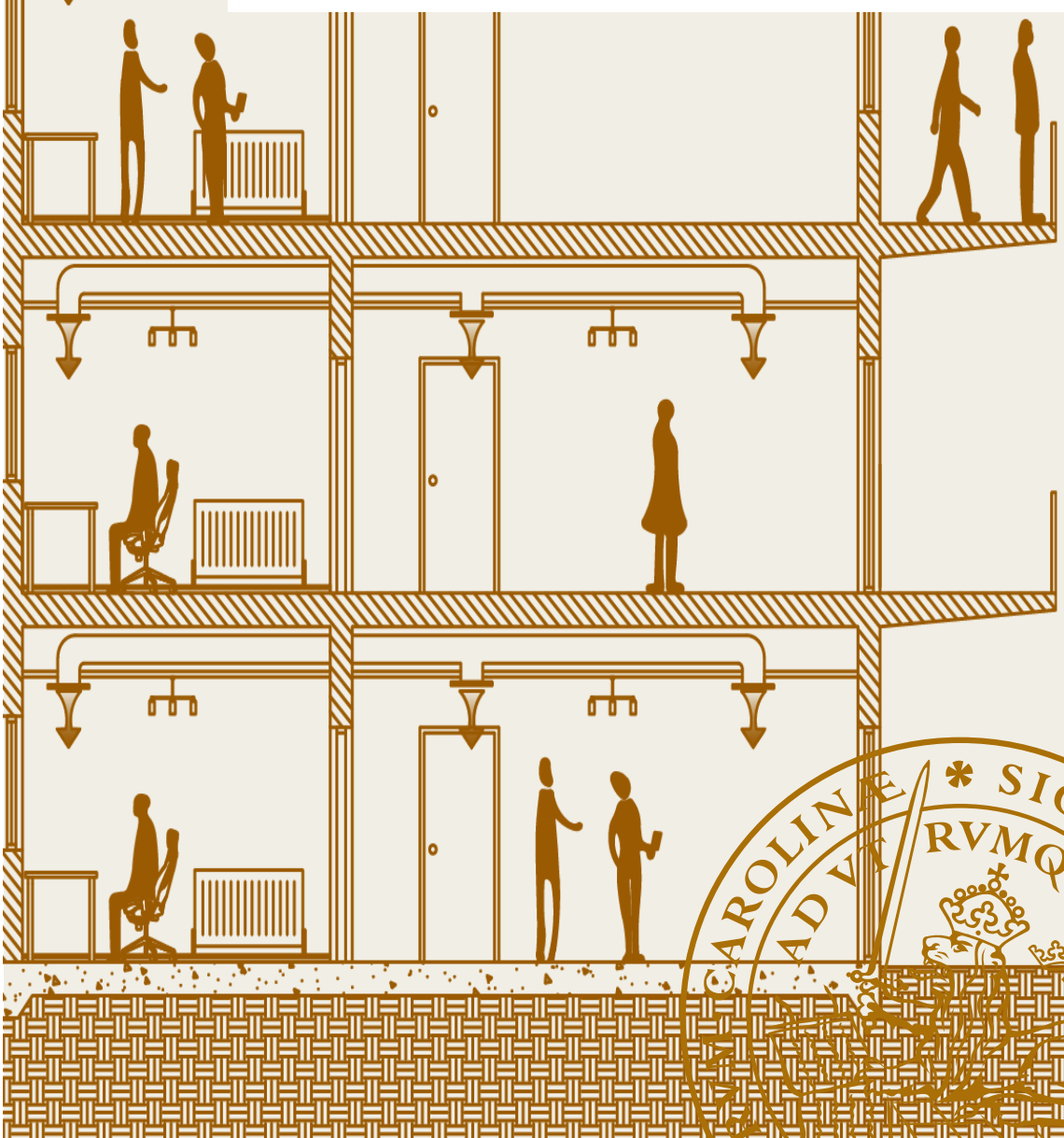

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Elna Jönsson

LUND
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Rethinking refurbishment projects for improved users' working environment

Abstract

The built environment is important to achieve a sustainable society. From a sustainability perspective, refurbishment can be preferable to building anew. A significant proportion of the built environment needs to be refurbished. Refurbishment projects also provide the opportunity to proactively upgrade the working environment for users during operation and use. Research concerning the working environment in the context of construction-related projects has mainly emphasized issues affecting construction workers. The central issue has tended to be the reduction of risks in relation to ill health, not factors that can contribute to prevent poor health or increase user well-being. Furthermore, there is a lack of understanding about the influence of refurbishment projects on user productivity.

The research undertaken builds on post-positivism. The chosen method is case studies, which have been built on triangulation and data gathered through document analysis, survey questionnaire and interviews. The studies examined refurbishment projects for offices. Different aspects of the refurbishment process and their influence upon the working environment for users has been studied. In all, four case studies were undertaken.The first case study investigated the influence of briefing. This study revealed deficiencies in the briefing process. The second case study considered facility management, especially the way in which deficiencies are handled during operation and how this can influence the working environment. This study revealed reactive and behaviour-centred facility management and an unexpected long period, measured in years, before rectification and remedy of deficiencies were undertaken. The third case study dealt with post-occupancy evaluation and if its inclusion can contribute to an improved working environment. This study showed that post-occupancy evaluation could contribute to a single refurbishment project as well as to the learning process, resulting in improved new refurbishment projects with regard to users' working environment. Case study four investigated the impact of project governance. This study revealed weaknesses in project governance in the form of unsatisfactory information exchange.

The research resulted in a new definition of briefing for refurbishment, which highlights the difference between briefing for refurbishment and new build projects. The research also resulted in a model which highlights the importance of establishing a balanced economy, organizational and service capacity in the early stages of a refurbishment or new build project so that steps can be taken if required to rectify defects and deficiencies, post-handover of the facility. The EOS model increases the awareness of the importance of linking facility management to the purpose of the facility; that is, as a production resource in supporting users' working environment and acknowledging the importance of productivity in this regard.

The studies showed that the fulfilment of the goal of a good working environment for users can be achieved by relatively small changes in the way that projects are undertaken.

Key words Refurbishment, Users' working environment, Project governance, Briefing, Facility management, Post-occupancy evaluation.

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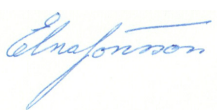
Signature  Date 2022-08-15

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Elna Jönsson

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Abstract

The built environment is important to achieve a sustainable society. From a sustainability perspective, refurbishment can be preferable to building anew. A significant proportion of the built environment needs to be refurbished. Refurbishment projects also provide the opportunity to proactively upgrade the working environment for users during operation and use. Research concerning the working environment in the context of construction-related projects has mainly emphasized issues affecting construction workers. The central issue has tended to be the reduction of risks in relation to ill health, not factors that can contribute to prevent poor health or increase user well-being. Furthermore, there is a lack of understanding about the influence of refurbishment projects on user productivity.

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The research resulted in a new definition of briefing for refurbishment, which highlights the difference between briefing for refurbishment and new build projects. The research also resulted in a model which highlights the importance of establishing a balanced economy, organizational and service capacity in the early stages of a refurbishment or new build project so that steps can be taken if required to rectify defects and deficiencies post-handover of the facility. The EOS model increases the awareness of the importance of linking facility management to the purpose of the facility as a production resource in supporting users' working environment and acknowledging the importance of productivity in this regard.

The studies showed that the fulfilment of the goal, a good working environment for users, can be achieved by relatively small changes in the way that projects are undertaken.

Key words: Refurbishment, Users' working environment, Project governance, Briefing, Facility management, Post-occupancy evaluation.

Scientific summary

Assets in the form of buildings are part of a sustainable society. From a sustainability perspective, it can be beneficial to maintain and refurbish instead of building anew.

A significant proportion of the built environment needs to be refurbished. At the time of the construction of the buildings which today are in need of refurbishment, working environment legislation was focused on industry and accident prevention and the working environment in office premises received less attention. This means that there is great potential during refurbishment for improvement with regard to working environmental issues influencing users. Existing shortcomings can be removed and at the same time new aspects such as the cognitive working environment, i.e. how the brain is affected during the working day by, for example, noise can be taken into account in connection with the refurbishment. This means that refurbishment can contribute to improvement in the working environment and increase productivity. The effects of the influence of the building may arise as result of actual conditions regarding different areas, i.e. thermal comfort, daylight, noise and ergonomic conditions. All these arise as the results of decisions taken as part of project governance, briefing and facility management.

The aim of the research was to understand the conditions and decisions that affect the outcome of the refurbishment and users' working environment during operation. A qualitative research strategy was chosen and four case studies were conducted regarding office environments intended for research and education. In case study III, the qualitative approach was complemented with a quantitative approach.

Case study I considered the briefing stage and identification of shortcomings that affect users' working environment on an individual level.

Case study II examined facility management after a refurbishment project was completed. The purpose was to understand how errors and shortcomings generated during the refurbishment were handled in the operational phase and how management of the facility during operation and use affects the users' working environment and productivity.

Case study III focused on the learning process and whether it was possible to draw general conclusions that can contribute to an improved working environment in the light of the results of post-occupancy evaluations of individual refurbishment projects.

Case study IV studied the governance process and its impact on the users' working environment.

The findings suggest that refurbishment affects the working environment for users both in a physical and psychological way. The studies revealed that it is possible to improve the results of refurbishment projects, with respect to the users' working environment, by identifying and integrating all users early in the refurbishment process with the goal of considering future aspects of working environment i.e. physical and psychological strain due to, for example, thermal climate, noise and awkward positions. Future facility management should also be integrated into the refurbishment process with the facility's management taking into account the users' need for active efforts to quickly minimize errors and shortcomings generated by the refurbishment to avoid a long-term negative working environment. The studies also revealed that post-occupancy evaluation of individual refurbishment projects could contribute to the learning process and the outcomes of future refurbishment projects with regard to users' experience of the working environment's influence on their working conditions. The studies showed that exchange of information within the governance process is of central importance to allow the project's management to gain access to critical information from users that could be used as a basis for decision-making during project governance to avoid negative influence on users' working environment.

Popular scientific summary

A series of studies reveals that key aspects of the working environment, from the perspective of individual users of a building, can be overlooked during the building's refurbishment. The working environment is often experienced by individual users on the micro level; for example, the room is perceived as cold, noise is experienced and disturbs concentration, and the lighting is not good enough for the work being undertaken. The working environment can be improved if the refurbishment process establishes early enough those characteristics that are important for the users of the building. A simple question, "what is important?", put to every user is likely to improve the working environment as well as productivity in the activities for which the building is intended. The state and conditions of the building also need to be recorded at the start of refurbishment; for example, are there external disturbances that can affect the working environment in the rooms? Are there shortcomings such as inadequate insulation in the building that must be remedied as part of the refurbishment? If the conditions change during the project, all previous decisions must be reconsidered to determine if they are correct or not for the new conditions.

It is the function of the project's governance process to ensure that all important aspects are included. All users should, therefore, be involved in the governance process, with change communicated in such a way that users fully understand the meaning of the decisions. Additionally, it is important to integrate the views of those involved in maintaining the building, such as cleaning personnel, since their work is affected by the design of the building. A choice as simple as the flooring material is of importance for cleaning personnel and should be discussed with them and the building owner's operations personnel during briefing, prior to design since it is difficult to remedy deficiencies after handover to operation and use. If the governance process involves post-occupancy evaluation, this can raise the prospect of successful outcomes, where deficiencies come to light earlier and so are capable of being remedied earlier. Post-occupancy evaluation can be further expected to expose issues that can be avoided or, at least, minimized on future refurbishment projects.

The studies also reveal that the facility management function employed after handover needs to be appropriate in terms of economy, organization and service level to enable deficiencies to be remedied within a reasonable time. If the facility management function is implemented for normal operation and use with respect to economy, organization and service level, it is unlikely to be possible to remedy deficiencies expeditiously. In one of the studies, shortcomings in the working environment included inadequate thermal climate, where some rooms were too hot during summer and others cold and draughty during winter. Several years elapsed before the bulk of the deficiencies were remedied; meanwhile, the well-being of users was impaired.

Finally, the studies confirm that the users' working environment should be a primary concern for refurbishment projects if they are to satisfy users' requirements and meet expectations. Small changes in the refurbishment process in the form of accurate recording of existing conditions, identification of all users, increased information exchange, more efficient communication, change control during the refurbishment process, an appropriate facility management function and post-occupancy evaluation, can collectively result in the fulfilment of requirements leading to a satisfactory working environment for all users and increased productivity in their work activities.

Populärvetenskaplig sammanfattning

En serie av studier visar att vid renovering av fastigheter kan aspekter som ur ett brukarperspektiv kan bedömas som viktiga för arbetsmiljön bli försummade. Den enskilde brukaren upplever oftast sin arbetsmiljö på mikronivån t ex rummet är kallt, det förekommer ljudstörningar som stör koncentrationen och ljuset är inte tillräckligt för arbetet. Arbetsmiljö upplevelser som kan förbättras om det i projekteringen i tid tas reda på vad som är viktigt för de som ska arbeta i fastigheten efter renoveringen. En enkel fråga ”Vad är viktigt för Dig?” ställd till alla grupper som ska använda fastigheten, kan förbättra arbetsmiljön för användarna och samtidigt bidra till ökad produktivitet för de verksamheter som ska bedrivas i fastigheten efter renoveringen. Studierna visar det är viktigt att fastighetens förutsättningar kartläggs från början t ex finns det yttre störningar som kan påverka arbetsmiljön inne i fastigheten eller finns det brister i form av otillräcklig isolering i väggar och tak? Ändras förutsättningarna under projektet måste också alla tidigare beslut gås igenom igen och vid behov revideras, för att fastställa och eventuellt revidera besluten så de är rätt även under de nya förutsättningarna.

Projektstyrningen ska garantera att alla viktiga aspekter blir beaktade. Studierna visar att för att detta ska kunna uppnås behöver alla användare vara delaktiga i projektstyrningen och informeras om ändringar på ett sådant sätt att de till fullo förstår innebörden av besluten. Speciellt viktigt är att tillse att all personal som ska arbeta med fastigheten efter renoveringen blir delaktiga i besluten t ex lokalvården. Ett så enkelt val som val av golvmaterial får stor betydelse för lokalvårdens arbetsmiljö och bör diskuteras med både lokalvården och fastighetsägarens driftpersonal redan under projekteringen, i efterhand är det svårt att åtgärda eventuella brister. Studierna visar också att om brukarutvärdering inkluderas i projektstyrningen så kan det bidraga till bättre renoveringar. Detta genom att brister i den aktuella renoveringen uppmärksammas tidigt och kan åtgärdas samtidigt som brukarutvärderingen kan uppmärksamma brister som kan minskas eller undvikas i framtida renoveringsprojekt.

Studierna pekar också på vikten av att den framtida fastighetsförvaltningen blir rätt dimensionerad avseende ekonomi, organisation och service så det blir möjligt att åtgärda brister omgående. Är fastighetsförvaltningen dimensionerad för normal drift med avseende på ekonomi, organisation och service kan det bli omöjligt att vidtaga åtgärder. I en av studierna fanns arbetsmiljöbrister bl.a. i form av bristfälligt termiskt inomhusklimat, en del rum var för varma under sommarhalvåret och andra kalla och dragiga under vinterhalvåret. Studien visade att det tog många år innan huvuddelen av de observerade bristerna kunde åtgärdas. Arbetsmiljön för användarna var påverkad fram tills åtgärd kunde genomföras.

Studierna visar att användarnas arbetsmiljö måste vara i centrum under projektstyrningen för att renoveringsprojekten ska uppfylla brukarnas krav och

förväntningar. Samtidigt visar studierna att relativt små förändringar i renoveringsprocessen t ex förbättrad kartläggning av befintliga förutsättningar, identifikation av alla användare, ökat informationsutbyte, förbättrad kommunikation, förankrade förändringar under renoveringen, korrekt dimensionerad fastighets-förvaltning och efterföljande brukarutvärdering, tillsammans kan bidra till ökad måluppfyllelse i form av god arbetsmiljö och ökad produktivitet.

1 Introduction

1.1 Background

"All workers should be able to enjoy the highest attainable standard of physical and mental health and favourable working conditions. The workplace should not be detrimental to health and well-being" (World Health Organization, 2007). There has been a paradigm shift from looking on work as a risk factor of ill health to see it as the source of a good standard of living (Partnership for European Research in Occupational Safety and Health, 2012). The report, "Transforming our world: The 2030 Agenda for Sustainable Development" (United Nations, 2015) includes 17 Sustainable Development Goals (SDGs). Of these goals, the eighth is to "promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all". Target 8.5 states: "by 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value". Target 8.8 states: "protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment" (United Nations, 2015). In a similar manner, a key priority for the EU is to promote high standards concerning the working environment (Eurofound, 2021). An EU Directive on measures to improve safety and health at work is aimed at protecting workers in their place of work and extends to promoting workers' rights (Eurofound, 2021). The international labour organization published a "Centenary Declaration for the Future of Work" (International Labour Organization, 2019) in which it stated that "Safe and healthy working conditions are fundamental to decent work".

Construction projects can be of two broad types, new build and refurbishment. Refurbishment is defined in ISO 20887:2020 as "modification and improvements to an existing building or civil engineering works in order to bring it up to an acceptable condition" (International Organization for Standardization, 2020). Refurbishment is separated from maintenance, which in this research is defined as "work required to keep a building functioning as intended".

Construction projects, new build as well as refurbishment, are often mentioned in the context of the need for sustainable development and, specifically, reducing energy consumption, i.e. best lifecycle energy, if the highest standard of building refurbishment is to be achieved when compared with new build (Weiler, Harter &

Eicker, 2017). According to Schwartz, Raslan and Mumovic (2018), refurbishments can achieve between 7-38% lower CO_2 emissions over an assumed life of 60 years and can cost between 5-20% less than replacements. At the same time, less attention is paid to the sustainability aspects of projects in terms of influence over the users' working environment. For a large part of the workforce, work in offices is a huge part of their lives. This implies that office buildings can be a key to workers' health, well-being and productivity. Kim, Hong, Kong and Jeong (2020) showed that if "occupants are exposed to an unhealthy IEQ (indoor environmental quality) condition below neutral, SBP (systolic blood pressure) can be increased over the hypertension warning state". In regard to lighting in the office environment, Hemphälä and Eklund (2012) found a relationship between eyestrain caused by insufficient lighting and musculoskeletal disorder, i.e. those with eyestrain had three times as many musculoskeletal disorders. Nevertheless, there is a lack of statistics as well as research concerning general office areas for dry research or administrative tasks and work-related issues.

1.2 The building as a workplace environment

Buildings used as workplaces set the workplace environment and affect the working environment of users by physical or psychological influences. Vischer (2007) presented the concept "workspace stress", defined as the degree to which there is a "misfit between what people need to perform their tasks and resources the physical environment provides", resulting in users being forced to compensate for adverse environmental conditions and expend additional energy to achieve work-related goals (Roskams & Haynes, 2021). The effects of the influence of the building may arise as result of actual conditions regarding different areas i.e. thermal comfort (Rupp, Vásquez & Lamberts, 2015), luminous comfort (Carlucci, Causone, De Rosa & Pagliano, 2015), daylight access (Lucas, Peirson, Berson, Brown, Cooper, Czeisler, Figueiro, Gamlin, Lockley, O'Hagan, Price, Provencio, Skene & Brainard, 2014), emissions, noise (Schlittmeier, Feil, Liebl & Hellbrück, 2015; Al Horr, Arif, Katafygiotou, Mazroei, Kaushik & Elsarrag, 2016a; Brink, Schäffer, Vienneau, Foraster, Pieren, Eze, Cajochen, Probst-Hensch, Röösli & Wunderli, 2019), and ergonomic conditions. All these conditions arise as results of the decisions taken during project governance, briefing, design and construction, and/or facility management. Remedies during operation and use lead to extra cost, which can mean no action being taken to remedy issues during operation and use, resulting an influence on the working environment for years to come.

1.3 Context of the case studies

In Sweden, heated buildings (e.g. residential buildings) comprise approximately 641 million m^2, of which buildings for industry, retail and office work make up about 26%. The majority, about 60%, of heated buildings was built before 1981 (Swedish National Board of Housing, Building and Planning & Swedish Energy Agency, 2016). In one year alone (2020), the amount of refurbishment undertaken was estimated at 34% of all construction-related projects (Building facts [Byggfakta] in Sezer & Bosch-Sijtsema, 2020, p.1690) by number of contracts. A major part is publicly owned facilities, which account for around 90 million m^2 of floor space, across 20 000 buildings (Public properties, 2015).

The International Labour Organization (2019) published a "Centenary Declaration for the Future of Work" in which it stated that "Safe and healthy working conditions are fundamental to decent work". The Swedish government emphasizes that the writings in the declaration "can help to increase the status of working environment issues and thereby contribute to strengthening beneficiaries' rights" and "the working environment perspective in working life" (Government of Sweden, 2020). The working environment issues have been formalized within legislation. This first appeared with the "Act on Protection against Occupational Risk in Private Industry" (1889), which was superseded by successive legislation in 1912, 1949 and 1977. The latest working environment legislation came into force in 1978. Since then, there has been an evolution regarding working life and many traditional working environment risks such as heavy lifting and chemical exposure have been reduced (Government of Sweden, 2021). This means apart from risks and accident prevention, focus should be extended to include health promotion (Government of Sweden, 2021). The government also states that:

- "there are gaps in knowledge about the positive effects of the working environment and what creates healthy workplaces;
- research in the field is mainly about factors that increase the risk of ill health; and
- there is a lack of knowledge about the importance of the working environment for production, growth and innovation."

In this connection, the government also mentions that "the cognitive working environment, i.e. how the brain is affected during the working day, plays an increasing role in working life" and so has set new requirements on the working environment (Government of Sweden, 2021).

1.4 Problem statement

The built environment is an integral part of a sustainable society. From a sustainability perspective, it can be beneficial to maintain and refurbish instead of building anew. A significant proportion of the built environment was constructed many years ago and needs to be refurbished due to ageing materials and components, as well as normal wear and tear. Refurbishment provides the opportunity to extend the useful life of buildings, retain our architectural heritage and meet new requirements; but it must also create a working environment that satisfies users' needs, promotes productivity and guarantees well-being. These goals are capable of being realized, yet an over-emphasis on any one of them can mean that the others receive less attention with consequences that might be felt for years to come. Previously, for example, research regarding the working environment has been concerned mainly with factors that increase the risk of ill health during construction and far less with factors that increase well-being during operation and use. Rebalancing these goals so that none are overlooked or downplayed is a reasonable goal. To achieve this change, understanding about the impact of refurbishment projects on the working environment during operation and use needs to be increased.

1.5 Aim and research questions

The aim of the research is to understand the conditions and decisions that influence users' working environment in refurbished facilities.

Three research questions are addressed:

1. How do decisions taken as part of project governance, briefing and facility management influence users' working environment during operation and use?
2. Can single post-occupancy evaluations make a meaningful contribution to understand and improve users' working environment?
3. How could increased attention to users' working environment improve the outcomes of refurbishment projects?

1.6 Limitations

The limitations that set the boundaries of this research area are as follows. First, the focus of attention is refurbishment projects: maintenance and new buildings are excluded. The effects of building environmental certification schemes on the indoor environment are also excluded. The type of facility is limited to combined office and educational buildings. The users' working environment is the outcome of refurbishment projects, not the working environment during construction. Issues that can be experienced in the working environment by the human senses are included, but particulate matter, emissions, airborne bacteria and viruses that can also impact human health are excluded. Personal characteristics such as, age, gender and education are excluded. Also personal health conditions of users, which can influence the experience, are not considered.

In terms of research method, document analysis had some limitation. All documentation linked to Project 1 was available in-house and accessible for analysis, while documentation for Project 2 was limited to online access.

1.7 Structure of the thesis

The dissertation contains five chapters.

- Chapter 1, this chapter, presents the background, the problem statement, aim, research questions, limitations and structure of the thesis.
- Chapter 2 presents the research methodology. It describes the research strategy and the research methods. The choice of research method, research design, literature review, data collection, validity and reliability are discussed.
- Chapter 3 contains the theoretical framework. It sets the research context within the areas of users' working environment, as well as in project governance, briefing, facility management and post-occupancy evaluation.
- Chapter 4 is devoted to the empirical studies. Four themed case studies are presented, namely briefing, facility management, post-occupancy evaluation and project governance.
- Chapter 5 presents the conclusions. They consist of three parts, each aligned with one of the three research questions. Findings are analysed in relation to previous research in the field, with the contribution of the research and suggested future research presented.

Appendices contain supporting material.

- A1: Survey questionnaire about building performance
- A2: Survey questionnaire about functionality (facilities/services)
- A3: Survey questionnaire about comfort
- A4: Survey questionnaire about personal control
- A5: Survey questionnaire about work productivity
- B1: Cover letter and survey questionnaire

2 Research methodology

2.1 Introduction

The construction management research field “draws from both natural and social sciences” (Dainty, 2008) and there has been and continues to be an evolution within the field over the years (Dainty, 2008; Gajendran, Brewer, Runeson & Dainty, 2011).

The main philosophical paradigms of science are positivism and post-positivism. Positivism has its tradition within natural science and builds on regularities (Persson & Sahlin, 2013). In positivism, the regularities and not the causes of the regularities are central (Persson & Sahlin, 2013). Post-positivism has its tradition within social science (Fox, 2008). Post-positivism attempts to explore a phenomenon as far as possible and examine causes (Panhwar, Ansari & Shah, 2017). Another difference between positivism and post-positivism is that positivism builds on the presumption that the researcher is objective, while post-positivism presumes that the researcher is not objective and that this can cause scientific bias (Guba & Lincoln, 1994). This questioning of reality is expressed in the concept of triangulation where post-positivistic research uses several different methods to validate results, since a single method alone might contain errors.

Since its emergence, construction management has mainly been developed in parallel with social science (Johansson, 2003) and because of that it was, in the beginning, based on positivism (Johansson, 2003). However, the research methods in social science have developed and today they include post-positivism. Positivism is based on the models within natural science, which is why quantitative methods are closely associated with them (Noor, 2008). In contrast, post-positivism focuses on understanding the subjectivity of social phenomena and is more closely associated with qualitative methods (Noor, 2008) (see table 1).

Table 1: Summary of features within positivism and post-positivism

Features	Positivism	Post-positivism
Background	Natural science	Social science
Researcher	Objective	Risk of subjectivity
Focus	Regularities	Causes of regularities
Methods	Quantitative	Qualitative and quantitative
Number of methods	Single	Plural and triangulation
Analysis	Hypothesis testing	Insight, discovery and interpretation
Reasoning/explanations	Deductive	Inductive

2.2 Research strategy

Generally, post-positivism has been seen as a reaction to the limitations of positivism (Panhwar, Ansari & Shah, 2017), mixing positivism with interpretivism. The difference between positivism and post-positivism is shown by changing the focus from hypothesis testing (used in positivism) to insight, discovery and interpretation (Noor, 2008). The arguments for post-positivism are that vital topics such as practical reasoning and knowhow, which are central concepts in much construction-related research, are not accessible by applying a single method (Seymour, Crook & Rooke, 1998). Instead, post-positivism promotes triangulation through use of both qualitative and quantitative methods (Clark, 1998; Fischer, 1998). Post-positivism classifies construction management as a sub-branch of management, but in a construction context (Seymour, Crook & Rooke 1998). Criticism of post-positivism has mainly been the risk of introducing subjectivity (Runeson, 1997).

Research strategy can be classified in different ways.

- Experimental, explorative and explanatory. In the experimental method, the researcher manipulates one or more variables and studies the influence of these variables on other variables. The explorative method concentrates on the nature of the problem that needs to be solved. In contrast, the explanatory method concentrates on increasing understanding of the problem.
- Quantitative or qualitative. Quantitative research is mainly built on, for example, statistics and experiments; while qualitative research is built on, for example, case studies, action research and participatory research. Quantitative research builds on the presumption that the researcher is objective and bias free, while qualitative research presumes that the researcher is neither objective nor bias free (Toloie-Eshlaghy, Chitsaz,

Karimian & Charkhci, 2011). Qualitative researchers study phenomenon in their natural settings to interpret them (Denzin & Lincoln, 2011).

- Deductive, inductive and abductive, with regard to the explanations that arise from the research. The deductive method is the classic variant built on a theory and performed by testing hypotheses. The inductive method adopts the opposite approach and builds on observations of real life resulting in generalizations within a frame of reference. Last, the abductive method is a combination of deductive and inductive methods. It refers to explanatory reasoning in justifying hypotheses that results in the best understanding based on the available data.

In this research, the post-positivist approach has been adopted and is based on an explanatory method with both qualitative and quantitative elements. The explanations are derived through inductive reasoning.

2.3 Research methods

2.3.1 Choice of research method

The case study, as a research method, provides an in-depth and holistic view of a phenomenon (Nilmanat & Kurniawan, 2021) and is used extensively in disciplines with a practical orientation (Nilmanat & Kurniawan, 2021); for example, government, management (Zainal, 2007) and service design (Tax & Stuart, 1997). Case studies explore and investigate real-life phenomena on a detailed level by mapping events and the relationships between them (Zainal, 2007).

Case studies have been classified into various categories by different researchers in an attempt to unify their work and increase understanding. Yin (2014) classified case studies as exploratory, descriptive or explanatory. McDonough and McDonough (1997, in Zainal, 2007, p.3) classified them as interpretive or evaluative and Stake (1995, in Zainal, 2007, p.4) classified them as intrinsic, instrumental or collective.

Research results from case studies are mainly built on analysis. It is, therefore, of utmost importance that a single case study is linked to a theoretical framework (Tellis, 1997, in Zainal, 2007, p.2) and stands on its own, providing a chain of evidence, especially if generalizations are to be made from the findings (Johansson, 2003). Furthermore, case studies offer opportunities to understand a phenomenon in depth and comprehensively by answering the questions: who, what, where, how and why? (Yin 1989, in Easton, 2010, p.119). This makes it possible to trace operational links over time. A characteristic of case study research is the utilization of various sources of evidence and variety in data collection methods (Nilmanat & Kurniawan, 2021), noting that triangulation is important to validate case study research

(Johansson, 2003). The case study builds on a phenomenon, which is the object of the study, and is specific to time and place.

The case study as a research method is widely recognized for in-depth explanations of, for example, social behaviour and can be considered a robust research method when a holistic in-depth investigation is needed (Zainal, 2007). Furthermore, it can be used to capture information in complex situations such as construction projects (Barrett & Sutrisna, 2009; Denscombe, 2010) and is also recommended for refurbishment projects, which are germane to this research and dissertation, since refurbishment projects can be found to be more complex than new-build projects.

The advantages of the case study as a research method are that it describes and explores data in real life, increasing the opportunity to explain complexities which are difficult to capture through experimental and survey research (Zainal, 2007). The examination of data can be conducted within the context of its use. The disadvantages of case studies and criticism concerning robustness have also to be taken into consideration. One particular perspective is that case studies can be complicated to conduct, generating considerable documentation (Zainal, 2007) that must be analysed thoroughly.

The design of case study research is an important consideration if the disadvantages are to be minimized. The case study can build on a single case or utilize a multiple-case design. Single-case design can be used if no other cases are available for replication or if an in-depth longitudinal case is needed for the phenomenon under examination (Zainal, 2007). The case can be chosen randomly or purposefully or analytically selected by virtue of its characteristics, primarily that it is information rich (Johansson, 2003). Furthermore, the purposefully selected case can help to generalize the findings (Johansson, 2003).

The research design adopted in this thesis is an explanatory case study method. The decision was grounded in the tradition and development of research within construction management. The explanatory case study was chosen as it provides an opportunity to examine and explain the data closely on both the surface and on a much deeper level (Zainal, 2007). The design is based on four case studies of which, studies I-III are built on single-cases and case study IV is built on two cases. The case studies are grounded on two projects, which were purposefully and analytically selected. The first project was chosen due to the opportunity to have access to material over a ten-year period, making it possible to study the phenomena over a relatively long timeframe, which is unusual in construction management. The second project was chosen due to access to documentation on a detailed level and created an opportunity to develop a survey questionnaire and conduct interviews. The outline of the research also lent weight to the possibility to include narratives, since this is a medium through which humans often make sense and express their views and understanding (Herr & Anderson, 2005).

Other methods were considered before the case study method was selected. Quantitative methods could have been one choice. However, there already was a large body of literature within construction management built mainly on quantitative research methods for generalizing and categorizing. There is then the need to contribute to filling the present gap in explanations of why a certain phenomenon occurs. The purpose was to find causal relationships, and for this reason, the case study method was more appropriate.

An alternative choice based on a qualitative method could have been action research as it can reveal relationships. Action research has been accepted in applied fields (Herr & Anderson, 2005) and construction management is an applied field. Action research builds on reflective theorizing which, under the impact of positivism seeks to emphasize issues of efficiency and improvement of practices (Herr & Anderson, 2005). Action research was used in the early stages of the research, with reference to refurbishment projects, to try to discern phenomena and situations occurring; for example, helping to explain why decisions regarding design were approved or rejected as would occur during design meetings. Unfortunately, because of the restrictions imposed on the researcher during the participation in these meetings, action research could not be implemented. In addition, ethical aspects of how the research, when published, could impact the construction company's and consultant's relationship with the client was also to be taken into consideration, since construction companies and consultants often depend on the goodwill of clients for their work. So, if this method should be applied, several projects would have been needed for analysis to make sure that the identity of the projects could not be traced. To fulfil such a time-consuming research project would not have been possible, as the design of a single refurbishment could take many years to complete.

A qualitative method, i.e. the case study, was chosen and applied to two refurbishment projects relating to state-owned facilities, one of which was refurbished and repurposed. This choice enabled data from all stages of the refurbishment to be accessible – from briefing to operation and use. The researcher had dealt with facility-related issues for the same tenant in both projects over almost 30 years and had previously been the tenant's representative for both facilities featured in the case studies. This increased the awareness of the routines, access to documents and so enabled understanding to be developed.

2.3.2 Research design

The research was, from the outset, concerned with understanding why shortcomings occur in refurbishment projects with respect to users' working environment. To achieve this, it was planned to analyse the whole process of delivering a refurbished facility. It meant all stages of interest: strategy, briefing, design, construction, commissioning, handover and, finally, facility management (i.e. operation and use).

It is acknowledged that, depending on the location and traditions in the local industry, different terms for the stages in the process for delivering a new or refurbished facility might be used.

The objective of case study I was, in line with this intention, directed at the briefing stage in a refurbishment project (see figure 1). During this case study, it became evident that several of the shortcomings generated during the briefing stage were persisting, with documentation about them available during the facility's management. A decision at this point was to use this opportunity to examine the facility's management directly after the briefing stage, instead of later as planned. Case study II was a consequence of this, concentrating on facility management.

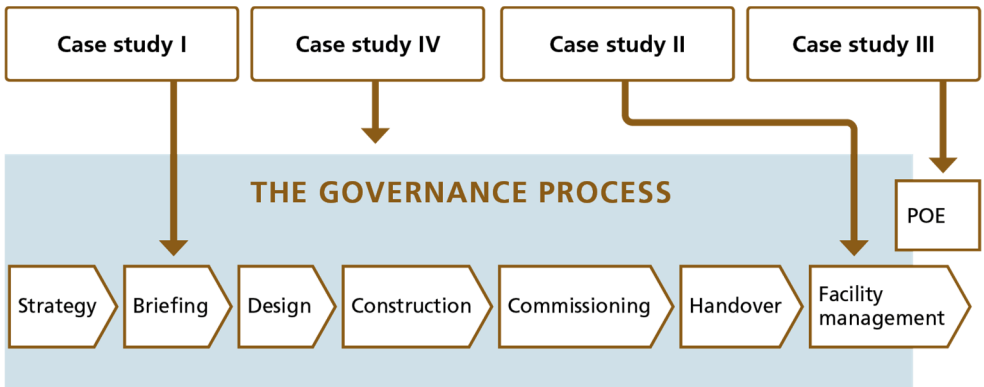

Figure 1: Overview of case studies I-IV related to the project life stages and governance process

Case study II revealed that several of the shortcomings generated during the briefing stage took years before they were resolved as part of facility management. Furthermore, some shortcomings were left unresolved at the end of the study (September 2015), resulting in a long-lasting negative impact on the users' working environment. This case study further revealed that no post-occupancy evaluation was undertaken after the refurbishment. It then seemed appropriate to determine if the use of post-occupancy evaluation could enhance the learning process, both single-loop learning (aiming at fixing a problem) and double-loop learning (aiming at reviewing the refurbishment process and, thereby, improving future refurbishment projects) (Argyris, 2002).

Case study III concentrated on post-occupancy evaluation to determine if, and how, post-occupancy evaluation could contribute, through double-loop learning, to an improved working environment for users. The results of case study III showed that post-occupancy evaluation can help to diminish the negative impact on the users' working environment.

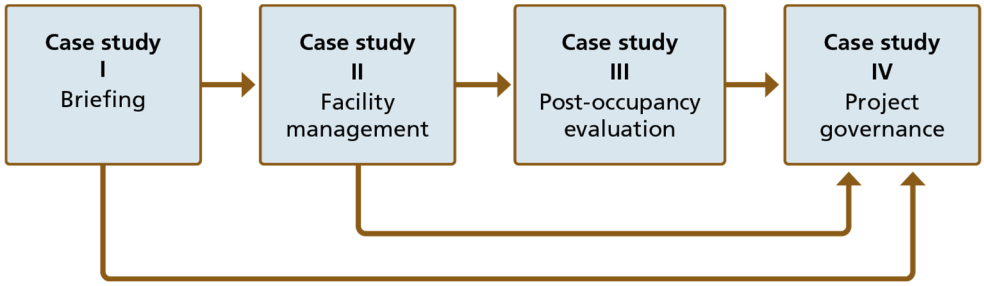

Figure 2: Learning path

Taken together, case studies I, II and III indicated that there was a need for future research concerning the governance process and, therefore, case study IV concentrated on governance (see figure 2).

The research process is summarized in figure 3.

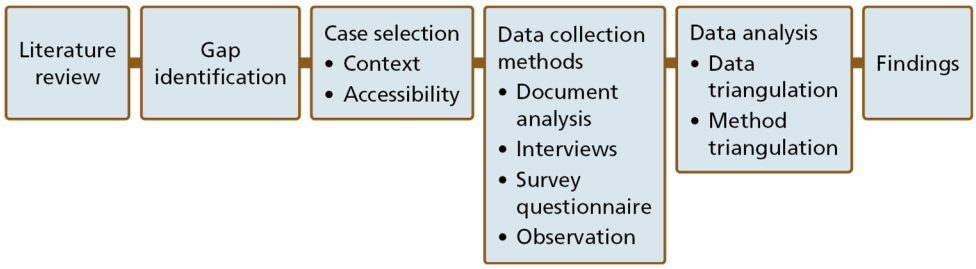

Figure 3: The research process

2.3.3 Literature review

The purpose of the literature review was to establish a theoretical base or framework in the form of a body of theory concerning the phenomenon (Seymour, Crook & Rooke, 1998). The literature review was essential to find the gaps and set the framework against which the phenomenon could be observed and evaluated. A literature review in the form of a survey of scholarly sources (i.e. research papers, theses, conference papers and books) was undertaken to build a body of literature setting the framework of the state of scientific knowledge concerning the process for the delivery of new, refurbished or repurposed facilities.

Literature searches were undertaken continuously throughout the period of the research to find scholarly sources within several different research areas, which directly or indirectly influence the delivery process. Those areas in which adequate research was found were as follows.

1. Facilities – building appraisal, facilities, intelligent buildings, paediatric nursing, real estate, retailing and sustainable built environment.
2. Information – information technology and information management.
3. Management – asset, architectural, business, construction, design, facilities, hospitality, human resource, operations, project, programme, portfolio, safety, service, and service quality management.
4. Project – industrial megaprojects.
5. Social behaviour – behavioural science and social science.
6. Working environment – environmental health, ergonomics, human factors, industrial medicine, paediatric nursing, public health, sound and vibration.

To further strengthen the body of knowledge concerning the delivery process, formal documents such as the recommendations of international bodies, international standards, certification schemes, laws and regulations have been included in the literature review.

The selected literature has been evaluated and searched to find patterns, identify themes, debates and gaps relevant to the researcher's interest in the delivery process.

The lack of strong and simple concepts and principles within the area of the working environment was evident from the literature review. Swedish legislation and the Swedish Code of Statutes, which influence the working environment for users have been included in the literature review, although do not extend to a definition of the working environment. Just one complete definition of the working environment was found and that was published by the World Health Organization (Burton, 2009) – see 3.2.1.

2.3.4 Data collection

Two projects were studied, both were total refurbishment projects undertaken by the same state-owned property company with responsibility for managing facilities used for education and research. Project 1 was a total refurbishment for repurposed use of the building. Project 2 was a total refurbishment where the building was intended to be used for the same purpose after the refurbishment.

This section describes the different techniques for data collection applied in the research: document analysis, survey, interviews and observation.

Document analysis

The word "document" has to be defined first to lay the ground for document analysis. Scott (1990), described document as "an artefact which has as its central feature an inscribed text". O'Leary (2014) described three types of material that can be documents: public records (e.g. ongoing records of an organization's activities); personal documents (e.g. e-mails); and printed evidence (e.g. flyers). Documents

are seen as primary sources that represent factual information (Karppinen & Moe, 2012). Other characteristics of documents are that the data in the documents are found and not created during the research process (Jensen, 2002, in Karppinen & Moe, 2012, p.5) and that they reveal something about the area being researched in an authentic way (Karppinen & Moe, 2012). Document analysis is an iterative process, since one document can lead to another (Pershing, 2002).

Document analysis is used to: choose relevant documentation; assess the credibility of the documentation; reflect on the intentions of the authors; and gain awareness of the context and social surrounding of the documents (Karppinen & Moe, 2012). It is important to be aware that even if documentation reproduces a problem-solving process, it has to be taken into account that the documents can also be a political phenomenon (Freedman, 2008, in Karppinen & Moe, p.12). Documentary material has to be sorted and sifted (Pershing, 2002). The document analysis has to cover frequency and consistencies and inconsistencies of patterns (Pershing, 2002). Tracking is one technique used for document analysis, built on categorizing and counting of numbers of incidents by type; content analysis is another built on coding of the material, i.e. text analysis based on the frequency of words (Pershing, 2002). Since research is always a social activity, it has to be borne in mind that the researcher always interacts even with documentary material by, for example, choice of material and context analysis (Karppinen & Moe, 2012).

Arguments for the use of document analysis are that: it can be the only way to obtain a specific piece of information (Pershing, 2002); documents are regarded as more credible and more objective than questionnaire-based surveys and interviews as documents are historical (Pershing, 2002); it can be a means for tracking change and development; it is not affected by the research process (Pershing, 2002; Bowen, 2009); and, can provide a broad coverage over long time spans (Bowen, 2009). The limitations of document analysis can be: availability of documentation (Pershing, 2002, Bowen, 2009); the quality of the documents (Bowen, 2009); the documents might have been edited to create an organizational record (Pershing, 2002); and they are limited to a historical focus (Pershing, 2002).

Surveys

Surveys are used in both quantitative and qualitative research and typically utilize questionnaires. A questionnaire is “a set of standardized questions, often called items, which follow a fixed scheme in order to collect individual data about one or more specific topics” (Lavrakas, 2008) and which often involves giving an opinion. Questionnaires can provide evidence of patterns amongst large populations (Harris & Brown, 2010). The questionnaire is most often administered in a standardized fashion. The logic behind the standardization of questions and answers is that the stimulus shall be the same for all the respondents (Lavrakas, 2008). A standardized

questionnaire also provides the opportunity to analyse the data quantitatively. The design of the questionnaire as well as the sampling method is therefore important.

Questionnaire-based surveys utilizing non-probability sampling have traditionally been the first choice for data collection within research, but declining response rates can increase the risk of selection bias in cross-sectional studies (Ebert, Huibers, Christensen & Christensen, 2018). Web-based questionnaires have been shown to have even lower response rates than paper-based questionnaires but also slightly lower numbers of missing values, as well as lower costs (Ebert et al., 2018). When sampled by paper or by web, the questionnaire is used asynchronously, with respondents answering and returning the completed questionnaire in their own time. It is, however, possible to use questionnaires synchronously in interviews (e.g. face-to-face in the physical sense or over the telephone and via videoconferencing). Deficiencies in the questionnaire, such as bias in design and wording, can be largely avoided by a pilot questionnaire (Oppenheim, 1992, in Harris & Brown, 2010, p.2). Analysis of the data from a completed questionnaire is clearly important and can take several forms; for example, statistical analysis, drop out analysis, interpretation of the data and decision regarding the exclusion of specific participants and/or items from the data and interpretation of the analyses (Oppenheim, 1992, in Harris & Brown, 2010, p.2).

Interviews

Interviews are a common format of data collection in qualitative research (Jamshed, 2014). A prerequisite to interviews is that the researcher has developed sufficient expertise in the researched area that informed questions can be asked (Qu & Dumay, 2011). Questions to be answered in the design of an interview survey are: choice of interviewees; number of interviewees; type of interview (structured, semi-structured or unstructured); telephone or face to face; and how the interview data will be analysed (Doyle, 2004, in Qu & Dumay, 2011, p.239; Qu & Dumay, 2011). There are practical differences between face-to-face interviews and telephone interviews as the former gives contextual information and can build rapport with the interviewee, while telephone interviews lack these characteristics. It can also be said that the telephone interview eliminates distraction caused by the interviewer's appearance (Farooq & de Villiers, 2017) or other factors such as surroundings. The increasing use of videoconferencing technology does, however, mean that distractions can be easily introduced on both sides. A further issue can be the use of words as they can have different cultural meanings for the interviewee and the interviewer (Qu & Dumay, 2011). A related problem is the power distance between the interviewer and interviewee during the interview (Qu & Dumay, 2011) and the interviewer's desire to create rapport.

Observation

Observation has been used in qualitative research for collecting data about people, processes and cultures (Kawulish, 2005). Together with interviews and document analysis, it has been classified as an ethnographic method (Kawulish, 2005). The use of observation can increase access to information not revealed in, for example, documents as nonverbal expressions, interaction schemes and time consumed for different discussions.

2.3.5 Validity and reliability

The concepts of validity and reliability

The concepts of validity and reliability are rooted in positivism and used in quantitative research to characterize the quality of the research. Validity has been defined as "the ability of research to measure that which it was intended to measure; the truthfulness of the research" (Joppe, 2000). Furthermore, validity means that measurement must be accurate and quantify what is to be measured (Golafshani, 2003). Three different measures of validity are often used: construct validity, internal validity and external validity (Gibbert, Ruigrok & Wicki, 2008; Runeson & Höst, 2009). Construct validity needs to be considered during the data collection stage to reflect on whether or not the measures used were adequate and measured what they were intended to measure. Internal validity refers to the data analysis stage and highlights causal relations, i.e. provision of a plausible causal argument and logical reasoning that can defend the research conclusions. External validity evaluates the extent to which it is possible to generalize (statistically or analytically) from the findings, i.e. are the results valid not only in the setting studied but also in other settings? To show construct validity in case studies, a chain of evidence and triangulation is used. Internal validity in case studies can be strengthened by a clear research framework, matching patterns between case studies and theory triangulation. External validity in case studies can be shown by analytical generalization built on deep clarity about the choice of case and its context. Even so, it has been emphasized that external validity is the measure most frequently used in case studies (Gibbert, Ruigrok & Wicki, 2008). Reliability has been defined as "the extent to which results are consistent over time and an accurate representation of the total population under study" (Joppe, 2000). Reliability implies that the study is replicable (Golafshani, 2003). Replicability can be regarded as an aspect of reliability and has been defined as "the ability to replicate or repeat a study to determine whether the same results can be obtained" (Joppe, 2000).

There is no consensus about how qualitative research should be judged (Rolfe, 2006) and so the concepts of validity and reliability need to be redefined to be relevant in qualitative research (Golafshani, 2003) within the post-positivistic paradigm. Three ways have been pointed out: (1) judging by the same criteria as in quantitative research (i.e. validity, reliability and generalizability); (2) development of new sets of criteria (i.e. truth value, consistency, neutrality and applicability, Noble & Smith, 2015); and (3) questioning the appropriateness of using predetermined criteria (Rolfe, 2006). Some general advice has been found to assist in achieving research validity and reliability within qualitative research: comparing different cases; describing the case selection; describing the context of the cases; ensuring sufficient depth and relevance of data collection and analysis; ensuring interpretation of data are consistent and transparent; describing why things happen, including verbatim descriptions; and applying data triangulation to find convergence. This advice has been used to build the research approach in the case studies.

Triangulation

Triangulation is used to prove the validity of qualitative studies by demonstrating that the findings both reflect the situation and, furthermore, are supported by the evidence (Guion, Diehl & McDonald, 2011). Several types of triangulations can be used: data, investigator, theory, methodological and environmental (Guion, Diehl & McDonald, 2011). Data triangulation uses different sources: investigator triangulation uses several investigators; theory triangulation involves different perspectives by the inclusion of investigators from different fields; methodological triangulation uses multiple qualitative and/or quantitative methods; and environmental triangulation uses different locations or settings, for example, day or season (Guion, Diehl & McDonald, 2011). Triangulation is aimed at providing a more comprehensive picture of the results than can be obtained by a single method (Heale & Forbes, 2013). The outcomes of the different methods used in the triangulation can converge, diverge or be complementary (Heale & Forbes, 2013); still, all three possible outcomes can contribute to increased understanding of a phenomenon. Problems to be considered when using triangulation are the weight of different methods and if the data obtained by the different methods were comparable (Heale & Forbes, 2013). Triangulation has been criticized for being time consuming and built on the assumption that more is better than less (Thurmond, 2001). The researcher needs to reflect on these points when deciding on the approach.

Implementation

The research process can be portrayed in the form of relationships between projects and case studies as shown in figure 4.

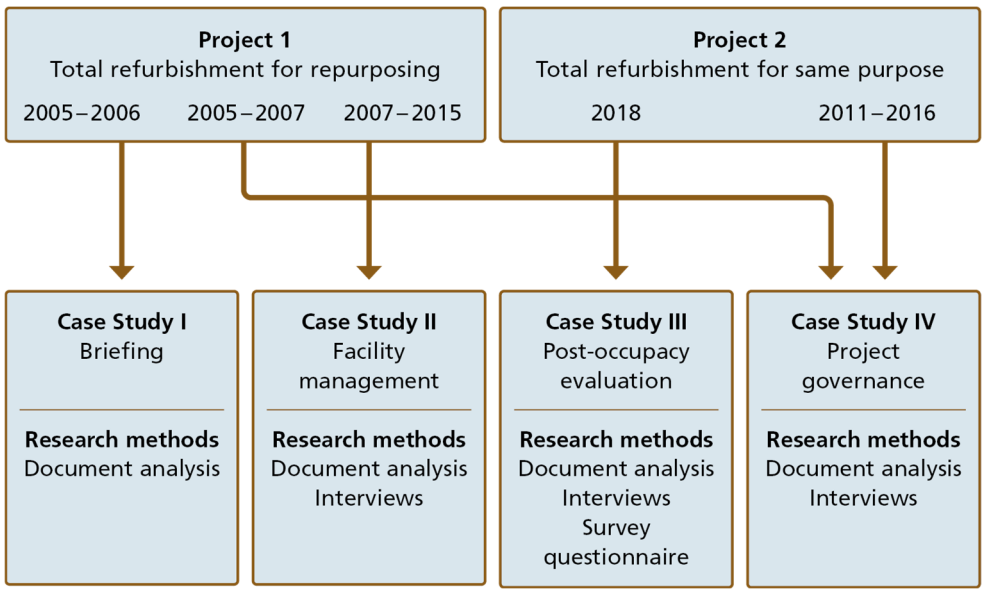

Figure 4: Relationship between projects, case studies and research methods

Implementation of Case study I on Briefing

Observation method was initially used in the beginning of the case study on another project but was rejected due to limited access to the project. On reflection, the presence of the researcher at design meetings and other key discussions might have unduly influenced the performance of the participants. The consequence was that document analysis became the main method in the case study. Later, supplemented by interviews undertaken in Case study II and field observation. Data triangulation was used. To fulfil the requirements for triangulation, data were chosen from different sources originating from the client, the tenant and users. A variety of documents was used: design specifications; minutes from briefing, design and facility management; formal documents and internal documents; and archived material. The minutes were confirmed by the participants.

All documentation was searched for data, which was classified in three areas.

1. General criteria.
2. Land configuration – subheadings: building location and traffic planning (traffic separation system, berthing, parking lots and bicycle parking).
3. Building design – subheadings: premises (classroom, seminar or group room, office and meeting room); other premises (living room, dressing room, cloakroom, sick room, toilet and cleaning room); communication areas (entrances, hall, corridor, staircase and elevator); indoor climate (general climate, comfort, sun screening, cooling, air quality, temperature and ventilation); sound (airborne sound insulation, room acoustics and noise); and electrical installation (substation and lighting).

The data were also classified with respect to the different sources:

- client guidelines;
- tenant guidelines;
- minutes from planning meetings;
- procurement documents;
- minutes from construction meetings; and
- minutes from users' house meetings during operation.

Together, the classifications formed an evaluation chart. The different kinds of material and purposes of the documents increased the opportunity to corroborate findings and thus reduce potential biases.

A separate class for "deficiencies" was inserted in the evaluation chart to record shortcomings and connect them with the different areas.

Implementation of Case study II on Facility management

Data triangulation and methodological triangulation were used in this case study. Document analysis was the main method as this was considered to be the most viable approach to obtain an accurate understanding of events since it referred to facility management between 2007 and 2015. To increase understanding of phenomena observed during the document analysis, five semi-structured telephone interviews were undertaken, recorded and transcribed. The selected interviewees included different types of stakeholders, namely researcher, research student, patent advisor and cleaning personnel. Field observation was also used as a supplement.

Implementation of Case study III on Post-occupancy evaluation

Methodological triangulation was used in the case study. The different methods were document analysis, survey questionnaire and face-to-face interviews. This was possible as the case study was built on more recent material.

Documentation was obtained from the intranet for the whole period of the refurbishment. Document analysis concentrated on clarifying the refurbishment process. No classification of the material was undertaken.

A web-based pilot survey questionnaire was designed and tested on one department before the final design of the survey questionnaire. In addition, an unstructured face-to-face interview was undertaken with one user using the pilot survey questionnaire. In this interview a paper-based version of the survey questionnaire was used. The aim of the interview was to determine if the wording was fully understood and if any questions on areas of interest for users had been missed. The test and interview resulted in changes concerning the wording of specific terms; i.e. building layout, thermal climate and risk level. The survey was undertaken in May and June 2018, two years after reoccupation. The survey questionnaire utilized the *SUNET* survey tool. The link to the survey was distributed by email to the central administrative staff of each department for further distribution to the target respondents: research staff, lecturers, research students and administrative personnel. The survey questionnaire excluded cleaning personnel and librarians as those two groups were so small that their answers would be easy to trace. Additionally, the librarians were restricted to a small part of the building. The survey questionnaire was available in Swedish and English.

The survey questionnaire was statistically analysed in different ways: frequency analysis and factor analysis with the computer program SPSS (Statistical Package for the Social Sciences). To evaluate the frequency analysis a level of 80% occupant satisfaction was chosen for the refurbishment to be evaluated as acceptable. 80% occupant satisfaction is the only evaluation level that has been found in recommendations or certification schemes. Swedish National Board of Health and Welfare (2005), states that if SS-EN ISO 7730 is fulfilled 80% occupant satisfaction with the thermal climate can be expected. The Swedish certification scheme "Environmental building", Manual 3.2 [Miljöbyggnad, Version 3.2] (Sweden Green Building Council, 2022) requires 80% of responding users to be satisfied for the result to be evaluated as acceptable at a response rate of at least 70%, with regard to the indicators noise, ventilation and thermal climate summer/winter. Lately, indices have been developed to evaluate the indoor environment, i.e. Aldren-tail index in which thermal comfort, acoustic environment, indoor air quality and light environment are evaluated (Wargocki, Mandin & Wei, 2019) and Belok (The client group for premises [Beställargruppen för lokaler]), indoor environmental requirements for buildings, mainly focused on the same areas (Belok, 2015). Also available for evaluation of the working environment is SS 807500:2014 (Swedish

Standards Institute, 2014) based on occupational health and safety indicators, developed in collaboration between employers and employees. However, none of these evaluation schemes focus on all the variables included in the case study survey questionnaire (building performance, functionality, comfort and personal control). No established general requirement level can be found for evaluation of all variables included in the survey questionnaire. As a result of this the 80% level is chosen as an evaluation level for all the four groups of questions building performance, functionality, comfort and personal control. The evaluation with the same level with regard to the four groups of questions make the evaluations of the four groups more uniform.

The factor analysis within SPSS was of an explorative type, i.e. factors were not defined at the outset. Factor analysis was used subsequently to describe the data and test any relationships between current variables which could explain the main part of the variation in the variables. In total, seven factor analyses within SPSS were performed – for the different groups of questions in the survey questionnaire (i.e. four for building performance, one for functionality of facilities/services, one for comfort and one for personal control over the working environment). Appendices A1-A4 present the results. Furthermore, the survey questionnaire's single question with regard to eventual effects on work productivity was separately analysed. Appendix A5 presents the result.

Semi-structured face-to-face interviews were undertaken, recorded and transcribed. In all, nine persons were interviewed, with two of them taking part in the same interview. The interviewees included different types of stakeholder: representatives of the project leadership for both the client and users, consultants and the intended users of the refurbished facility (i.e. researcher, research student and cleaning personnel). Analysis of the interviews did not include coding and counting of terms or words of a specific type as the material was limited to nine interviews. Field observation was used as a supplement.

Implementation of Case study IV on Project governance

Data triangulation and methodological triangulation were used. The different methods were document analysis and interviews. The analysis was built on the documents and interviews used in case studies I, II and III. The documents and interviews were analysed again, but this time with respect to the governance process.

2.4 Conclusions

The chapter has considered the methodological aspects of the research and provided the arguments for the choices made during the research design as well as information about implementation. In summary, the research approach has been grounded on a philosophy of post-positivism, case studies, including both qualitative and quantitative methods, with data collection in the form of document analysis, survey questionnaire and interviews to support triangulation and ensure validity and reliability.

3 Theoretical framework

3.1 Introduction

The theoretical framework is built from the literature review. The body of theory consists of results generated from searches of literature within construction-related fields focusing on users within the themes of working environment, project governance, briefing, facility management and post-occupancy evaluation.

3.2 Working environment

3.2.1 Users' working environment

People in developed countries spend most of their time indoors; therefore, it is important that the built environment contributes to the health and well-being of users, i.e. occupiers, service personnel and maintenance personnel, by eliminating or reducing hazards affecting well-being for users.

The World Health Organization (WHO) defined a healthy workplace as "one in which workers and managers collaborate to use a continual improvement process to protect and promote the health, safety and well-being of all workers and the sustainability of the workplace" by considering the following matters:

- "health and safety concerns in the physical working environment;
- health, safety and well-being concerns in the psychosocial working environment including organization of work and workplace culture, and personal health resources in the workplace; and
- ways of participating in the community to improve the health of workers, their families and other members of the community" (Burton, 2009).

The health aspects of users have been highlighted by European Union Directives (European Union Framework Directive, 89/391/EEC; and, European Union Construction Site Directive, 92/57/EEC) and were transposed into Swedish law in 2009 (Aulin & Capone, 2010) in the form of the requirement for a health and safety coordinator responsible for preventing health problems during construction and operation and use SFS 2008:934 (Swedish Code of Statutes, 2008). Similar

legislation exists in other countries within the European Union. The correct functioning of the working environment depends on operations in the form of maintenance (Lee & Scott, 2009) and is influenced by the location and surrounding environment. The users' working environment covers several areas: acoustic comfort, air quality, emissions, lighting, thermal climate, transport paths, workload, functionality and delivery of facility services (e.g. cleaning and security).

3.2.2 Working environment considerations during refurbishment

Occupational health and safety (OHS) is recognized as a key concern in the workplace. Correct attention to the requirements for OHS reduces the threat of harm to people and can result in increased productivity and lower absenteeism (Fernández-Muñiz, Montes-Peón & Vázquez-Ordás, 2009). Requirements are normally included in project governance in high-hazard industries such as chemicals, oil and gas, rail and nuclear. In general, the construction industry pays attention to health and safety, although the focus is the construction stage. Occupational health and safety during construction tends to vary depending on the size of project (Jones, Gibb, Haslam & Dainty, 2019).

The need to take into consideration human behaviour and actions during operation and maintenance has long been evident in the design of equipment (Fadier, 2008). Inclusion of human factors (HF) knowledge has also resulted in optimization of task performance and a reduction in accidents. The same applies to human-centred safe design, a process centred around eliminating workplace hazards by the systematic inclusion of user aspects in the design of equipment, e.g. in high-hazard industries (Horberry, Burgess-Limerick, Cooke & Steiner, 2017). To achieve proactive safety awareness in design (Fadier, 2008), it is important to find out how to ensure operational input and to identify how activities, both routine and non-routine (Hale, Kirwan & Kjellén, 2007), will be performed during the operational phase (Fadier, 2008). No evidence has, yet, been uncovered to show that methods or frameworks having health, safety and hazards during the operational phase as central issues, have found their way into the design of buildings.

Arguments for the low interest in health-related issues for users during construction can include the specific conditions of the construction industry (i.e. project based, temporary structures, multiple tiers of contractors, and unclear responsibility for health issues), that make implementation more complicated , as well as the weak link between health issues and their cause which can be the result of repeated events. For example, awkward postures that can result in repetitive strain injury (RSI).

3.2.3 Indoor environment

User comfort and health are influenced by the indoor environment (Choi, Loftness & Aziz, 2012). Factors having an impact on the indoor environment are air quality, dampness, moisture and flooding, infectious agents and pests, thermal stress, ventilation, weatherization and energy use (Institute of Medicine, 2011), as well as emissions and particulate matter. Health conditions of the users' can also influence the experience of thermal climate; for example, thyroid dysfunction causes higher sensitivity to thermal climate as the production of thyroid hormone is important for thermo-regulation and adaptation to thermal environmental conditions (Castaldo, Pigliautile, Rosso, Cotana, De Giorgio & Pisello, 2018). Evaluation of the indoor environment that builds on technical measurement has long been popular because of the availability of measurement equipment, for example, ventilation flow in ducts. More advanced measurement is available, e.g. Fanger's comfort equation (Givoni, 1998) based on clothing, activity and environmental variables. Nevertheless, these more developed measurements are rarely used within requirements management and the consideration of user needs. Research has instead been built on users' experience of the indoor environment as buildings affect us through our sensory organs (i.e. eyes, ears and thermal sensors) (Szokolay, 2004). Cultural aspects of thermal comfort shall also be taken into consideration (Shove, Chappells, Lutzenhiser & Hackett, 2008). Castaldo et al. (2018) showed that dissatisfaction with comfort differs between seasons.

The literature review revealed that there were shortcomings in several areas:

- Acoustics – research into acoustic comfort is limited. Problems can be divided in two major classes, namely annoying noise and lack of privacy (Al Horr et al., 2016a).
- Air quality – research results relating to users' experience have shown that 33% of workers were slightly dissatisfied, dissatisfied or very dissatisfied with the air quality at their workstations (Choi, Loftness & Aziz, 2012).
- Emissions and particulate matter – within the body of construction-related literature a few papers only have been found that are concerned with how materials can influence users' working environment. Samet & Spengler (2003) discussed chemicals such as phthalates, organophosphates and pyrethroid pesticides and their health consequences. Additionally, Al Horr et al. (2016a) highlighted how high energy-efficiency can result in a low rate of dispelling particulate matter that can affect users' health negatively. The lack of further validated research findings concentrating on design considerations, with respect to the choice of materials and their impact on users' working environment through emissions and particulate matter, means that their ability to influence the development of standards and regulations of practice can be a lengthy process.

- Thermal climate – experience of indoor climate has been shown to depend on the intersection of physiological, psychological and social factors (Chappels & Shove, 2005; Cole, Robinson, Brown & O'Shea, 2008). Variations in environmental conditions are considered to be desirable (original source Steemers & Steane, 2004, in Cole et al., 2008, p.325). The importance of personal control over the indoor climate has been underlined (Brager, Paliaga & de Dear, 2004; Boerstra, Beuker, Loomans & Hensen, 2013). At the same time, it is important to recognize that today's standard (Swedish National Board of Health and Welfare, 2005) mandates 80% occupant satisfaction with the thermal climate to qualify as acceptable.

3.2.4 The working environment's influence on productivity

Production builds on factors necessary to produce goods and services. Traditionally, these factors are divided into three main groups: capital, work and natural resources. The production factor of capital includes fixed capital, for example facilities. Fixed capital has a direct impact on productivity but also indirectly through work which affects our well-being, for example, facility management and, hence, productivity (Miller, Pogue, Gough & Davis, 2009; Clements-Croome, 2015).

The definition of the healthy workplace is closely linked to Maslow's hierarchy of needs. The model can be used to explain how workers are motivated to work. Maslow's hierarchy is based on five different levels (i.e. physiological, safety, love/belonging, esteem and self-actualization). The lowest level must be fulfilled before the next level is triggered. The rationale is that physiological needs such as an acceptable indoor temperature must first be fulfilled before a worker can start to produce. On the highest level, self-actualization is needed in order for employees to work at the peak of their potential (Kaur, 2013). Duncan and Blugis (2011) used Maslow's hierarchy of needs as a conceptual framework to understand how a facility should function to fulfil users' needs. This is in line with other research results. For instance, Clements-Croome (2013) showed that fixed capital has the opportunity to influence the levels of physiological and safety needs and Kaur (2013) highlighted self-actualization. Inclusion of aspects such as occupational health and safety are recognized as resulting in increased productivity and lower absenteeism (Fernández-Muñiz, Montes-Peón & Vázquez-Ordás, 2009) and are normally included in project governance in high-hazard industries.

Research papers in which productivity is central are uncommon due to the difficulty of measuring increased productivity, especially in office work, as it is problematic to measure content and quality of work. Even so, the results show that the built environment can influence the productivity and well-being of users. Ulrich, Quan, Zimring, Joseph and Choudhary (2004) undertook a literature study concerning healthcare environments in which it was shown that improving workplaces can

increase users' effectiveness and improve outcomes. Parish, Berry and Lam (2008) have also shown that the design of the facility can have an effect on job satisfaction and employee commitment, and that the design of a specific place used for intense service work can be especially important. Specific areas, for example air quality and thermal climate, have also been shown to influence productivity.

Findings by Wargocki, Wyon and Fanger (2000) imply that doubling the outdoor air supply (given constant pollution load) could increase productivity by 1.9%. For example, in a call-center, installation of new filters in the ventilation decreased work time by 10% for performance of a given task (Wargocki, Wyon & Fanger, 2004). The Rehva Guidebook, No.6 (Wargocki & Seppänen, 2007) established that performance can be reduced by 5-15%, due to thermal conditions within the comfort zone. Geng, Ji, Lin and Zhu (2017) demonstrated a quantitative relationship between productivity and the thermal environment in that relative productivity decreased approximately 8% as a result of thermal discomfort when the air temperature was either too high or too low.

In a case study by Niemelä, Rautio, Hannula and Reijula (2002), it was shown that the renovation of a storage facility with an emphasis on thermal conditions, air quality and lighting increased labour productivity by 9%. More recently, Geng et al. (2017) showed that when the thermal environment was unsatisfactory, the comfort expectations of lighting and acoustics were lower, resulting in less dissatisfaction. Interestingly, once satisfaction with the thermal environment had been achieved, dissatisfaction with lighting and acoustics increased, which aligns with Maslow's theory. The risk of sick leave has been shown to increase by 35% with lower outdoor air supply rates (Milton, Glencross & Walters, 2000). Miller et al. (2009) found that healthy facilities reduced the amount of sick leave and increased productivity.

More recently, Al Horr, Arif, Kaushik, Mazroei, Katafygiotou and Elsarrag (2016b) found that thermal comfort, indoor air quality, layout, noise and acoustics affected users' productivity in offices. The physical environment's impact on productivity is further strengthened by the methods used to measure productivity developed by Clements-Croome and Baizhan (2000) and Geng et al. (2017).

3.2.5 Research gap concerning users' working environment

A gap between users' needs and the as-built facility has been highlighted in several studies (Kaya, 2004; Elf, Svedbo Engström & Wijk, 2012; Pegoraro & Carisio de Paula, 2017). The reason is a lack of understanding of the required operational performance, especially regarding the working environment. Performance is defined in ISO 21932:2013 as "ability to fulfil required functions under intended use conditions or behaviour when in use" (International Organization for Standardization, 2013b) and in ISO 15928-5:2013 as "behaviour of houses related to user needs" (International Organization for Standardization, 2013a).

Lindahl and Ryd (2007) have also argued for greater attention to users' needs during briefing. Here, there is a weak link between facilities and human-use factors (Vischer, 2008). Facilities are an essential asset for the development of organizations and the working environment (Jensen, 2006) and so they must perform as expected in operation and use.

3.3 Project governance

3.3.1 The project governance concept

Project governance is defined in ISO 20700:2017 as "system by which an organization makes and implements decisions in relation to projects" (International Organization for Standardization, 2017c) and in ISO 21506:2018 as "principles, policies and procedures by which a project is authorized and directed to accomplish agreed deliverables" (International Organization for Standardization, 2018a). ul Musawir, Abd-Karim and Mohd-Danuri (2020) describe project governance as a system that provides oversight of the project management system. The emphasis is on the institutional environment of project management, the whole lifecycle of the project and beyond (ul Musawir, Abd-Karim & Mohd-Danuri, 2020), the value creation from the use that the project is intended to enable (Hjelmbrekke, Klakegg & Lohne, 2017) and the achievement of both project (strategic level) and project management (tactical level) success.

3.3.2 The project governance tradition

Project governance is recognized as of utmost importance for project achievement (ul Musawir, Abd-Karim & Mohd-Danuri, 2020). Project governance can be structure based or relationship based (Hjelmbrekke, Klakegg & Lohne, 2017). Structure-based governance concentrate on formal elements, i.e. approval process, stakeholder representation, formal roles and responsibilities; whereas, relationship-based governance concentrates on non-hierarchical elements, i.e. leadership, involvement of stakeholders and informal relations and communication (Hjelmbrekke, Klakegg & Lohne, 2017) (see table 2).

Table 2: Project governance (after Hjelmbrekke, Klakegg & Lohne, 2017)

Project governance	
Structure based	Relationship based
– Hierarchical – Approval process – Stakeholder respresentation – Formal roles – Responsibilities	– Non-hierarchical – Leadership – Involvement of stakeholders – Informal relations – Communication
Adaptation with regard to: complexity, level of risks, purpose of projects and number of involved organizations.	

The importance of project governance being adapted to the specific project is underlined by ul Musawir, Abd-Karim and Mohd-Danuri (2020), who regarded complexity, level of risk, purpose of project and number of involved organizations as key factors. Furthermore, attention should be drawn to the project's objectives and the use to which the deliverable (i.e. facility) is able to fulfil its purpose (ul Musawir, Abd-Karim & Mohd-Danuri, 2020). Issues to be avoided include the project being undertaken by external resources that are unaware of the success factors related to the project owner's goal(s) (Hjelmbrekke, Klakegg & Lohne, 2017) and participants in the project being without power over who to work with and also having limited experience of working together (Svalestuen, Frøystad, Drevland, Ahmad, Lohne & Lædre, 2015). Different theories are involved in project governance, for example, agency theory on the project level and stakeholder theory on the organizational level (ul Musawir, Abd-Karim & Mohd-Danuri, 2020), where the latter applies to users as a key stakeholder group. The responsibility on the tactical level rests with the project manager defined in ISO 6707-2:2017 as the "person appointed by the client to manage the design and construction work for a building or civil engineering works" (International Organization for Standardization, 2017a). Project managers have traditionally concentrated on the iron triangle (i.e. cost, time and quality objectives) (Ika, 2009) and technical processes and not on stakeholders' needs (McLeod, Doolin & MacDonell, 2012). Nowadays, it is normal to analyse customer satisfaction and how to achieve a project's strategic objectives (Badewi, 2016).

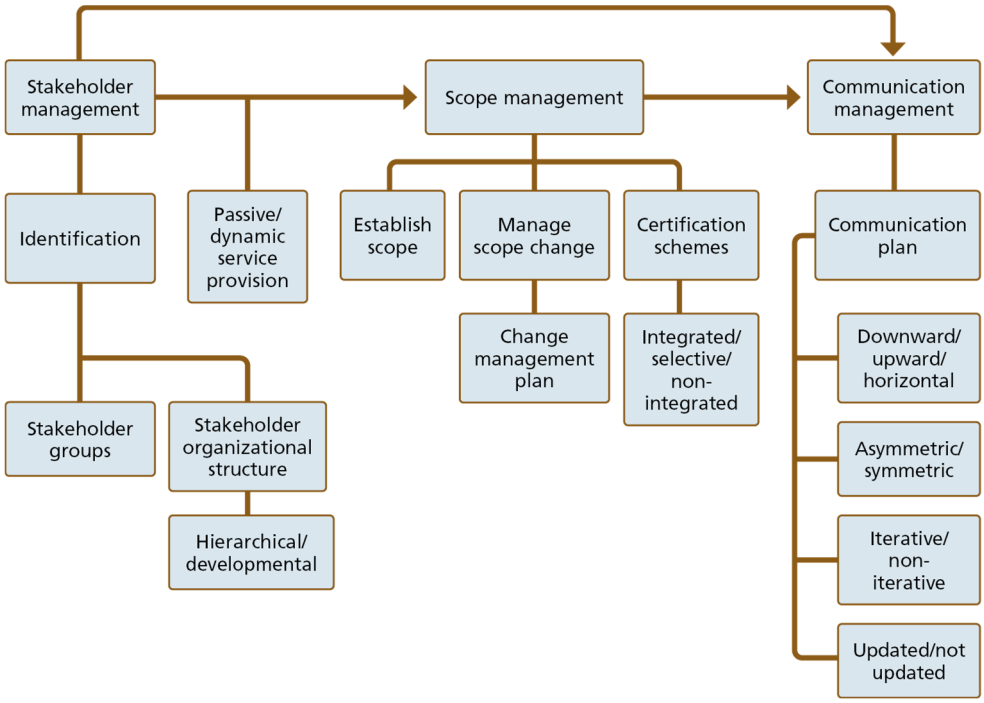

Figure 5: Model relationships between concepts in project governance

Project governance deals with three main concepts in regard to management: stakeholder management, scope management and communication management. These concepts and their interrelation are summarized in the model shown in figure 5. The three concepts as described in the literature review will be separately analysed.

3.3.3 Stakeholder management

To reveal the requirements that lay the ground for determining the scope of a project necessitates stakeholder contribution. Stakeholders are creators and targets of value (Derakhshan, Turner & Mancini, 2019), as well as decision makers accountable to higher-level management (Too & Weaver, 2014). Identification of stakeholders, their involvement (Sharma & Lutchman, 2006) and communication with them (Yu & Kwon, 2011) has become a matter of significant interest given the requirement to capture users' needs both at the front-end and during the project, and to capture any changing needs as they are translated into deliverables (Waheed & Ogunlana, 2019). All stakeholders need to be accounted for and considered before defining requirements (Mirza, Pourzolfaghar & Shahnazari, 2013). Passive involvement of stakeholders in requirements management results in the likelihood of an increased need for change (Farok & Garcia, 2016). The most influential stakeholder is the

owner. Stakeholders identified as key brokers of users' knowledge are the project sponsor and facilities manager (Waheed & Ogunlana, 2019). Conscious or unconscious omission of input from any stakeholders can result in an incomplete project scope definition, which can also be the result of unbalanced involvement of stakeholders (Sharma & Lutchman, 2006). The importance of stakeholder management including individuals and minorities has been highlighted (Plummer & Taylor, 2004, in Oppong, Chan & Dansoh, 2017, p.1045), as well as equal opportunity and ability to articulate needs and expectations. Conflicts between stakeholder interests have to be managed to avoid future change (Yu & Kwon, 2011).

Two different ways in which stakeholder management can capture the essence of stakeholders' needs are suggested: passive or dynamic service provision (Farok & Garcia, 2016). In passive service provision, the stakeholders tell the project management what they need; in dynamic service provision, the project management works with the stakeholders to establish their needs (Farok & Garcia, 2016). Inclusion of co-creation and service design has been mentioned as one way to improve the result of projects (Bettencourt, Lusch & Vargo, 2014) and especially the result of construction projects (Fuentes, 2019). Molwus, Erdogan & Ogunlana (2020) found that procurement routes which facilitate stakeholder management are built on clear assignment of responsibilities, cooperation among stakeholders, control and communication. The importance of these areas has also been highlighted by Derakhshan, Turner & Mancini (2019), while Yap, Leong & Skitmore (2020) underlined the importance of handling of team dynamics.

3.3.4 Communication management

The communication process and the communication management during the construction project has been regarded as highly influential in the success of construction projects (Xue, Wang, Shen & Yu, 2007; Ye, Jin, Xia & Skitmore, 2014; Senaratne & Ruwanpura, 2016). Furthermore, communication has been held up as a source of problems in construction projects (Ceric, 2014; Fageha & Aibinu, 2013) as the gaps in communication cause incomplete requirements which in turn result in project scope deficiencies (Bjarnason, Wnuk & Regnell, 2012, in Ajmal, Kahn & Al-Yafei, 2020, p.488). Good communication amongst the different stakeholders, especially users, plays a key role in project success (Rose, Engelund Thomsen, Domingo-Irigoyen, Bolliger, Venus, Konstantinou, Mlecnik, Almeida, Barbosa, Terés-Zubiaga, Johansson, Davidsson, Conci, Mora, Ferrari, Zagarella, Sanchez Ostiz, San Miguel-Bellod, Monge-Barrio & Hidalgo-Betanzos (2021). Different stakeholders have different beliefs of how the transmission of project culture takes place and the ways in which it can influence the project (Samaraweera, Senaratne & Sandanayake, 2018).

The communication process is iterative and includes both social and technological perspectives (Senaratne & Ruwanpura, 2016). It includes a large amount of information in a wide variety of document formats, i.e. drawings, cost analysis sheets, contract documents and planning schedules (Xue et al., 2007). The information can also be asymmetric, i.e. the different parts in the process do not have access to the same information at the same time (Ceric, 2012). Information flow in three directions (downward, upward and horizontal) has to be considered (Lunenburg, 2010, in Senaratne & Ruwanpura, 2016, p.5). Also to be taken into consideration are the legal aspects resulting in the need for written documentation, the preference for face-to face meetings with verbally communicated information and the chance of information overload (Senaratne & Ruwanpura, 2016). In the communication process, five steps have been recognized: stakeholder identification, development of the communication plan, distribution of information, stakeholder management and performance reporting (Senaratne & Ruwanpura, 2016).

The communication plan is intended to support the achievement of consensus and satisfaction, as well as realistic stakeholder expectations. Project preparation in the form of a communication plan with the inclusion of relation-building between project management and stakeholders, and information exchange is recommended by Ajmal, Kahn and Al-Yafei (2020) and its importance has been underlined by Badewi (2016). El-Sawalhi and Hammad (2015) highlighted the importance of stakeholder involvement for two-way communication. During the development of the communication plan, consideration should be given to differences in stakeholders' organizational culture (i.e. hierarchical or developmental) as this can affect communication (Butt, Naaranoja & Savolainen, 2016). Project culture is not static during the project lifecycle (Loo, 2002) and so the communication plan needs to be kept up to date (Butt, Naaranoja & Savolainen, 2016). Improper stakeholder management can result in stakeholders experiencing alienation and resentment towards the project (Alami, 2016).

3.3.5 Scope management

The project scope sets the formal and confirmed boundaries of the project. A definition of project scope is in ISO 21506:2018 "authorized work to accomplish agreed deliverables" (International Organization for Standardization, 2018a). To define the scope, a process that builds on the collection of prerequisites and requirements is needed. The scope definition process is iterative (Kumari & Pillai, 2014) and is concerned with identifying, prioritizing and quantifying purpose, goals and [translating] requirements into deliverables (Alp & Stack, 2012; Kumari & Pillai, 2014; Farok & Garcia, 2016). During the scope definition process, all stakeholders have to reveal their requirements (Kerzner, 2006, in Ajmal, Kahn & Al-Yafei, 2020, p.485). Complex requirements must be analysed to reduce the complexity of the project (Alami, 2016). Complete, rigorous and documented

requirements are the core of scope definition (Dekkers & Forselius, 2007). Mirza, Pourzolfaghar and Shahnazari (2013) point at real needs as the central point of the investment in a project. The project definition process ends in a formal project scope statement, which is defined in ISO 21506:2018 as a "documented detailed description of a project scope" (International Organization for Standardization, 2018a). The statement can include, for example, project scope, major deliverables, assumptions and constraints.

Mirza, Pourzolfaghar and Shahnazari (2013) highlight the difference between project scope and product scope. The project scope focuses on how to create the project deliverables and is measured against the project plan (Mirza, Pourzolfaghar & Shahnazari, 2013). Product scope, as a part of the project scope, focuses on the attributes and characteristics of the deliverables and is measured against the requirements (Mirza, Pourzolfaghar & Shahnazari, 2013). When the project scope statement is agreed, project scope management starts. The definition of project scope management in ISO 24765:2017 is "project scope management includes the processes required to ensure that the project includes all the work required, and only the work required, to complete the project successfully" (International Organization for Standardization, 2017d). It is also important to identify and take into account external drivers in the specific context of, for example, regulations, standards and laws when preparing the project scope (Mirza, Pourzolfaghar & Shahnazari, 2013).

Project management has evolved through standardization resulting in different management systems and their associated certification schemes, analysing different aspects of scope, for example, quality management, environmental management, occupational health and safety management (Wiengarten, Humphreys, Onofrei & Fynes, 2017). There is also a difference between how these different management systems might be used during construction, i.e. integrated, selective integration or non-integration (Chountalas & Tepaskoualos, 2019), with some evidence of management systems being integrated. Wiengarten et al. (2017) found support for this tendency in the award of triple accreditation (ISO 9001, ISO 14001 & OHSAS 18001, which has been replaced by ISO 45001) albeit in manufacturing industry. Integration of different management systems can, however, result in reduced attention being paid to the central areas within the individual management systems, i.e. quality, occupational health and safety (Chountalas & Tepaskoualos, 2019).

The main purpose of scope management is to capture and keep control over the requirements of the project (Tsiga, Emes & Smith, 2017). Scope management is concerned with the analysis and approval of changes in the project (Nahod, 2012). It consists of strategic and operational management. Strategic management considers the initial project stages, establishing guidelines for operational management and scope change during the project (Nahod, 2012). Operational management concentrates on tactical, operational and interface layers in the project (Nahod, 2012).

The major components in scope management are establishing the scope, managing scope change, verifying the scope (Pheng, 2018) and getting the scope and any changes approved by all affected stakeholders (Kumari & Pillai, 2014). As changes are a feature of projects, it is important that they are categorized correctly (i.e. scope change or non-scope change). Non-scope changes (e.g. the cost of something increases beyond that estimated) can impact significantly on time and budget if there are enough of them. All changes to the scope should be evaluated and approved before being implemented (Hao, Shen, Neelamkavil & Thomas, 2008). A change management plan that covers the whole change process from the request for change to close-out of the change has to be established prior to project definition. The change management plan needs to prescribe procedures for the verification of proposed changes and their impact on the project scope (Nahod, 2012). The effects of change and scope creep are usually concentrated on tangible aspects such as the project objectives and their impact on time and cost (Sun & Meng, 2009). Although, change can also influence more intangible aspects as occupational health and safety (Sun & Meng, 2009).

Scope change has been defined in ISO 24765:2017 simply as "any change to the project scope" (International Organization for Standardization, 2017d). A more meaningful definition would be "any alteration to the approved baseline of the project", where baseline is the reference level for the project's agreed scope, time and cost. Scope change is a formal decision initiated by the project sponsor or other key stakeholders to expand, reduce or alter the project scope. A scope change often necessitates adjustment of the project cost/budget or time/schedule. An extensive scope change includes the unfreezing of existing project scope, applying the change and refreezing the new project scope. Projects in construction are prone to a high degree of scope change (Sun & Meng, 2009). Change usually emerges as the result of a combination of causes and an effect of that can result in dispute over responsibility for the change between different stakeholders (Sun & Meng, 2009). It has been noted that stakeholders, especially users, are rarely informed about change and have insufficient understanding of the consequences of it (Butt, Naaranoja & Savolainen, 2016).

Two root causes of change are poor involvement of stakeholders and poor communication. Other causes of change are design errors and omissions (Sun & Meng, 2009). Inexperienced clients are more prone to cause late changes (Sun & Meng, 2009). The effects of change and scope creep can influence both upstream and downstream processes and activities, and all have to be taken into consideration.

Scope creep is referred to as the phenomenon where the agreed project scope changes gradually without formal scope change. The International Organization for Standardization (2018a) has defined it in ISO 21506:2018 as "unauthorized and uncontrolled increases to the project scope". Scope creep can emerge as a result of poorly defined scope (Farok & Garcia, 2016), inadequate management and control, dysfunctional communication (Ajmal, Kahn & Al-Yafei, 2020) and insufficient

involvement of stakeholders when preparing the scope definition (Yu & Kwon, 2011, in Ajmal, Kahn & Al-Yafei, 2020, p.488). It usually happens slowly during the project. A related issue is scope discovery, which results from the identification of necessary scope that has been omitted from the agreed (i.e. frozen) scope. This can occur through carelessness, but also from scope that was excluded in the belief that it would not be necessary.

3.3.6 Research gap concerning project governance

Project governance can help close the strategy-to-performance gap and increase the performance of projects (Mankins & Steel, 2005). Yet, little research has been undertaken concerning project governance within construction (Hjelmbrekke, Klakegg & Lohne, 2017) and, where it has, it has tended to be fragmented (ul Musawir, Abd-Karim & Mohd-Danuri, 2020). In construction, the emphasis has been on delivering the product and not how the facility or facilities support the needs of its users. The need to study project governance both at the front-end and back-end of projects has been pointed out (ul Musawir, Abd-Karim & Mohd-Danuri, 2020). One important part of project governance is change management; even so, research concerning change management in construction projects is especially limited (Hao et al., 2008). There have been few studies on either the impact of scope on project success (Mirza, Pourzolfaghar & Shahnazari, 2013) or scope creep (Shirazi, Kazemipoor & Tavakkoli-Moghaddam, 2017). None has been found concerning the impact of governance on users' working environment. Even so, there is awareness of the problems (e.g. effects of poor project management, destructive team behaviours, weak accountability systems, short-term achievement and lack of investment in technical expertise) (Merrow, 2011).

3.4 Briefing

3.4.1 The briefing concept

The brief can be regarded as an information carrier (Ryd, 2004) that builds on interaction (El Reifi, Emmitt & Ruikar, 2014), communication and learning, including cultural learning, as well as reflective learning (Thomson, 2011). There are several definitions of briefing; for example, a "process of identifying the needs, aims and constraints (the resources and the context) of the client and the relevant parties, and of formulating any resulting problems that the designer is required to solve" (British Standards Institution, 2015); "the process running throughout the construction project, by which means the client's requirements are progressively captured and translated into effect" (Barrett & Stanley, 1999); "the process of gathering, analysing, and synthesising information needed in the building process

in order to inform decision-making and decision implementation" (Kelly & Duerk, 2002) and "a front-end process which deeply explores opportunities and understands who the client is and what he/she needs, as well as revealing how those needs will be answered" (El Reifi, Emmitt & Ruikar, 2014). Kelly and Duerk (2002) use two levels of briefing, strategic briefing and project briefing. The strategic briefing focus on identification of the goal of the project and project briefing focus on gathering facts concerning the building project (e.g. the context in which to design) (Kelly & Duerk, 2002).

3.4.2 The briefing process

Nutt (1993) suggested strategic briefing and a division into different briefs: one to cover the pre-design process and others to cover design, construction and commissioning, and post-occupancy evaluation. Relevant parties in the project include the owner/client, designers, constructor(s), suppliers and users, with the latter categorized into groups. Vischer (2008) identified three such groups of users (of office buildings): individual, workgroup and organization. Christiansson, Svidt, Pedersen and Dybro (2011) also included service providers and operational and maintenance (i.e. service) personnel. It is necessary to identify all stakeholders (Shen, Li, Chung & Hui, 2004) and be aware of the impact of the differences between them (Olander, 2007) and the likelihood of conflicting requirements (Christiansson et al., 2011; Newell, Gregor, Morgan, Pullin & Macaulay, 2011; Olander & Landin, 2005), as well as different value systems, power and interest (Olander & Landin, 2005). Emergent internal requirements must be identified and negotiated too (Thomson, 2011). Internal conflicts should be allowed to develop so that they can be resolved. It is important to make issues visible and tangible and, as a result, facilitate discussion and decision-making within design teams and between designers and users (Newell et al., 2011).

The importance of providing time for social interaction and knowledge sharing in the briefing stage among stakeholders to construct a common understanding of the project has been highlighted (Chandra & Loosemore, 2011; Thomson, 2011). The intention is to map the users' absorptive capacity and capture their axiomatic knowledge. Absorptive capacity was defined by Cohen and Levinthal (1990) as prior related knowledge needed to assimilate and use new knowledge and has been used frequently in innovation work, i.e. how knowledgeable different stakeholders are to absorb information from drawings.

Axiomatic knowledge is one of four parts in the classification of cultural knowledge in organizations (Sackman, 1992) concerned with understanding the 'why', not just the descriptive 'what' and 'how'; i.e. why do you need a working room with low noise level? Axiomatic knowledge is regarded as the hardest to observe, acquire and decipher (Chandra & Loosemore, 2011). Axiomatic knowledge and its transfer are

considered to be central to the briefing process and vital for the cultural learning process (Bood, 1998; Chandra & Loosemore, 2011). To extract axiomatic knowledge and translate it into a consistent design, Christiansson et al. (2011) argued that it required a systematic and coherent approach to user involvement. It is necessary to understand the user's background, surroundings and future use of the building and to organize a design process where user needs are incorporated at the appropriate point. Although these factors have long been known, far more effort must be put into briefing to ensure that the needs of users are properly considered (Lindahl & Ryd, 2007). This was further underlined by Mokariantabari, Adnan, Hussin, Abidin, Baharuddin and Ismail (2019), who showed that the highest rank of complexity in briefing for refurbishment was "lack of client's knowledge and ambiguity of client's needs".

In searching for arguments that can explain the lack of interaction with users, Jensen, Alexander and Fronczek-Munter (2011) referred to a European facility management standard (European Committee for Standardization, 2006) in which interaction takes place on different levels: the client on the strategic level, the customer on the tactical level and users on the operational level. This simple categorization helps draw an important distinction between the different stakeholders in a facility. In addition, Soetanto, Dainty, Glass and Price (2006) saw the need to consider behavioural competencies, such as negotiation and communication, to better capture and understand the needs of users.

3.4.3 The briefing tradition

The use or refurbishment of a specific facility is driven by an organization's objectives and intentions with the organizational characteristics contributing to the concept of usability of the resultant working environment (Jensø, Hansen & Haugen, 2004). Traditionally, briefing has centred on design considerations, with little thought for the impact on construction (i.e. buildability) and operation and use (i.e. operability). Similarly, the construction process centred on delivery on time and within budget, instead of achievements with regard to the value of the outcome (El Reifi, Emmitt & Ruikar, 2014). This has resulted in impacts on human health being overlooked, resulting in suboptimal indoor environment and unhealthy interior materials (Loftness, Hakkinen, Adan & Nevalainen, 2007). To add weight, evaluations of performance have been built on conventional perception studies that concentrate on one sensory mechanism omitting the user's total experience of the facility (Vischer, 2008). There has, though, been a move towards briefing that emphasizes the use of the facility (Alexander, Fenker, Granath, Haugen & Vissanen, 2004; Christiansson et al., 2011; Ryd, 2003). All the same, there were prior to 2008 no theories relating to users and user's experience, at least none that might be regarded as sufficiently robust (Vischer, 2008).

3.4.4 Governance of the briefing process

The governance of the process for delivering a new or refurbished facility should be set out at the beginning of the project by a framework that fixes the organizational structures, decision rights, knowledge governance (Foss, 2007) and change management (Steffens, Martinsuo & Artto, 2007). Change during the project process is almost unavoidable and the change management process, including recognition of change, evaluation of the change impact and change implementation, has to be considered (Steffens, Martinsuo & Artto, 2007). Isaac and Navon (2009) noted that project teams often implemented changes without understanding the impact on the final product. Given the greater complexity encountered with refurbishment projects, it is essential to understand the current state of the building, especially its condition and constraints (van Leuween, de Vries & van den Oetelaar, 2000).

An important aspect of project management is requirements management, which involves the identification and documentation of stakeholders and how their needs should be communicated and implemented. Relevant documentation should be grouped into two parts: a user requirements document and a system requirements document. The user requirements document is an all-embracing, structured expression of users' needs for a bounded operational capability (Ministry of Defense, 2002).

3.4.5 Research gap concerning briefing

Historically, briefing was embedded in design. The greater visibility now given to briefing is a response to the longstanding dissatisfaction with the low priority accorded to the needs of a facility's users (i.e. entities on the organizational as well as individual level) and other key stakeholders. As Jensen (2006, 2011) has pointed out, there must be user participation in the project for delivering a new or refurbished facility from the outset. Bruce and Cooper (2000) noted that user participation directly affects subsequent cost. Changing the brief after it has been finalized also has an impact on time and risk (Othman, Hassan & Pasquire, 2005). Further evidence of the inadequacy of briefing and its links to failures in the operation and use stage has been reported many times over the years (see, for example, Barrett & Stanley, 1999; Kamara, Anumba & Evboumwan, 2001; Shen et al., 2004; Yu, Shen, Kelly & Hunter, 2007). Practical guidance on briefing has tended to assume new-build projects, whereas a sizeable proportion of projects involve refurbishment. These projects are generally regarded as attracting higher risk than new-build projects and are often more complex (Lee & Egbu, 2005). Complex projects are also difficult to govern (Jallow, Demian, Baldwin & Anumba, 2014). Few studies can be found concerning complexity and uncertainty factors in the briefing stage for refurbishment projects (Mokariantabari et al., 2019).

3.5 Facility management

3.5.1 The facility management concept

Previously, buildings were maintained, serviced, cleaned and there was no explicit role that embraced the softer side of an organization's support services and concern for the well-being of users. Facility management can be recognized as: (1) the technical, legal and financial management of property to create space with service (Hansson, Olander & Christiansson, 2009); (2) a custodian of the workplace and workspace environment (Then, Tan, Santovito & Jensen, 2014); (3) support for the working environment of users (Chotipanich, 2004); and, (4) providing the operational environment needed to support and enhance an organization's core business processes and activities (Atkin & Brooks, 2021). Another definition of facility management is in ISO 41011:2017 the "organizational function which integrates people, place and process within the built environment with the purpose of improving the quality of life of people and the productivity of the core business" (International Organization for Standardization, 2017e). A further definition which, in this case, acknowledges the importance of the core business is the "integration of processes within an organization to maintain and develop the agreed services that support and improve the effectiveness of its primary processes and activities" (British Standard Institution, 2015).

Facility management has also been described as a support function with similarities to finance, IT and human resources (Then et al., 2014) and the workplace or workscape as part of strategic human resource management (Price, 2004). Financial management concentrates on strategic issues such as portfolio management, facility planning and development (Chotipanich, 2004) aimed at obtaining the highest net profit from property through its lifecycle. Facility management has been criticized for an over-concentrating on cost and, as a consequence of that, being unable to express its contribution to the core business (Price, 2004).

A critical issue in facility management practice is the business sector in which the organization is placed (Price, 2004; McLennan, 2004), which can be divided into four sectors according to business impact and technological complexity and risk: (1) higher and faster business impact and high technological complexity and risk, for example hospitals; (2) slower or indirect business impact and high-technological complexity and risk, for example power plants; (3) higher and faster business impact and low technological complexity and risk, for example hotels; and (4) slower or indirect business impact and low technological complexity and risk, for example offices (Price, 2004). Complexity, high costs and challenges in hospitals and hotels have been a spur to the development of facility management (Loosemore & Hsin, 2001), while the office sector generally lags behind (Price, 2004).

3.5.2 Alignment with the core business

The importance of the idea of aligning or linking facility management to the core business of the organization, using the facility to increase the strategic relevance of facility management, has been long promoted (see, for example, Loosemore & Hsin, 2001; Green & Jack, 2004; Nutt, 2004; Osgood Jr, 2004; Then et al., 2014). Included in the alignment concept are physical facilities, support services and intangibles such as mission, vision, values, culture and competencies (Osgood Jr, 2004). The purpose of the alignment concept is to achieve synergy (Kaplan & Norton, 2006, in Then et al., 2014, p.81). The alignment process must, however, be managed proactively, continuously and be assessed with respect to conformity of, for example, demand and supply, service, resources and organizational alignment (Then et al., 2014). In this sense, alignment is described as both active and passive. Active facility management alignment exists when the facility management is fit for purpose and when it and the users' organization move together in the same direction, supporting a common purpose. On the other hand, passive facility management alignment builds on the absence of conflict between the facility management and the users' organization (Then et al., 2014). Misalignment can occur, with symptoms in the form of a mismatch between demand for, and supply of, appropriate space, services delivered and resources allocated (Then et al., 2014). Additionally, the facility management function has to adapt to fluctuations in the organization to fulfil a strategic function that reduces downside risks (i.e. threats) and enhances upside risks (i.e. opportunities during expansion), while in stable periods concentrating on securing routine operations (Nutt, 2002 in Chotipanich, 2004, p.367).

3.5.3 Service perspective

The service perspective of facility management is underlined in the definition of facility management (British Standards Institution, 2015) and is about maintaining and developing the agreed services that support and improve the effectiveness of the primary processes and activities including users' working environment. One way to ensure effectiveness after handover is by inclusion of aftercare management defined in ISO 11074:2015 as "measures applied on completion of remedial works or as an integral part of a containment strategy to ensure continued effectiveness over the long-term" after handover (International Organization for Standardization, 2015b). Aftercare is included, for example in *Soft Landings* (BSRIA, 2021), and can apply for up to three years after handover. An aftercare manager (or defects manager) can be involved during pre-handover, handover and the defects liability period of a project (Building People, 2020).

Edvardsson and Gustavsson (2003) have defined the service concept as the "overall description, from the [organization's] perspective, of both what customers get during the service process and how they get it". The service concept builds on a

large number of decisions at different levels in the organization and the challenge is to make those decisions consistent (Goldstein, Johnston, Duffy & Rao, 2002).The service concept is an important part in an organization's market positioning (Goldstein et al., 2002). Servicescape is one part of the service concept and deals with the built environment's impact on users' behaviour influenced by, for example, cleanliness, layout and comfort (Lee & Kim, 2014). Other parts of the service concept, for example service quality and service recovery, are used to elaborate service management.

Service quality from a US perspective is built on functional quality while the European perspective of service quality also includes technical quality and image, according to Brady and Cronin (2001, in Kang & James, 2004, p.266). Service recovery is defined by Grönroos (1988, in Dong, Evans & Zou, 2008, p.125) "as the actions taken by an organization in response to a service failure" and builds on the assumption that it is impossible to ensure totally error-free service (Lewis & McCann, 2004; Dong, Evans & Zou, 2008). As a consequence, it is important to have effective service recovery to secure user satisfaction when a service has failed (Dong, Evans & Zou, 2008).The service management literature points to several types of organizational responses to complaints from users, namely remedial reaction in the form of monetary or psychological compensation, employee behaviour and promptness (Gelbrich & Roschk, 2011). In this assessment of organizational response, several characteristics are noted, namely justice perception in the form of perceived fairness concerning the outcome (distributive justice), the manner of treatment of the complaining part (interactional justice) and the process of the rectification (procedural justice). Lewis and McCann (2004) suggest a new recovery strategy where facility management actively seeks out failures to be able to correct them before complaints arise, as might be seen, for example, in the hotel sector. In stark contrast to Lewis and McCann, views on the users of services in other areas, for example social support, have been marginalizing, invalidating and discriminating (Beresford, 2000). On the other hand, Grégoire, Tripp and Legoux (2009) revealed that the best users of services have the longest unfavourable reactions after service failure and insufficient service recovery. In other words, after a strong relationship negativity decreases more slowly and avoidance increases more rapidly than after a weak relationship. Poorly perceived service can arise as a result of the mismatch between what the organization intends to provide (i.e. its strategic intent) and what the users (i.e. customers) might require or expect (i.e. customer needs) (Goldstein et al., 2002).

3.5.4 Research gap concerning facility management

A critical factor in the successful delivery and operation of a facility is the principle of design and construction for operability (Atkin & Rowlinson, 2019), which is the ability to create and maintain a safe and reliably functioning working environment for users according to predefined operational requirements. Views on buildings have

changed from being an architectural expression or passive physical construction to become a support function for the organizations and people that use them. Whether it is a new or refurbished facility, the operational requirements and expected performance outcomes should be considered through all lifecycle stages (i.e. strategy, briefing, design, construction, commissioning, handover and facility management) to ensure that users of the facility are able to work safely and productively. Facilities that fail to fulfil their function impact the working environment negatively, potentially impairing users' health as well as lowering their productivity.

The built environment's impact on human health is an area of importance but too-often neglected (Loftness et al., 2007). Suboptimal indoor environments and unhealthy interior materials have been documented as causes of a variety of health effects (Loftness et al., 2007). Examples of other documented effects are stress from noise (Rylander, 2004), musculoskeletal disorders from non-optimal working conditions (da Costa & Vieira, 2010) and lower productivity (Miller et al., 2009; Clements-Croome, 2015; Al Horr et al., 2016b; and Geng et al., 2017).

Atkin and Brooks (2021) claimed that among the issues known to affect productivity positively are the prevention of accidents and disease, resulting in a reduction of sick leave and lower personnel turnover, reduced operational costs, better working conditions, commitment of personnel and improved quality of work. The impact of facilities on the indoor environment and the quality of the public environment depends on the adequacy of briefing, design, construction and facility management. When given due attention, these aspects create a facility that can be used for its purpose as a factor of production. Way and Bordass (2005) claimed that the post-handover period of a new or refurbished facility is the most neglected; additionally, Kärnä, Sorvala and Junnonen (2009) found that handover inspections were the least successful.

A mismatch between the agreed operational performance requirements of the facility and its operation and use, especially in terms of users' working environment, has been highlighted by BSRIA (2021) as a performance gap between design intentions and operational outcomes. Jensen and van der Voordt (2020) state that there is limited research about how workplace layout and design influence facility management and corporate real estate management. This suggests the need to analyse the impact of defects and deficiencies during operation, use and maintenance on users' working environment and productivity to find the causes of the mismatch.

3.6 Post-occupancy evaluation

3.6.1 Systematic evaluation of building performance

Systematic evaluation of building performance arose during the 1960s and 1970s (Preiser & Schramm, 2002) and has been undertaken in different ways without much consensus on the methods adopted. Post-occupancy evaluation is one example; however, it is rarely used. Clark (2015) found that only 3% of British-based architectural practices undertook post-occupancy evaluation regularly (in Hay, Samuel, Watson & Bradbury 2018, p.699). Evaluations undertaken in the construction industry are usually built on technical evaluations related to questions about materials, engineering or construction of a facility (Preiser & Vischer, 2006) because these are largely prescribed under legislation. In contrast, evaluation methods during occupation, which are based on building performance and occupant satisfaction are underdeveloped (Li, Froese & Brager, 2018) with occupant feedback poorly considered (Alborz & Berardi, 2015).

3.6.2 The post-occupancy evaluation concept

The conceptualization of post-occupancy evaluation by Preiser (1995) as a diagnostic tool and system that allows systematic identification and evaluation of critical aspects of building performance has changed little over the years. Preiser and Vischer (2006) subsequently defined post-occupancy evaluation as "the act of evaluating buildings in a systematic and rigorous manner after they have been built and occupied for some time". The definition looks on post-occupancy evaluation as a means to support facility management. Another definition can be found in the British Standard, BS 8536-1:2015, namely the "process of evaluating an asset/facility after it has been completed and is in use to understand its actual performance against that required and to capture lessons learned" (British Standards Institution, 2015). The final product of the project to be assessed by post-occupancy evaluation, includes both the completed facility and the contracting service (Yasamis, Arditi & Mohammadi, 2002). This interaction between the building and service complicates the quality evaluation of the project (Yasamis, Arditi & Mohammadi, 2002), as it can be difficult to determine the cause of a deficiency as it can emerge from the building, service management or both. Post-occupancy evaluation differs from other building performance evaluations as it focuses on users' requirements including their comfort and satisfaction (Dabaieh & Johansson, 2018).

3.6.3 The tradition of post-occupancy evaluation

The purpose of post-occupancy evaluation is to: (1) collect information that can be used to improve the overall procurement (Hadjri & Crozier, 2009), briefing and

design of facility; and (2) update the facility owner's information so facility management can provide a building that can result in increased productivity for the users. Procurement is defined in ISO 20400:2017 as the "activity of acquiring goods or services from suppliers" (International Organization for Standardization, 2017b). The procurement process spans from identification of requirements to project closeout (Ruparathna & Hewage, 2015). Sourcing is a part of the procurement process that includes planning, defining specifications and selecting suppliers.

Post-occupancy evaluation can change procurement from considering the facility as a physical object, or an end in itself, to regard it as a means to achieve a defined purpose (Bordass, Leaman & Ruyssevelt, 2001). Post-occupancy evaluation can also be used to identify more efficient and cost-effective design options and lower operational costs. One of the main aims of post-occupancy evaluation is to feed forward lessons learned during facility management into new projects. The benefits of post-occupancy evaluation can be realized over three time-horizons: short (e.g. resolving defects), medium (e.g. optimizing services installations) and long term (e.g. sustainable operation and use). Undertaking a single post-occupancy evaluation means concentrating on just one time-horizon. Alternately, Cole et al. (2008) recommended undertaking continual post-occupancy evaluation during the whole lifecycle of the facility and not to rely on a single post-occupancy evaluation following new construction or refurbishment.

Post-occupancy evaluation has, over the years, been classified in various ways. The classification has mainly been grounded on an evaluation method (Preiser 1995; Bordass & Leaman, 2005; Hay et al., 2018) and the purpose of that evaluation, especially the stage in the delivery process that it is supporting (Cooper, 2001; Vischer, 2001, in Anonymous, 2008, p.2). Post-occupancy evaluation can also be used to analyse different issues, for example, energy use, comfort and satisfaction. The purpose to which post-occupancy evaluations have been put is, therefore, diverse and helps to explain why there is relatively little consensus on what exactly post-occupancy evaluation is.

Several barriers to implementing post-occupancy evaluation have been highlighted as the causes of the relatively low interest in post-occupancy evaluation: (1) absence of post-occupancy evaluation on the educational curriculum (Zimmerman & Martin, 2001); (2) designers not being paid to go back and review outcomes (Zimmerman & Martin, 2001); (3) eventual impact on the consultants' indemnity insurance (Cohen, Standeven, Bordass & Leaman, 2001); (4) the facility owner (as client) and designer perceive themselves as being potentially exposed to reputational damage by the results (Hadjri & Crozier, 2009); (5) proponents of post-occupancy evaluation not being involved in the procurement process (Hadjri & Crozier, 2009) where the post-occupancy evaluation needs to be incorporated in requirements for design and construction; (6) recipients of the results of post-occupancy evaluation, namely facility managers, not being involved in the briefing stage (Eley, 2001); (7) fragmentation and division of responsibilities (Meir, Garb, Jiao & Cicelsky, 2009;

Leaman, Stevenson & Bordass, 2010); and (8) lack of uniform protocols, measures and procedures making comparisons difficult (Meir et al., 2009). Deficiencies in procurement methods have also been shown to have a negative influence on efficiency in the early design stage of projects by, for example, allowing design issues to be ignored (El Reifi & Emmitt, 2013).

3.6.4 Post-occupancy evaluation in certification schemes

Despite the noted drawbacks, post-occupancy evaluation is emerging in building environmental certification schemes which are centralized around green aspects, for example, WELL Certification, *Passivhaus*, Building Research Establishment Environmental Assessment Method (BREEAM) (Hay et al., 2018) and Leadership in Energy and Environmental Design (LEED) (Huizenga, Zagreus, Abbaszadeh, Lehrer, Goins, Hoe & Arens, 2005). Nonetheless, post-occupancy evaluations centralized around user aspects are uncommon and, for instance, the LEED rating system does not mandate occupant feedback (Alborz & Berardi, 2015). The body of knowledge in the area of post-occupancy evaluation (in the form of scientific papers) is still also low in comparison to other bodies of knowledge concerning buildings, for example building information modelling (BIM) and facility management (Roberts, Edwards, Hosseini, Mateo-Garcia & Owusu-Manu, 2019). At the same time, post-occupancy evaluation is regarded as having higher financial importance to the project lifecycle than BIM (Roberts et al., 2019).

3.6.5 Research gap concerning post-occupancy evaluation

Design decisions are based on intuition instead of empirical evidence (Vischer, 2009), i.e. functional and performance-related requirements from the users' perspective of the working environment. Evaluation methods during occupation, which concentrate on building performance and occupant satisfaction, are underdeveloped (Li, Froese & Brager, 2018) and do not adequately consider occupant feedback (Alborz & Berardi, 2015). There is also lack of evidence of post-occupancy evaluation contributing to the learning process in general.

3.7 Conclusions

The theoretical framework developed from literature studies of research within the areas of working environment, project governance, briefing, facility management and post-occupancy evaluation have revealed limited outputs in those areas focusing on how the building influences users' working environment and productivity.

4 Case studies – Findings and discussions

4.1 Introduction

Two projects were studied, both of which were total refurbishments undertaken by the same state-owned property company with responsibility for managing facilities used for education and research. Project 1 was a total refurbishment for repurposed use of the building. Project 2 was a total refurbishment where the building was intended to be used for the same purpose after the refurbishment.

The organizational context for the refurbishments was the same for both projects. A project agreement was signed by the tenant (i.e. the university) and the client (i.e. the property owner). Decisions concerning the implementation of the two projects were made by a central unit at the university on the behalf of users. Users were to pay for the refurbishment through increased rent. During operation and use, there would be a facility management organization existing between the client, tenants and users.

In this context, facility management includes coordination meetings four times a year, in which three organizations (i.e. the client, tenant and users) are represented. Additionally, error reports are communicated by the users' facility manager directly to the clients' operation technician or by individual users by report in the computerized error reporting system. The client's financial manager is responsible for the financial and technical management of the facilities, while the tenant's facility planner is a function for coordinating the tenant's need with respect to facilities and the rental costs for them. The users' facility manager concentrates on safeguarding and coordinating the interests of users in regard to facility issues.

4.1.1 Project 1

The facility was constructed in the 1940s. The original purpose of the building was laboratory-based work involving the use of radioactive materials. The facility was used for its original purpose until the refurbishment; but, it was vacant when the project started in 2005. The refurbishment took place during 2007. The case study documentation covers the period 2005-2015. The facility was situated next to a

major crossroads and was a split-level traditional brick structure, which retained its original timber-framed windows.

The facility comprised three buildings (H1, 900 m^2; H2, 160 m^2; and H3, 1400 m^2).

- H1 was a narrow building with three floors. The two upper floors were to be used for offices and the bottom floor was to be used for lectures, group work and library.
- H2 was a small building with two floors situated between H1 and H3. The bottom floor in H2 was to be used as the entrance and the second floor was to be used as a common lunchroom.
- H3 was the largest building and contained two floors which were to be used for offices. H3 was twice as deep as H1 and the first floor, which was to be used as offices, had earth up to the windows along two elevations.

The facility was to be totally refurbished and totally repurposed for dry science and organizations whose work tasks were research, education and patenting (see figure 6). The total number of users was anticipated to be around 240, comprising researchers, lecturers, patent advisors, students, administrators and service personnel. The stakeholders involved in this project were the facility owner, tenant and users (i.e. organizations, private companies and service personnel).

The refurbishment project was initiated by the intended users and involved converting two of the three buildings (H1 and H2) into office space. Half-way through the project, there was a scope change and the project increased substantially, as it was decided that all three buildings (H1, H2, and H3) should be included in the refurbishment. A near doubling of the scope of work resulted, since the additional floor area for the third building (H3) was as large as the first two buildings combined. The documents from the briefing process show that the scope change was not followed up by any reconsideration of earlier briefing decisions.

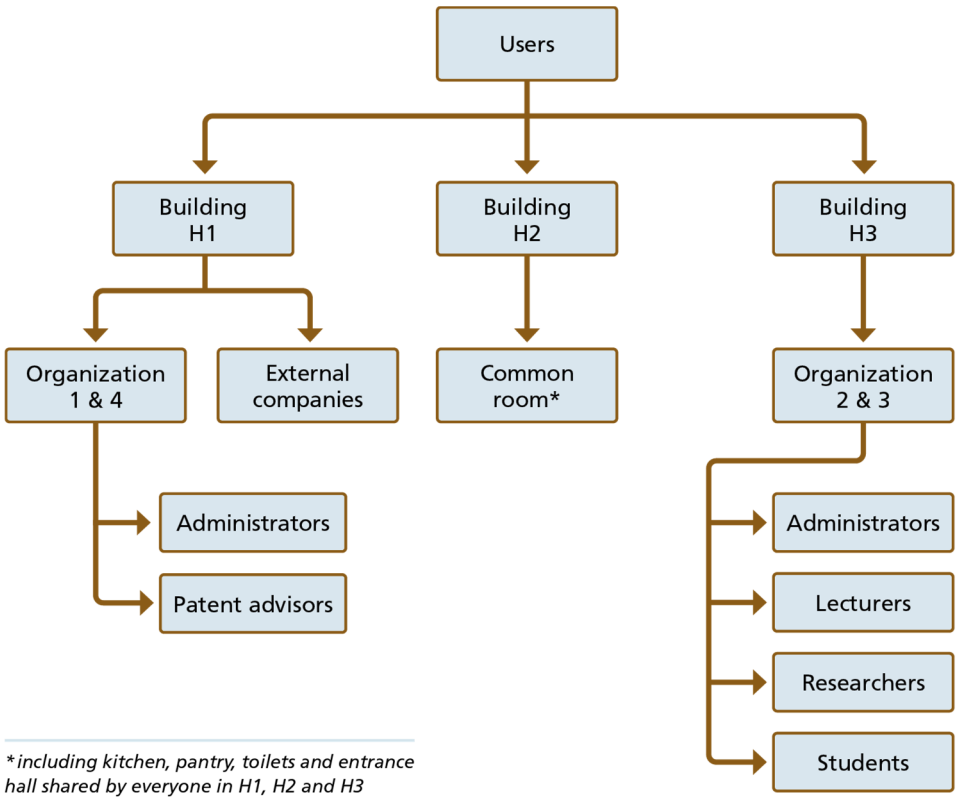

Figure 6: The users in building H1, H2 and H3 – Case study 1 and 2

During the operational phase, users experienced an inadequate working environment. This was documented in minutes from the users' regular meetings concerning the facility's influence on the working environment during the period 2008-2015. The shortcomings that were experienced related to the refurbishment and were unevenly distributed in the three buildings that made up the whole facility; and, in some rooms, the shortcomings were quite extensive. They included the internal climate (e.g. draught from windows, walls and ceilings, inadequate temperature during both summer and winter), noise and the risk of injury due to vehicle movements around the main entrance.

4.1.2 Project 2

The facility to be refurbished was designed in the 1960s. The original purpose of the facility was the education of engineers. The project started in 2011 and the refurbishment took place during the period 2013-2016 and was performed in two stages. The case study documentation covers the period 2011-2016.

The facility was situated in a campus area and had a traditional cast in-situ concrete structure with brick-faced external walls. Regular activities were moved temporarily in phases throughout the refurbishment to another facility close by. The refurbishment involved about 16,500 m^2 of floor area which included an extension of 400 m^2. The facility consisted of several buildings with varying numbers of floors from one to five and a basement. Users numbered around 1,400 including lecturers, researchers, administrative personnel and students. When the discussion on the refurbishment of the facility began in 2010, the purpose was the same although the number of students and employees had increased significantly since the 1960s. The total investment was estimated to be approximately SEK 300 million (approximately USD 30 million at current prices).

The starting point was the need for total refurbishment and the requirement for individual student workplaces and updating of teaching rooms to accommodate modern teaching methods and supporting technology. Expansion in the number of students and employees had impacted the internal environment because the mechanical services installations, notably the ventilation equipment, were under-sized for the increasing demands placed on them. This had caused thermal discomfort. The proposed refurbishment project would be aimed at improving the environmental performance of the facility to the extent that it could be classified on the silver level under the Swedish certification scheme "Environmental building", Manual 2.2 [Miljöbyggnad, Version 2.2] (Sweden Green Building Council, 2014).

Participants in the refurbishment project included the client, the tenant and client's consultants and users of the facility. The project organization (see figure 7) created to handle the refurbishment consisted of three organizations working in parallel coordinated by a project group with four representatives: two from the client and one each from the tenant and users.

- The client's organization coordinated the client's consultants in the areas of architecture, construction, mechanical installations (primarily ventilation), plumbing and electrical installations (primarily lighting).
- The tenant's organization covered environment, working environment, furnishings, computer installations, security and included the tenant's own consultants.
- The users' organization, which included representatives in the form of 38 employees and six students, was formed into nine working groups. These working groups were not, however, responsible for reading the consultants' drawings of the refurbishment or observing any deviations from the required design. This responsibility was still with each department. Neither the users' main safety representative nor the cleaning personnel were represented in any of the users' working groups.

– The tenant's and the users' work was finally reported to and coordinated in a steering committee, where decisions would be taken by the vice chancellor.

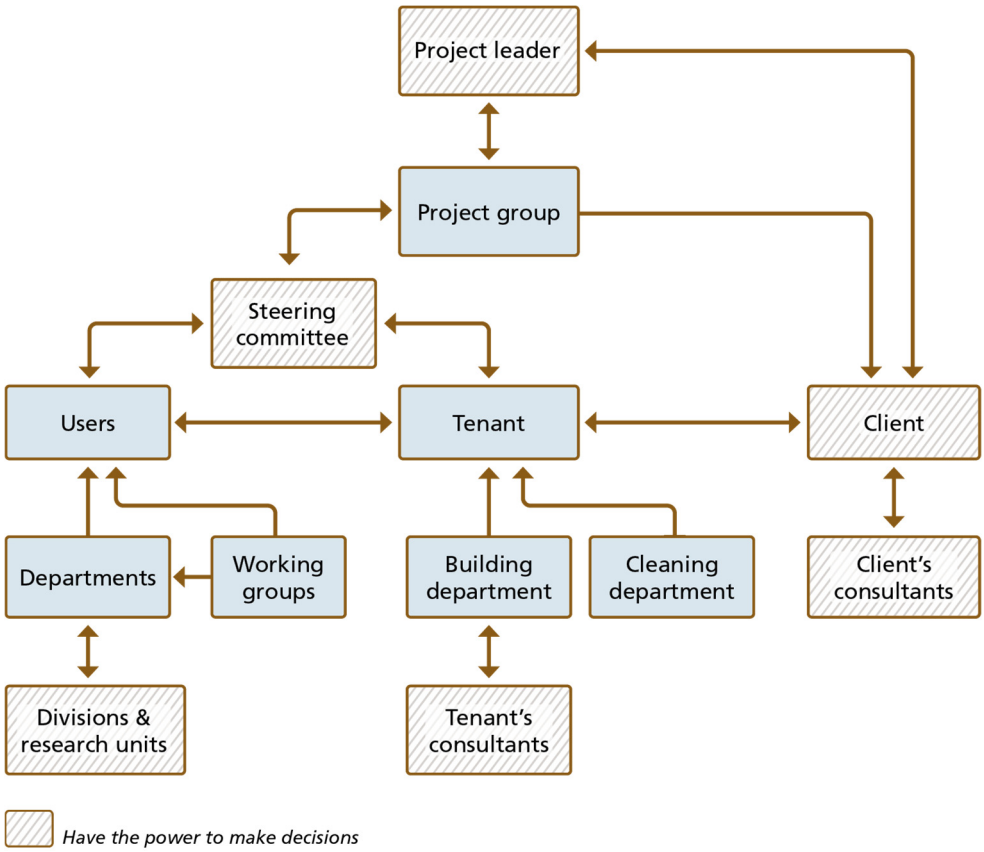

Figure 7: The project organization – Project 2

Formally, all decisions were based on four referral rounds from 2011-2013 (i.e. feasibility study, program stage, system stage and contracting) using drawings and room function programs (i.e. facilitating specifications of requirements for each room, for example the number of power outlets required).

The cases based on these two projects were as follows: case study "briefing" – Project 1; case study "facility management" – Project 1; case study "post-occupancy evaluation" – Project 2; and case study "project governance" – projects 1 and 2.

4.2 Case study I – Briefing

4.2.1 Aim

The intention was to focus on the gap in theory concerning refurbishments projects with regard to users' working environment. The aim was to: (1) identify shortcomings in the briefing stage and the effects on users' working environment on the individual level during operation; and (2) make recommendations for improved briefing.

4.2.2 Methods

A literature study was followed by a retrospective, in-depth case study of a refurbished facility to determine the root causes of identified shortcomings with respect to its operational performance (i.e. the working environment) and which were believed to have been generated during the briefing stage. The project was chosen as it offered the opportunity to gain access to material from the briefing, design, construction, commissioning, handover, and facility management stages for a period of approximately ten years.

A case study method was chosen as it was felt to offer a better chance of unravelling the complexities of a given situation, helping to explain why certain outcomes might occur (Denscombe, 2010), rather than a questionnaire-based survey that would narrow the focus of inquiry. Document analysis involved a systematic comparison with "Guidelines for Design, 2015" established separately by the facility owner (a state-owned property company) and "Requirements and Advice 2002" established by the tenant (a university). Document analysis covered: (1) the design stage (2006), i.e. minutes from planning meetings during the period January to November 2006 and procurement plan; and (2) the construction stage (2006-2007), i.e. minutes from construction meetings from November 2006 to September 2007, environmental reconciliation and final inspections (2006-2007). One part was missing from the documentation, as this was left out of the final inspection and that was the insulation of the attic and the matter of if it had been undertaken in accordance with the brief and procurement plan. The document analysis was supplemented by interviews undertaken in Case study II and field observation.

4.2.3 Results and analysis

The case study identified nine decisions leading to deficiencies affecting the users' working environment.

i. Absence of a single, documented and agreed aim for the refurbishment project.
ii. Deviation from guidelines.
iii. Organizational framework not elicited.

iv. Decisions before scope change not reconsidered.
v. Conditions due to location not included in considerations.
vi. The facility's existing characteristics not included in considerations
vii. Time not allocated for determining users' axiomatic knowledge.
viii. Users' absorptive capacity not mapped.
ix. Post-occupancy evaluation not implemented.

Each of the above is now discussed.

Absence of a single, documented and agreed aim for the refurbishment project

The most significant deficiency during briefing was the absence of a single, documented and agreed aim for the refurbishment project: the facility owner was interested in generating income from its portfolio of facilities; the tenant was concerned with delivering a refurbished facility for use as offices; the user organizations were seeking an environment to develop their organizations, increase creativity and integration, maintain a sustainable working environment and raise productivity; and individual users wanted a workplace to support research, teaching and patent-related work.

The minutes from the briefing process showed that the facility's users were never fully identified and communicated to the project team. The project team consisted of about twenty representatives for most of the briefing stage: just two of them – administrators – represented the users' interests. The objective of the project was summarized in both the brief and lease as providing a facility for office work; yet, users were a complex mix of research and teaching units, patent advisory board and private companies. In the room function program, the users' businesses were described as:

> "office work, about 50 workplaces. Preferably one person/room; but if necessary, some rooms can be multi-person rooms. Some of the office rooms should be able to function as meeting rooms. Flexibility should be sought" (Room function program, 01/02/06).

Deviation from guidelines

A set of practice guidelines, the occupier's "Requirements and Advice 2002" had been used from the beginning of the project. During briefing, at planning meeting 7 of 15, a decision was taken that the guidelines should no longer be followed.

> "This project shall not follow 'Requirements and Advice'. All texts in the documents referring to requirements and advice must be removed" (Item No.4, Projection, Planning Meeting No.7, 10/05/06).

This decision affected the briefing process negatively. The excluded guidelines covered risk assessment, consideration of day-to-day servicing and the engagement of an acoustician during briefing. Consequently, the facility's exposure to risks was not assessed. The minutes from the briefing process showed that the risk of potential background radiation, arising from earlier radioactive experiments in the building, were not evaluated during the entirety of briefing. The risks of mixed traffic around the main entrance (i.e. pedestrians, bicycles, cars and heavy-goods vehicles) were also never considered; neither was the potential risk of assaults evaluated, as a result of a badly lit main entrance. This lack of action, resulted in action in the form of supplementary planning and remodelling of the entrance area during operation, to minimize the risks by separating the different types of traffic. Furthermore, measurement of the eventual background radiation had to be done some months before occupation during refurbishment to reassure that it was safe to use the building for offices.

Organizational framework not elicited

Briefing took place over 11 months in 2006. The briefing process was documented in the form of a room function program, minutes from 15 planning meetings and a procurement plan. Participants in the planning meetings were the facility owner (7 representatives), the tenant (2 representatives), the users (2 representatives) and consultants (12 representatives). Formally, the minutes were written by the tenant and confirmed on the next planning meeting. A building permit from the municipality was not required, just building registration and a removal plan for the ventilation system.

The documentation showed that no governance framework, structure, roles or responsibilities were established during the briefing stage.

Decisions before scope change not reconsidered

From the outset of the refurbishment project, only two of the facility's three buildings (H1 and H2) were included in the refurbishment project. The major change of scope to include building H3 resulted in a near doubling of the area to be refurbished.

> "The management verbally has agreed that facility H3 shall be included in the project, provided that rent equal to H1 and H2 can be offered, which the facility manager is hoping for. The meeting decided that the planning is based on facility H3 being included in the project" (Planning meeting No.8, 23/05/06).

Change management was never considered during planning meetings; neither was it considered in the guidelines, so the result was not affected by the decision to exclude the guidelines. The documents from the briefing process showed that the

scope change was not followed up by any reconsideration of earlier briefing decisions. The lack of change control resulted in a failure to update earlier briefing decisions and contributed to a negative impact on the users' working environment. New prerequisites due to the inclusion of building H3 was the uninsulated attic, soil up to the windows on two elevations and excessive width of the building body. To solve the problems with the excessive width and the need for daylight, rooms with full glass walls and sliding doors were installed and the dark area used for meeting rooms were designed with glass walls on two sides. This created exposure to indoor noise and a stressful working environment due to lack of privacy. The minutes from the operation and use stage showed that the users' most frequent complaints referred to building H3, which were included half-way through the briefing process.

Conditions due to location not included in considerations

The location of the facility was not described at the start of briefing, notably existing conditions and constraints that eventually needed to be taken into consideration during briefing and design, i.e. a location near to a main cross-road that was close to facilities with explosive and poisonous material with mixed traffic around the entrance.

The facility's existing characteristics not included in considerations

The existing characteristics of the buildings in the form of split-levels, gaps around the windows, significant heat differential between the ceilings and walls and large windows in the south-facing façades, as well as their previous use for radioactive laboratory work, were not taken into consideration. The reason why this was not done is to be found in the project description.

> "Refurbishment of house H1, H2 into offices. Former laboratories are divided into smaller office rooms or converted into large offices. House H3 may also be relevant for refurbishment. The refurbishment includes some new walls, layers and new ventilation and electrical installation" (Environmental reconciliation, No.1, 27/04/06).

This limiting project description resulted in no action being taken on facts discovered in Environmental Reconciliation No.1, i.e. uninsulated attics, U-values for existing windows 1.6 (Recommended value, 1.2; Swedish National Board of Housing, Building and Planning [Boverket], Building regulations [Byggregler], BFS 2011:26).

> "The entire facility today has poor energy values. Building body H3 has a large uninsulated area in the attic where remedial action is considered in case of remodelling" (Energy issues, Environmental Reconciliation No.1, 27/04/06, Facility owner).

> "Existing windows have a U-value of 1.6" (Materials and chemical products, Environmental Reconciliation No.1, 27/04/06, Facility owner).

This resulted in frequent complaints, from individual employees during facility management, regarding the thermal climate. The complaints arose from employees situated in corner rooms, on the top floors beneath uninsulated attics and close to windows with oblique wooden window frames. There were also significant complaints during facility management about the hot indoor climate during summer months in the rooms and lunchroom situated to the south-facing façades due to the large windows without sun screening combined with the uninsulated attics. The existing undersized elevator was not considered and remained unchanged after the refurbishment, prohibiting access by electric wheelchairs and the delivery of consumable materials on pallets to the upper floors.

Time not allocated for determining users' axiomatic knowledge

Users' axiomatic knowledge was never elicited, so there was no awareness of users' need for: (1) unstructured meeting points to increase creativity and integration; (2) undisturbed office area for researchers to read and write in quiet; (3) space for the supervision of students; (4) separate common rooms for students; (5) local storage space for research material; (6) transportation capacity between the different floors for heavy goods in the form of office supplies on pallets; (7) accessibility to different floors with an electric wheelchair; and (8) cleaning with a scouring machine. Moreover, users' needs were not specified and neither was a user requirements document nor a system requirements document produced. No discussion could be found in the minutes regarding the special requirements expressed by the users, either on the organizational or individual level. This lack of capturing users' axiomatic knowledge meant that the opportunity for their businesses to expand or decrease was not taken into consideration. A consequence was that two of the main organizations moved out of the facility.

Organizational level:

> "The office environment didn't really match the culture, there were long corridors and closed rooms" (Interview, patent advisor #1, H1).

> "…when we established ourselves on two floors there were stairwells between and locked doors and so on and so the everyday contact, the spontaneous contact with the colleagues… did not at all become the same" (Interview, patent advisor #2, H1).

Individual level:

> "The light was good except in "the goldfish room", the seminar room. It was glazed on both sides,… yes but yes it was an annoying factor you sit and look really at the glazed side and when people then pass by you automatically follow (the person) and it was annoying" (Interview, researcher, H3).

Furthermore, neither of the documents show that users' needs in the form of good working environment were prioritized during briefing. The users' working environment was also not mentioned in the facility owner's "Sustainability Accounting 2008" although it included a reference to the working environment for its own service personnel.

Users' absorptive capacity not mapped

Two notable deficiencies were that users were unaware of what was expected from them and there was no estimation of the user organizations' absorptive capacity in the form of prior related knowledge needed to assimilate and use new knowledge occurring during the briefing process.

Post-occupancy evaluation not implemented

Handover took place directly after the post-construction (final) inspection. The transition from the end of construction and commissioning into operation and use was not considered during briefing. No post-occupancy evaluation was planned for or decided during briefing and procurement. However, this was not a result of the decision to exclude the existing guidelines, as the transition into operation and use was not mentioned in the guidelines. The climatic requirements in the procurement plan to be followed up during operation were stated in terms of quantities of air flow through ventilation ducts not in room-specific values measured at individual workplaces.

4.2.4 Discussion

Refurbishment and its dependence on axiomatic knowledge and absorptive capacity

The need for a front-end process which deeply explores opportunities and understands who the client is and what is needed is underlined by El Reifi, Emmit and Ruikar (2014). The users organization's objectives, intentions and characteristics need to be taken into consideration (Jensø, Hansen & Haugen, 2004). All stakeholders need to be identified (Shen et al., 2004) and included, even service providers and operational and maintenance (i.e. service) personnel (Christiansson et al., 2011). The impact of differences between them shall also be considered (Olander, 2007). Stakeholders' needs should be fully identified (Christiansson et al., 2011; Olander, 2007; Olander & Landin, 2005; Shen et al., 2004; Vischer, 2008). Time for social interaction needs also to be allocated (Chandra & Loosemore, 2011; Newell et al., 2011; Thomson, 2011). The users' absorptive capacity has to be elicited (Cohen & Levinthal, 1990) and axiomatic knowledge exchange should take place (Bood, 1998; Chandra & Loosemore, 2008; Mokariantabari et al., 2019; Sackman, 1992) to make cultural

learning occur (Chandra & Loosemore, 2011). This is also underlined in practical recommendations, i.e. Ministry of Defence (2002), then mentioned as "requirements management", involving identification and documentation of stakeholders and their needs. Even the users' behavioural competencies such as negotiation and communication needs to be mapped and considered (Soetanto et al., 2006). The case study shows that all these steps were not fully undertaken and this resulted in an aim that did not capture the users' underlying purpose, resulting in organizations and companies moving out of the refurbishment.

Refurbishment has concentrated on delivery on time and within budget, instead of on the value of the outcome (El Reifi, Emmitt & Ruikar, 2014). In addition, the working environment was poorly considered (Loftness et al., 2007; Vischer, 2008); when it was, there was no prioritization or key decision points.

The guidelines, organizational framework, scope change and post-occupancy evaluation

Guidelines were available at the outset of the refurbishment. Halfway through briefing, a decision was taken that the guidelines should no longer be followed. This decision affected the briefing process negatively with respect to risk assessment and issues related to acoustics. Established guidelines can be seen as part of a governance framework.

The process for delivering a new or refurbished facility should be set out at the beginning of the project by a framework that fixes the organizational structures, decision rights, knowledge governance (Foss, 2007) and change management (Steffens, Martinsuo & Artto, 2007). In this project, the documentation showed that no governance framework, structure, roles or responsibilities were established during the briefing stage. This lack of a governance framework influenced the outcome of the refurbishment.

Change during the project process is almost unavoidable and a change management process, including recognition of change, evaluation of the change impact and change implementation, has to be considered (Steffens, Martinsuo & Artto, 2007). Isaac and Navon (2009) noted that project teams often implemented changes without understanding the impact on the final product. Change management was not considered during planning meetings, neither was it considered in the guidelines. Documents from the briefing process show that the scope change was not followed up by any reconsideration of earlier briefing decisions. The lack of change control resulted in a failure to update earlier briefing decisions and contributed to negative influence on the users' working environment. Even the requirement for a post-occupancy evaluation (Vischer, 2008) to be undertaken was not included despite the existence of measurable outcomes (Elf, Svedbo Engström & Wijk, 2012).

Location and the facility's physical condition

Practical guidance on briefing has tended to assume new-build projects; whereas, a sizeable proportion of projects involve refurbishment. Refurbishment projects are generally regarded as attracting higher risk than new-build projects and are often more complex (Lee & Egbu, 2005); moreover, complex projects are difficult to govern (Jallow et al., 2014). Given the greater complexity encountered with refurbishment projects, it is essential to understand the current state of the building, especially its condition and constraints (van Leuween, de Vries & van den Oetelaar, 2000).

In the project, the main cause of the risks linked to the traffic situation at the main entrance was a result of the location of the building and the existing traffic types and traffic flows. The main cause of the external noise was also due to the building's location close to the main cross-roads and heavy transportation. The inadequate thermal climate was due to the failure to capture existing conditions and characteristics of the building. Together, this shows that the risks associated with refurbishment projects can have their causes in a failure to capture existing conditions and characteristics.

Summary of the case study

The aim of the refurbishment project was never properly defined, formulated and communicated; neither were the current conditions, characteristics and constraints of the facility (van Leuween, de Vries & van den Oetelaar, 2000) nor its location. In addition, the working environment was poorly considered (Loftness et al., 2007; Vischer, 2008); when it was, there was no prioritization or key decision points and no post-occupancy evaluation (Vischer, 2008) despite the existence of measurable outcomes (Elf, Svedbo Engström & Wijk, 2012). This, together with the lack of change control after the expansion of the project, resulted in a failure to achieve the objectives for the refurbished facility as well as its expected operational performance, especially the desired working environment.

In light of the findings, a new definition of briefing is proposed that stresses its introduction before any design takes place. In this regard, it is necessary to capture all users' needs (work related and working environment related). Time should be allocated for social interaction early in the briefing stage to allow discussion to take place with all stakeholders to enable a socially constructed understanding of requirements (Thomson, 2011) and to capture both the users' absorptive capacity (Cohen & Levinthal, 1990) and their axiomatic knowledge (Bood, 1998; Chandra & Loosemore, 2011; Sackman, 1992). Early capture of this knowledge as argued by El Reifi, Emmit and Ruikar (2014) and progressively gathering it, as proposed by Barrett and Stanley (1999) and Thomson (2011), would increase the likelihood of satisfying the objectives for refurbishment as well as ensuring the operability of the facility at the lowest practicable cost. Users' lack of understanding of construction

terminology and processes (Barrett & Stanley, 1999) is no barrier to communication in this early stage and might even increase discussion and avoid conflict. This early involvement of users is supported by Christiansson et al. (2011).

The new definition is in alignment with earlier definitions of briefing (Barrett & Stanely, 1999; Kelly & Duerk, 2002; El Reifi, Emmit & Ruikar, 2014; British Standards Institution, 2015). It comprises two parts, one generic and one aimed specifically at briefing for refurbishment. This division is argued as necessary since there is a considerable difference between the two types of briefing, namely the conditions, characteristics and constraints of the existing facility. The case study findings reveal the importance of emphasizing this difference.

A generic definition is "the process by which the requirements for a facility are captured at the outset, interpreted, implemented and evaluated at key decision points", where "requirements" include users' wants, needs and acceptance criteria taken into account during briefing. A specific definition for refurbishment can be stated as "the process by which the requirements and constraints for a refurbished facility are captured at the outset, interpreted, implemented and evaluated at key decision points". Furthermore, an expansion of the sustainability statement of the facility owner is recommended to include the working environment; not just for the facility owner's personnel, but for all users including service personnel. This will probably indirectly result in an increased interest at the outset of the briefing stage and, thereafter, contribute positively towards a healthy working environment for users.

4.2.5 Conclusions

The main message stemming from the findings is the importance of installing a governance framework that includes capturing scope change; defining a clear need for the refurbishment project (i.e. users' objectives for the project); capturing the current state, conditions, characteristics and limitations of the facility and its surroundings and their possible influence; and setting relevant evaluation criteria for the project (e.g. thermal climate measured at individual workplaces).

4.3 Case study II – Facility management

4.3.1 Aim

In this case study, the operation and use stage is the concern. The purpose was to: (1) understand how defects and deficiencies arising during operation of a facility are handled; (2) analyse the impact of facility management on users' working environment and productivity; and (3) make proposals on how facility management can provide a more appropriate working environment for users.

4.3.2 Methods

The case study approach has been considered reliable for capturing information as it offers a better chance to unravel the complexities of a phenomenon and to explain how and why certain outcomes might occur. Project 1 offered the opportunity to gain access to material from the briefing, design, construction, commissioning, handover and facility management stages, spanning a period of approximately ten years. The material was diverse and included documents on users' experiences and complaints concerning their working environment. Furthermore, the documentation included documents on users' complaints concerning their working environment during the operation and use stage (2007-2015): 1) minutes from quarterly meetings with the facility owner, tenant and users; and 2) minutes from the users' facility group meetings approximately monthly during the period June 2008 to September 2015. The minutes from the users' facility group recorded users' official complaints forwarded to the facility owner. Each complaint in the minutes was based upon several individual complaints. While the number of different complaints might not have been so great, their occurrence and the repeated attempts to have them resolved were many times greater.

The document analysis has also been supplemented with five interviews: two patent advisors from H1; one researcher from H3; one research student from H3; and, one representative of the cleaning personnel for H1, H2 and H3. All were working in the facility after the refurbishment.

The analysis was restricted to documented complaints, as no post-occupancy evaluation was undertaken. A triangulation of the material was possible as documents were written by both the client and users and complemented by interviews.

4.3.3 Results and analysis

Users' complaints were regarded as indicators of a lack of satisfaction. The nature of the complaints excluded more challenging impacts on the working environment; for example, inadvertent choice of carcinogenic materials in the refurbishment.

After handover, the project proved to be unsuccessful in delivering a functional building that satisfied the needs of its users. In short, problems generated during briefing, design, construction, commissioning, handover and facility management affected the achievement of the required operational performance, especially in relation to the users' working environment. The handling of defects and deficiencies reported by users during the period of operation and use from 2007 to 2015 is discussed (see figure 8 for the chronological order of events).

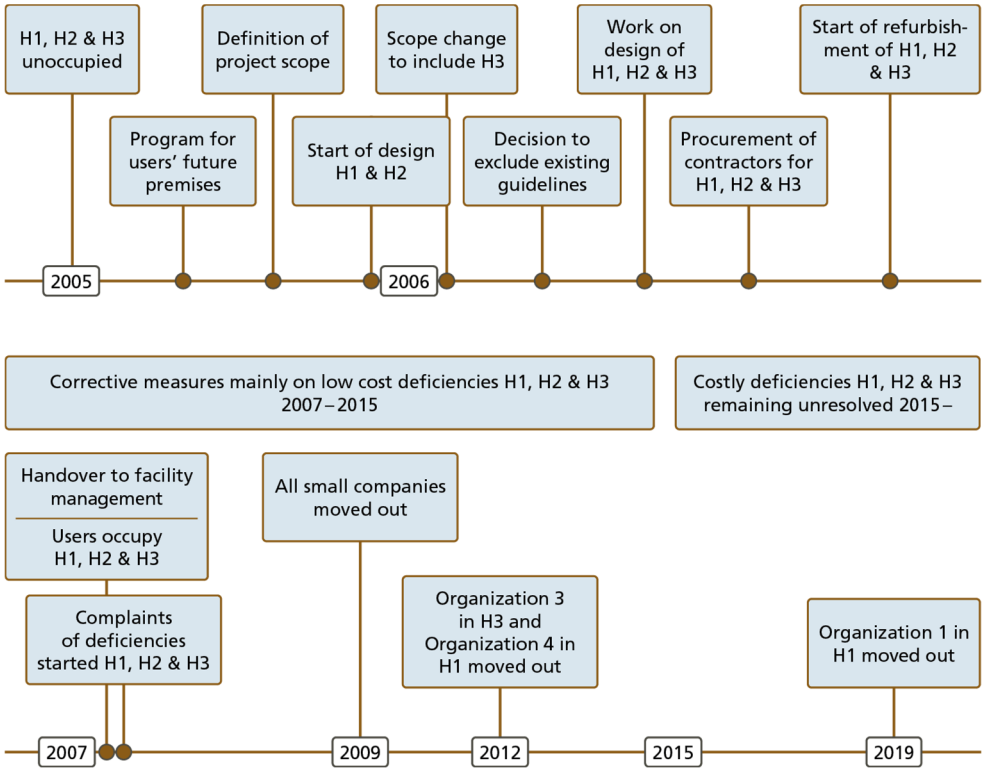

Figure 8: Refurbishment events in chronological order – Project 1

Facility management was defined for normal operation with respect to staffing (three persons) and budget, not for handling complaints of the magnitude generated by the refurbishment. No arrangements or time for aftercare were included in the invitations to tender to the design and construction team engaged in the refurbishment. Facility management, in terms of service concepts, service quality and service recovery, was not agreed, planned or even discussed with the tenant holding the direct tenancy agreement (or those users to whom space was sublet) during briefing, design and construction. Additionally, measures intended to reduce downside risks (i.e. threats) and enhancing upside risks (i.e. opportunities) were not discussed. The management of the facility was determined by the owner alone. The facility owner adopted a portfolio approach to the management of all of its facilities and comprised a group of three persons: the group leader, who was a property manager specializing in financial management, a technical property manager and an operations technician.

The tenant had secured an agreement running for several years. The tenancy agreement included provision for all remedial work required to keep the facility in good order. Since there was a stream of defects and deficiencies during the facility's

operation and use, this agreement affected progress in dealing with the remedial work which eventually cost more than anticipated when the rent was agreed. The facility management decided which remedial work to undertake, since the tenant and users had no financial means, or inclination if they did, to deal with anything. Contact with users was formalized through quarterly meetings between the facility owner, the tenant and users. The facility manager logged the complaints and inspected the reported defects and deficiencies but only minor items were remedied directly. This action affected daily operations and the overall operational performance of the facility with problems piling up, leading to a negative impact on the users' working environment and productivity. Neither the budget nor the facility management was enough to solve the extensive defects and deficiencies that remained.

> "I thought that they always acted on things that you raised… I believe that the result was not so dramatically different; things could last for a long time, such as the odour, and they did not really discover the cause… they were there many times and poked around and thought they were doing something, which was really not enough and then they did not find the cause… it was more [a matter of] sticking plasters, when they might have needed to do something bigger" (Interview, patent advisor #2, H1).

Deficiencies influencing the working environment and productivity during operation and use

The facility was handed over in September 2007. The extent of the deficiencies was neither captured nor recorded during the initial stage of occupation. Nine months later, there was noticeable friction between users and the facility manager because the former were tired of the unresolved operational problems which affected their work performance. The users decided to act and formed a "facility group".

The facility group consisted of representatives from each of the main users – three organizations in all, organization 1-3 (see figure 9). The group's main task was to systematize and formalize the complaints concerning the defects and deficiencies and the lack of remedial work. However, no representatives of the other users – a small organization (organization 4) and four small private companies – and the tenant's service personnel (mainly for cleaning) were invited to participate in any of the facility group meetings. The facility group was not able to get the facility owner to act on all of the required remedial work. In the end, the facility group sought support from the tenant's safety engineer and the tenant's chief safety representative. The tenant's safety engineer performed investigations concerning indoor climate and indoor noise. Risks associated with mixed traffic in the vicinity of the main entrance were conducted by tenant's safety engineer and safety representatives.

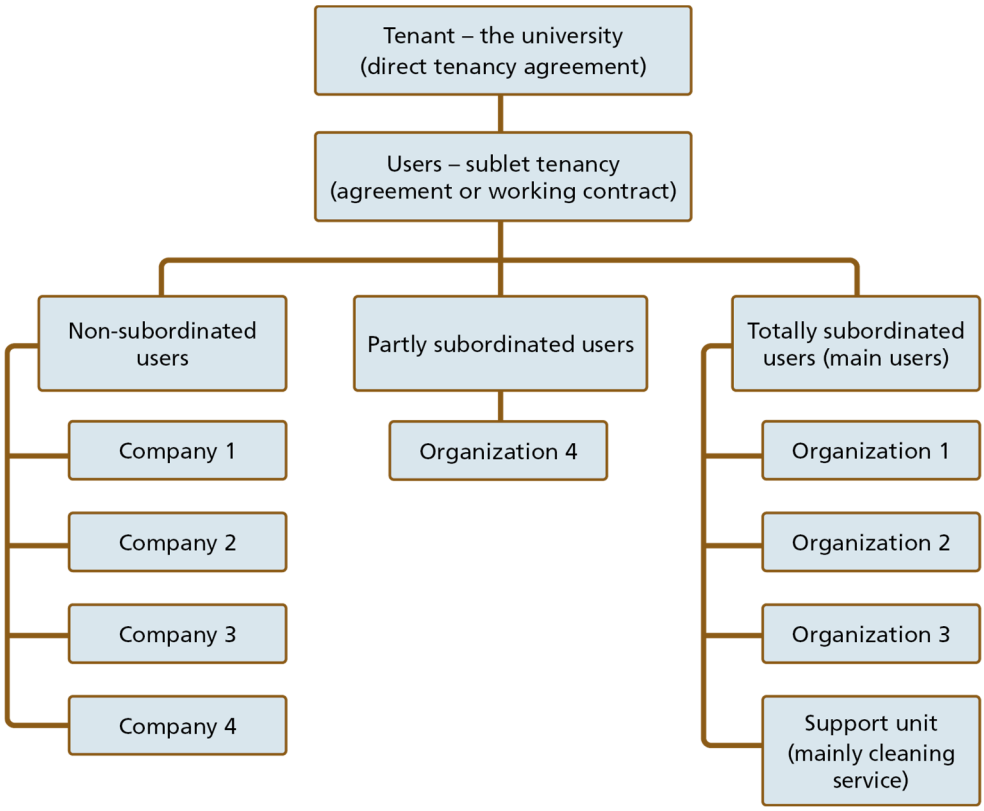

Figure 9: Users in Project 1

The four small private companies with a sublet tenancy agreement left the facility after 24 months when their agreements allowed. Meanwhile, the other four organizations, also with sublet tenancy agreements, continued to experience problems and could not relocate as they were totally or partly subordinated to the tenant (i.e. the university). After a couple more years, two of the main organizations totally subordinated to the university (organization 1 and 2) considered moving out but they were still not allowed to do so. After six years, two of the four organizations, one of the main organizations totally subordinated to the university (organization 2) and the smaller organization (organization 4) partly subordinated to the university, moved out of the facility. A new organization, also totally subordinated to the university, moved in; but, this organization was totally unrelated to the original purpose of the refurbishment. After 12 years, another of the main organizations totally subordinated to the university (organization 1) had moved out; the exodus was, according to the interviewees, not caused by the facility management but by the rent and need for more space.

The work of the facility group continued during the entire period of the case study (from the formation of the facility group until September 2015), with the purpose of accelerating remedial work on the facility to minimize the impact of the poor working environment on users' productivity.

Totally resolved deficiencies

The analysis of 67 minutes from the users' facility group meetings during the period 3 June 2008 – 7 September 2015 (see figure 10) shows that only two types of deficiency had been totally resolved during the period: foul odour (2 years after handover, following 4 complaints) and mixed traffic in the vicinity of the main entrance (3 years and 7 months after handover, following 8 complaints).

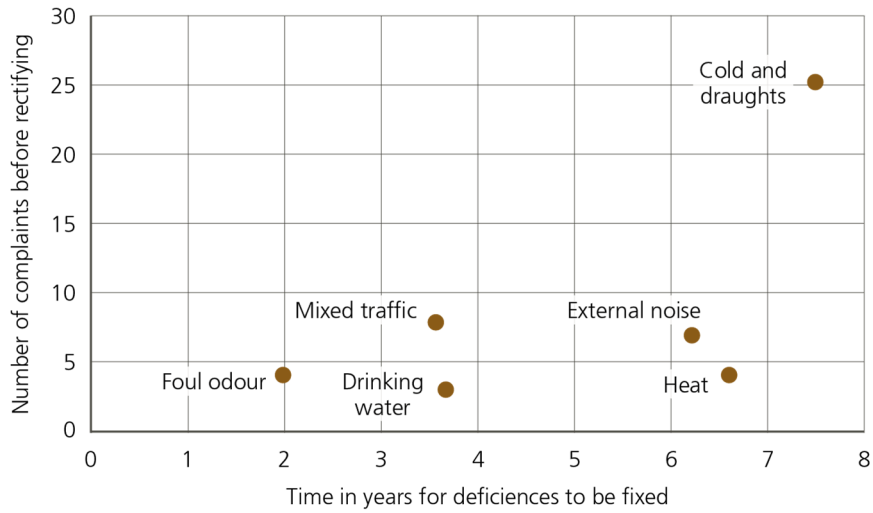

Figure 10: Number of documented complaints for various deficiencies and time taken before rectification (Result of analysis of 67 minutes from users' facility group meetings during the period 03/06/08 – 07/09/15).

Foul odour

Many complaints arose during the first few months of operation and use. Most were concerned with persistent problems having a significant impact on the users' working environment and productivity, for example, a foul odour in large parts of the facility and an unpleasant taste in the drinking water.

The document analysis revealed that such a basic condition as odourless air was not achieved even one-and-a-half years after handover. The users had to work despite the odour, named by one of the interviewees as sewage. Eventually, it was found out that the odour was caused by non-sealing waste pipes in the risers of H1 and H3.

> "The cause of odour in the library (H1) has been found, according to the property manager. However, the problem remains, so it must be investigated further, ("Facility group" meeting minutes, 18/11/08).
>
> "Odour in the library (H1) is better but not good" ("Facility group" meeting minutes, 01/12/08).
>
> "Found that foul odour is still present on floor 2 (of H1) ("Facility group" meeting minutes, 10/02/09).
>
> "There was some sewage odour but that was fixed and so it was no longer a problem" (Interview, researcher, H3).

Mixed traffic

The traffic at the building's main entrance consisted of pedestrians, bicycles, cars and trucks with dangerous goods, without any separation between them. The mixed traffic was noted by users in 2008. The facility management took the question seriously after some time and two years later a proposal to rebuild the entrance area was developed. After a further year, the entrance area was rebuilt and the different types of traffic separated.

> "I remember we discussed it a lot, the rebuilding of the entrance. There was much traffic: there were cars but there were also trucks that transported dangerous goods (e.g. gas cylinders)" (Interview, research student, H3).

Partially resolved deficiencies

Drinking water

One of the partially resolved deficiencies is regarding drinking water. The problems with the drinking water were due to oversized water pipes that resulted in standing water during the summer, making the water unpalatable. This deficiency was solved temporarily (3 years 8 months after handover, following 3 complaints), by discharging water during the summer period, which is an action that can be questioned from a sustainability perspective.

External noise

The external noise problem was remedied (6 years 3 months after handover, following 7 complaints). The intermittent noise above the recommended level was generated from the frequent bus traffic and trucks during the sugar beet harvesting season. The noise was not reduced as the old timber-framed windows offered insufficient noise reduction, because they were distorted and did not seal properly. The eventual remedial action was straightening-up and sealing the old timber window frames. The internal noise problem, which was due to insufficient noise reduction through glass partition walls (with sliding doors situated close to common rooms), remained in 15 offices at the end of the study period.

> "According to the user's guidelines, the noise level from traffic in office rooms should not exceed 30 dB(A) equivalent and 45 dB(A) maximum" (The Tenant Safety Engineer missive, 22/10/13).

> "The noise level was up to 46 dB (A) when a bus or truck drove by outside the room, while the equivalent noise level for 1 minute was 35-36 dB (A). Sealing of windows had taken place since the previous measurement, which meant that the noise level decreased by up to 2-4 dB (A) when a bus drove by" (The Tenant Safety Engineer missive, 22/10/13).

Thermal climate

Problems of over-heating due to the lack of sun screening on south-facing windows was resolved by the users but only in the lunchroom (6 years 7 months after handover, following 4 complaints) by fitting interior sun-shading curtains. The problem remained in 30 offices.

Cold and draught problems were present from handover and caused by high U-values (i.e. 1.6), an uninsulated attic in H3 (Environmental Reconciliation No.1, 27/04/06, Facility owner), an uninsulated attic in H1 and design of heat sources not taking into account the facility's condition (i.e. split-level building, gaps around the windows and a significant heat differential between the ceiling and walls). The cold and draught problems were resolved in almost the whole building (7 years 6 months after handover, following 25 complaints). Even so, these problems remained in 4 rooms in H3, situated in the split-level part of the building, at the end of the study period (8 years after handover). The problems were resolved in sequential order starting with small rectifications because of the lack of budget and then major problems rectified one by one over the years. As a consequence, some users had to work in unsatisfactory thermal conditions for several years.

> "It has been decided that two radiators should be installed in the meeting room on floor 1, H3 along the east wall and one radiator in the meeting room on floor 2, H3 also along the east wall. The costs are to be met by the facility owner and is a necessary measure to make the climate in the meeting rooms good during winter-time" ("Facility group" meeting minutes, 31/08/10).

> "The lunchroom has been checked and found to have temperatures below 20 degrees" ("Facility group" meeting minutes 18/01/11).

> "The lunchroom has achieved a good temperature. The issue was [caused by] a small fault in an internal valve in the radiators not previously discovered" ("Facility group" meeting minutes, 01/03/11).

> "H1 is generally cold" ("Facility group" meeting minutes, 23/10/12).

> "The complaints about cold in the work rooms have produced results. The facility owner has decided to install additional insulation in the attic of H1. Possibly additional insulation in the attic of H3 will also be taken up by the facility owner, but such a measure is more costly as H3 has old ventilation units that must be dismantled before additional insulation can be installed" ("Facility group" meeting minutes, 05/02/13).

> "The facility owner has informed [us] that additional insulation to the attic of H3 is in the budget for 2014. Possibly, such an effort will be made, with a planned timing of summer 2014" ("Facility group" meeting minutes, 08/10/13).

> "It was cold during the winter, but whether it was each winter, I do not remember; but I think it was cold and you sat wrapped in a blanket" (Interview, research student, H3).

Work-related musculoskeletal disorders

Cleaning personnel faced problems with increased risk of work-related musculoskeletal disorders due to the parquet floors along the corridors and common areas needing to be cleaned manually.

> "We cannot use the floor scrubber cleaning machine as it can damage the floor irreparably… I have to do it manually" (Interview, cleaning personnel, H1, H2 and H3).

The facility group fought against this issue during the facility management stage but was unsuccessful and gave up complaining about this problem (5 years 5 months after handover, following 4 complaints). The problem remained unresolved at the end of the study period (8 years after handover).

Order of notification of deficiencies

The study also revealed that two kinds of complaints were not noted in the "facility group" meetings until several years after handover, even though they were known at handover: (a) extreme heat from the sun in the lunchroom during summer (3 years 1 month after handover); and (b) noise due to insufficient acoustic reduction in the building envelope as well as through the interior glass partition walls (3 years 8 months after handover).

Some of the deficiencies due to design failures that users faced seemed impossible to resolve due to the lack of budget. Examples were: (1) an undersized elevator of around 1 m^2 that prevented transportation of goods on pallets and access for electrically operated wheelchairs, resulting in heavy lifting and limited access to upper floors; and (2) ten small toilets each of 2 m^2 with floor-mounted WCs, instead of wall mounted WCs, which have a direct impact on the health of cleaning personnel.

A complete list of notified deficiencies and the status of the deficiencies of the facility at the end of the study (September 2015) is shown in table 3.

Table 3: Complete list of notified deficiencies and the status of the deficiencies of the facility at the end of the study (September 2015)

Notified deficiencies missed in briefing	Resolved	Unresolved
Comfort		
Foul odour	x	
Unpalatable drinking water	x	
Thermal climate		
Insufficient climate envelope	x	
Under-dimensioned radiators	x	
Non-divided radiator circuits		x
Insufficient attic insulation	x	
Insufficient ventilation control equipment	x	
Absence of solar shielding		x
Noise		
Inadequate noise reduction in the building envelope	x	
Inadequate noise reduction in interior glass walls		x
Accessibility		
Under-sized elevator*		x
Workload and working positions		
Under-sized elevator*		x
Absence of wind catchers and fixed entrance mats		x
Inadequate floor material		x
Small and tight toilet space		x
Top kitchen cabinets placed too high		x
Safety		
Mixed traffic	x	
Under-sized elevator*		x
Low height for staircase		x

*Under-sized elevator, affecting accessibility, workload and working positions, and safety

4.3.4 Discussion

Impact of deficiencies on the working environment and productivity

Earlier research has demonstrated that the influence of thermal conditions, air quality and noise and their impact can influence productivity by 8-9% (Niemelä et al., 2002; Geng et al., 2017). Ulrich et al. (2004) showed that workplace improvements can increase users' effectiveness as well as outcomes. Furthermore, Kaur (2013) emphasized that the highest level of Maslow's hierarchy of needs (i.e. self-

actualization) is needed to make employees work at their maximum potential. The thermal climate and sound environment proved to be unsatisfactory for several years for users. These factors can be assumed to have influenced the users' productivity in a negative way. Brager, Paliaga and de Dear (2004) showed that personal control over the indoor climate can influence one's experience of the work environment. Users' personal control over the indoor environment could be said to be almost zero, as not even repeated formal complaints over several years led to an acceptable indoor climate or acceptable acoustic environment. The formation of a special group on the part of users to pursue the resolution of the deficiencies demonstrates the high level of concern within the organizations, resulting from the significant negative effects on core business activities.

Delayed appearance of complaints

The study revealed that two complaints were not noted in the facility group meetings until several years after handover, even though they were known at handover: extreme heat and noise. The late appearance of complaints concerning acoustics find support in the work of Geng et al. (2017), who showed that while the thermal environment (in this case, cold and draughts) was unsatisfactory, the comfort expectations of indoor air quality, lighting and acoustic environment were lower, resulting in less dissatisfaction.

Facility management role

A critical issue in facility management has been shown to be the business sector in which the organization is placed (Price, 2004; McLennan, 2004), with the office sector generally lagging behind (Price, 2004). The project was a facility for office work, where the lack of a budget was limiting remedial work. The importance of alignment between the facility management and users has been pointed out by Then et al. (2014). Alignment must be actively pursued by both parties if an acceptable working environment is to be achieved and maintained. In none of the minutes did the facility owner show any concern for the effect the deficiencies could have on core business activities. The establishment of the facility group nine months after handover indicates that conflict existed between the users and facility management.

The idea of aligning or linking facility management to the core business of an organization to increase the strategic relevance of facility management has been promoted over a long period (Loosemore & Hsin, 2001; Green & Jack, 2004; Nutt, 2004; Osgood Jr, 2004; Then et al., 2014). Two levels of alignment, active and passive, have been identified (Then et al., 2014). The first level is centred on moving in the same direction as the users and the second level around the absence of conflict. Neither of these levels were evident in the project; instead, there was a misalignment, confirmed to some extent by the users' formation of the facility group. The need to adapt the facility management function to fluctuations in the

organizations they support is further underlined by Nutt (2002, in Chotipanich, 2004, p.367). Yet, no such adaptation to changes in the lifecycle of users' organizations during their occupation of the facility was present in the project and so the facility management was unaltered during the entire period of investigation. The arrangement of the facility management in terms of budgets, organization and service concept was not considered in any of the guidelines separately established by the facility owner and tenant, neither was it discussed during briefing, design or construction. The facility management was concentrated on strategic matters and strict financial management, for example portfolio management, facility planning and development, and high net profit from the facility.

The service perspective of facility management is underlined in the definition of facility management (British Standards Institution, 2015). Generally, the service concept includes service management, servicescape, service quality and service recovery. However, in the project, the facility management did not incorporate any requirement to integrate processes and achieve agreement on the services to be provided. The service concept, in the form of a detailed description of what should be done for users, was never discussed. Service quality was not defined in collaboration with users; furthermore, it was not re-assessed and neither was there any post-occupancy evaluation from which to learn lessons for the future. The result was a performance gap in operability with the facility management failing to create and maintain the expected function of the facility to fulfil the users' needs post-handover. Service recovery was reactive, based mainly upon defects and deficiencies reported by users and was not a proactive recovery strategy built on an active search for failures in advance of users' complaints. Service recovery to secure user satisfaction was not attempted and users' viewpoints and complaints were marginalized and undermined. The service recovery built on employee behaviour and a fast response but without meaningful quality in the response. It took a high frequency of official documented complaints (3-25 counts per type of deficiency) over unreasonably long periods (from 2 years to 7 years 6 months after handover per type of deficiency) to rectify the defects and other deficiencies passed to the facility management.

The study showed that neither organizational nor service aspects were designed to cope with the extensive deficiencies that remained after handover; additionally, no account was taken of the impact on the users' working environment and productivity by the facility management. At the same time, economic considerations (e.g. operation and maintenance costs and the provision appropriate budgets) received little attention.

Proposed model for development of facility management

The findings revealed the importance of a balance between economy, organization and service in facility management. Importantly, they indicated the need for alignment with the users' working environment during facility management to achieve the desired operational performance. The results also indicated that the requirement for resources diminished as the basic needs according to Maslow's hierarchy were fulfilled by remedial work.

Earlier research has used Maslow's hierarchy of needs as a conceptual framework to understand how a facility should work to fulfil users' needs (Duncan & Blugis, 2011). It has been shown that the facility has the opportunity to influence the different stages in Maslow's hierarchy of needs, i.e. physiological, safety (Clements-Croome, 2013) and self-actualization (Kaur, 2013). Furthermore, the use of Maslow's hierarchy of needs is also recognized in the development of sustainable designs (Woods, 2008). Evaluation of facilities based on the two principles of WHO's definition of healthy workplace and Maslow's hierarchy of needs are recommended as they offer synergistic benefits (Woods, 2008). Separately, Then et al. (2014) has emphasized a model based on alignment.

The findings from the case study have revealed the importance of a balance between economy, organization and service in facility management. Importantly, they indicate the need for alignment with the users' working environment to achieve the desired operability. The results also indicated that the requirement for resources diminished as basic needs were fulfilled by remedial work. In order to conceptualize the need for designing facility management with a focus on economy, organization and service built on alignment with the users' working environment, as the case study has shown, a new way of looking at facility management is proposed through the EOS model (see figure 11). This new focus aligns with Then et al. (2014) who highlighted facility management's increasingly critical role as custodian of the workspace environment, by synchronizing with the needs of users to create synergies. The model also receives support concerning alignment of the facility management function with the core business of an organization through earlier research (Loosemore & Hsin, 2001; Green & Jack, 2004; Nutt, 2004; and Osgood Jr, 2004). The EOS model is also in conformity with the definition of facility management in ISO 41011:2017 as the "organizational function which integrates people, place and process within the built environment with the purpose of improving the quality of life of people and the productivity of the core business" (International Organization for Standardization, 2017e).

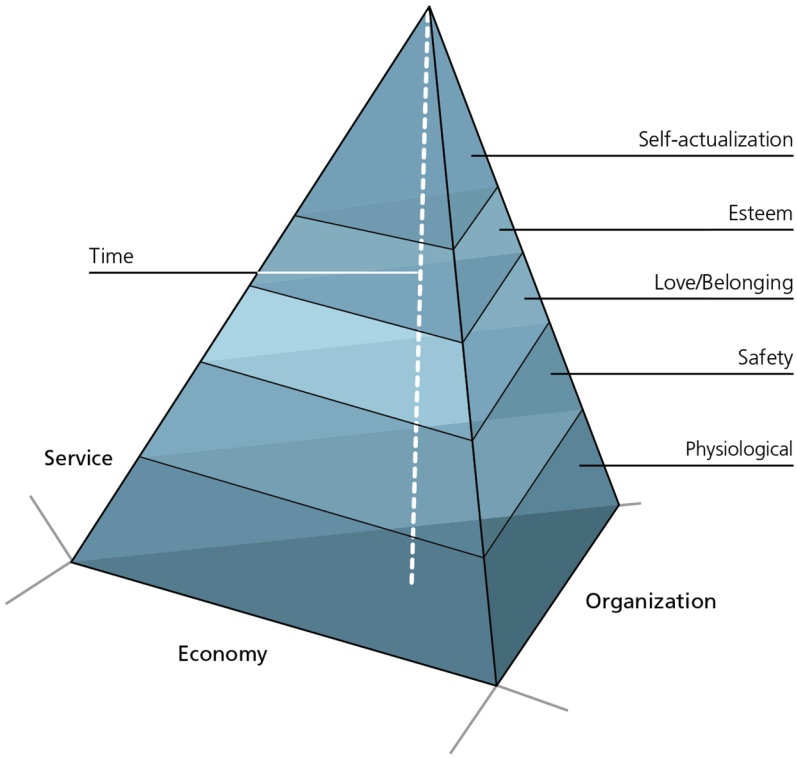

Figure 11: The EOS model for facility management

The EOS model integrates Then's model of alignment and Maslow's hierarchy of needs, including aspects of the working environment and change over time. The EOS model underpins the necessity to put emphasis on the adequacy of economy, organization and service.

The EOS model is built on three parameters: economy, organization and service to create a tetrahedron that encloses Maslow's hierarchy of needs concerning the working environment for users. The EOS model is aligned around the working environment of users. The model conceptualizes the importance of adequacy concerning economy, organization and service, and that the need for facility management reduces over time when sufficient efforts have been taken to resolve deficiencies associated with the lower levels of Maslow's hierarchy of needs, i.e. physiological and safety. The model also shows that the requirement for resources in regard to economy, organization and service is greatest immediately after handover, when physiological and safety errors appear as a consequence of a lack of briefing, shortcomings in the execution of the planned measures and problems with the adjustment of control systems such as ventilation.

4.3.5 Conclusions

The study has traced the refurbishment of a facility from handover into a multi-year period of operation and use. Whilst no claims as to the uniqueness of this study could be justified, it does nonetheless offer valuable insights into the effectiveness of capturing and managing users' operational requirements during briefing to show what happens when deviations from the agreed plan occur. This latter aspect is especially marked during operation and use, where the function of facility management, as presently defined, has been called into question. It has been shown that the service concept (e.g. service management, servicescape, service quality and service recovery) cannot be assumed to form an integral part of facility management. For it to provide active support for the organization and its users, facility management must always be aligned with the core business objectives.

The proposed EOS model highlights the importance of establishing a balanced economy, organizational and service capacity in the early stages of a refurbishment or new build project so that steps can be taken if required to rectify defects and deficiencies, both major and minor, post-handover of the facility. Doing so can strengthen the effectiveness of facility management. The model increases the awareness of the importance of linking facility management to the purpose of the facility; that is, as a production resource in supporting users' working environment and acknowledging the importance of productivity in this regard, instead of viewing the facility as mostly a resource for profit for the facility owner. The model also explains in a simple way the importance of appropriate sizing of facility management with respect to economy, organization and service. If applied correctly, the model can help to reduce the dimensions of economy, organization and service as soon as a steady state of operation and use has become established.

4.4 Case study III – Post-occupancy evaluation

4.4.1 Aim

The aim of the study was to determine if a single post-occupancy evaluation of a refurbishment can contribute to single- and double-loop learning to understand and improve users' working environment.

4.4.2 Methods

The study concentrated on just one time-period, the performance of the refurbishment in May and June 2018. It included the completed facility and the contracting service. The study was undertaken two years after re-occupation of the refurbished building, through document analysis, a post-occupancy evaluation and

interviews, and considered the refurbishment on both the macro and micro levels with regard to users' experience.

The post-occupancy evaluation incorporated both quantitative and qualitative elements involving different feedback techniques i.e. document analysis, a questionnaire-based survey and complementary interviews. The documentation pertaining to the refurbishment and its organization was examined; but inspection of tender documentation was not possible. The document analysis included legislation that could impact the refurbishment, regulations from the tenant and documentation on the refurbishment published on the homepage.

The questionnaire and interviews were built on users' experience of the facility based on their senses (i.e. visual, auditory and olfactory). This form of evaluation takes into consideration experience of the indoor climate, recognizing that it depends on the intersection of physiological, psychological and social factors.

Survey questionnaire

The questionnaire was included in an online survey undertaken in May and June 2018, using the *SUNET* survey tool. It also included questions regarding working environmental issues to be used eventually in future working environmental research studies, for example, nature of employment and working time at the computer (see appendix B1). The link to the survey was distributed by email to the central administrative staff of each department for further distribution to the target respondents: research staff, lecturers, research students and administrative personnel. Students at the undergraduate level were excluded as the focus was on the working environment for employed personnel. The total number of responses was 103, out of a possible 404, which corresponded to a response rate of 25.5%.

The questionnaire's main body was divided into four groups of question, all which centred on users' needs and how well the selected variables matched those needs. They were: (1) building performance; (2) functionality of facilities/services; (3) comfort; and (4) personal control over the working environment.

1. Building performance – layout, privacy, ease of interaction, safety and security. The evaluation scale was unacceptable (i.e. falls below my minimum requirements), inadequate (i.e. does not meet my essential requirements), adequate (i.e. meets my essential requirements) and delighted (i.e. exceeds all my requirements).
2. Functionality of facilities/services – general, lecture rooms, offices, heavy transport (i.e. goods and waste) and service recovery (i.e. remedial actions taken after reporting of complaints). The evaluation scale was unacceptable, inadequate, adequate, delighted and not applicable.

3. Comfort – indoor temperature, thermal comfort, air quality, draught, noise level and visual comfort. The evaluation scale was unacceptable, inadequate, adequate and delighted.
4. Personal control over the working environment – heating, ventilation, lighting, noise, privacy and waste disposal/recycling. The evaluation scale was 1-5, with 1 being no control and 5 full control.

The questionnaire allowed additional comments to be made concerning each group of questions. The reason for giving the opportunity to comment freely was to qualify the responses and draw attention to whether or not any aspect had been missed in the questionnaire.

The questionnaire also included an open-ended question about productivity. This open-ended question was formulated as follows. “In what ways, if any, has the renovated building either improved or decreased your work productivity?”.

Responses were analysed using different statistical techniques. Frequency analysis was used to capture the distribution of the responses. Factor analysis was used to clarify if it was possible to identify underlying dimensions (i.e. factors) that could ease the understanding of the complex phenomenon regarding the refurbishment and its influence on users’ working environment (see appendices A1-A4).

Interviews

The aim of the interviews was twofold:

1. examine the briefing and design process to identify any deficiencies experienced by users; and
2. find explanations to increase understanding of the results reported in the survey questionnaire.

Prior to each interview, a set of questions that was deemed capable of highlighting interesting issues was prepared based on the role of the interviewee. The emphasis was put on the working environment from the user’s perspective in the context of briefing and design. The interviews were exploratory, semi-structured, in depth and undertaken face to face, recorded and then transcribed.

The interviewees were: the client’s construction manager in charge during briefing and construction (i.e. project leader); two consultants (both architects participating together) who were involved in briefing and design; three facility supervisors who shared responsibility for representing the users’ perspective of facility management in the building during the project from briefing until operations; one researcher; one research student and two cleaning personnel.

4.4.3 Results and analysis

Survey questionnaire

Frequency analysis

The frequency analysis revealed to the following:

- building performance was acceptable for all evaluated variables;
- functionality was acceptable for 12 and unacceptable for three of the evaluated variables;
- comfort was acceptable for three and unacceptable for five of the evaluated variables; and
- personal control was acceptable for one and unacceptable for seven of the evaluated variables.

The variables that were evaluated as acceptable were:

- building performance − general building layout, current personal workspace, your workspace in relation to the surrounding workspaces, privacy of your workspace, personal computer facilities, amount of space available for individual work and storage, ease of interactions with co-workers, safety in the building, security in the building, hygiene and cleanliness in the building, and overall quality;
- functionality − individual/shared workspace, accessibility, classrooms, lecture theatres, computer laboratories, foyer/common areas, kitchen and eating places, toilets, elevators/lifts, goods delivery entrances, library and outside areas within the boundary of the building;
- comfort − draught in your workspace, noise level within or immediately surrounding your workspace, noise level in the building in general; and
- personal control − artificial lighting.

The variables that were evaluated as unacceptable were with regard to:

- building performance − none (see table A1/BPIV in appendix A1);
- functionality − laboratories/workshops (non-computer), waste collection entrances and speed of service recovery (i.e. remedial actions taken after reporting of complaints). The percentage of respondents that rank functionality in these three areas <80% were between 63-71%, (see table A2/FIV in appendix A2);
- comfort − summer indoor temperature, winter indoor temperature, thermal comfort of your workspace, air quality of your workspace and visual comfort from the lighting in your workspace. The percentage of respondents that rank comfort in these five areas <80% were between 64-79%, (see table A3/CIV in appendix A3); and

– personal control – heating, ventilation, daylight lighting, noise, privacy, waste disposal and waste recycling. The percentage of respondents that rank personal control in these seven areas <80% were between 14-76%, (see table A4/PCIV in appendix A4).

The project-specific context of room allocation (i.e. individual/shared room) was not considered in the design of the questionnaire. Its inclusion could have contributed to increased understanding concerning the experience of thermal climate, noise and privacy.

Factor analysis

Analysis showed that some of the variables within each of the four groups of questions had similar response patterns. This could indicate that it was possible there was an internal correlation between those variables. This finding motivated testing by factor analysis to clarify the connection between the variables. Two tests were performed to measure the inter-correlation within each set of questions (the correlation between the different variables): Kaiser-Meyer-Olkin test (KMO) and Bartlett's test of sphericity. Both tests indicated, within each of the four groups of questions, that a factor analysis could contribute to increased understanding of the questionnaire. Factor analysis was implemented for each group of questions. For detailed information, see appendices A1-A4.

The Scree plots generated within each set of questions showed that two factors within each group of questions had an Eigenvalue above 1, which indicated that these new factors can to, a large extent, explain the variation in the questionnaire.

Building performance

- Factor 1 in analysis 1 (Eigenvalue, 4.4) consists of the variables: your workspace in relation to surrounding workspaces; privacy of your workspace; current personal workspace; amount of space available for individual work and storage; personal computer facilities; and ease of interaction with co-workers. These variables all relate to the *micro level* of the users' working environment and not the common area.
- Factor 2 in analysis 1 (Eigenvalue, 1.5) consists of the variables: security in the building; hygiene and cleanliness in the building; overall quality of the building; safety in the building; and general building layout. These variables relate to the *macro level* of the users' working environment, namely the design.

To find out if the exclusion of some variables could increase understanding of the questionnaire, three further iterations of factor analysis were undertaken. First, in analysis 2, the variables that could depend on decisions other than the refurbishment

were excluded, namely personal computer facilities and hygiene and cleanliness in the building. Successively, in analysis 3 and 4, the variables that had the lowest importance within Factor 1 and 2 in the rotated component matrix were successively excluded. In analysis 3, ease of interaction with co-workers was excluded in Factor 1 and in analysis 4, general building layout was excluded in Factor 2. The highest value of KMO was reached in analysis 4 (0.797) compared to analysis 1 (0.780) in which no variables were excluded.

- Factor 1 in analysis 4 (Eigenvalue, 3.3) consists of the following variables in decreasing order of importance: your workspace in relation to the surrounding workspaces; privacy of your workspace; current personal workspace; and amount of space available for individual work and storage. These variables all relate to the *workspace level* of the users' working environment, the individual user's absolute closest working area, the individual working place.
- Factor 2 in analysis 4 (Eigenvalue 1.3) consists of the following variables in decreasing order of importance: security in the building; safety in the building; and overall quality of building. The two dominant variables in this factor relate to the *personal safety* of the users' working environment.

Factor analysis 4 further emphasises the users' priority on the *micro level* in form of *workspace* and *personal safety* and not the common area of the refurbishment.

Functionality

- Factor 1 (Eigenvalue, 3.0) consists of the variables: kitchen and eating places; foyer/common areas; outside areas within the boundary of the building; and individual/shared workspace. These variables all relate to areas that can be seen as *living space*.
- Factor 2 (Eigenvalue, 1.1) consists of the variables: toilets; elevators/lifts; and accessibility. These variables relate to areas that can be seen as *necessity functions*.

The factor analysis did not include premises intended for teaching (see appendix A2).

Comfort

- Factor 1 (Eigenvalue, 4.0) consists of the variables: winter indoor temperature; thermal comfort of your workspace; air quality of your workspace; draught in your workspace; and summer indoor temperature. These variables mainly relate to *thermal climate* of the users' working environment.
- Factor 2 (Eigenvalue, 1.1) consists of the variables: noise level in the building in general; visual comfort from the lighting in your workspace; and noise level within or immediately surrounding your workspace. These variables relate to *other comfort areas* of the users' working environment.

Personal control

- Factor 1 (Eigenvalue, 3.0) consists of the variables: control waste disposal; control waste recycling; control privacy; control artificial lighting; and control noise. These variables all relate to *low operation costs* variables. Note that users pay for their own consumption of electricity.
- Factor 2 (Eigenvalue, 1.6) consists of the variables: control heating; control ventilation; and control daylight lighting. These variables relate to *high operation costs* variables.

The factor analysis contributed to the understanding of the users' experience of the refurbishment by reducing 43 variables to eight variables. A contribution that can increase the understanding of the users' experience of a refurbishment. The new variables can be used in future questionnaires to reduce the number of questions needed to capture the users' experience of a refurbishment.

Productivity – frequency analysis

The questionnaire contained an open-ended question for the refurbishment's impact on productivity. The question resulted in 30 responses (out of 103 respondents), which corresponds to a response rate of 29.1% (see appendix A5). This is a low response rate. Nonetheless, an analysis of the 30 responses was undertaken. The analysis indicated that 19.4% of respondents experienced increased productivity as a result of the refurbishment. To be able to draw general conclusions from this question, it would have been necessary to formulate it as a mandatory question with fixed response options in the form of increased, unaltered or decreased productivity.

Document analysis

Legislation

The context of the project was shaped by two pieces of legislation that can influence building projects. The first is the "Act on copyright in literary and artistic works", SFS 1960:729 (Swedish Code of Statutes, 1960), which expressly includes noteworthy architectural design where changes can depend on the original architect giving permission. The second is the "Work Environment Act", SFS 1977:1160 (Swedish Code of Statutes, 1977), which requires that all workplaces with more than five employees have an elected safety representative. Workplaces with more than 50 employees must have a working environment committee too. The safety representative and the working environment committee are required to participate in the planning of new or changed facilities.

The restriction imposed on the design by virtue of the Act on copyright in literary and artistic works, SFS 1960:729 (Swedish Code of Statutes, 1960), limited the facility

owner's ability to change the façade and interior walls that were an integral part of the original design. The Act influenced the tender, by imposing three exclusions.

1. Changes to the external walls were not permitted. A consequence was the inability to classify the building according to the certification scheme "Environmental building", Manual 2.2 [Miljöbyggnad, Version 2.2], (Sweden Green Building Council, 2014) on the gold level as this would have required the addition of insulating material on the building façade. This limited the opportunity to improve thermal performance for the benefit of users and reduced the buildings' environmental credentials.
2. Changes to the internal walls in the basement. This exclusion meant that 60-year-old standards would continue to be applied to the size of toilets indefinitely, directly impacting the cleaning personnel as well as users.
3. Lecture halls designed in theatre style. The exclusion of lecture halls with theatre-style seating meant that current legislation concerning accessibility could not be applied, and that access to the lecture halls for disabled persons had to continue to be through the basement and with wheelchairs having to be placed on the lecture floor, meant to be used by the lecturer.

The Work Environment Act, SFS 1977:1160 (Swedish Code of Statutes, 1977), laid the foundation for the refurbishment project. According to the Act, the users elected safety representatives shall be included in the planning of the future working environment. The users' elected safety representatives have responsibilities for approving the future working environment and for the working environment during the construction stage if the users still have to work in parts of the building during construction. This was the case here, as not all parts of the main activities could be relocated. Furthermore, all users must inform their elected safety representative about their needs. This means that a large part of the responsibility for consideration of work environment related issues during design ends up with users and their representatives, previously not skilled in briefing or design.

Documents covering the refurbishment

The "Requirements and Advice 2002" established by the tenant was followed during the whole project, which was the opposite of what was decided in Project 1. The working environment with respect to office work was handled by creating standard types of working rooms. The pre-negotiated standard layout of working rooms included uniform layout of furnishings with fixed lighting installations and glazed doors. All other questions concerning researchers and administrative personnel's work environment were handled issue by issue.

The documents showed that the working environment issues were handled separately by the three organizations as follows.

- Client organization: a safety and health coordinator for matters during the project preparation stage, a role assigned by one of the client's representatives in the project group.
- Tenant organization: the tenant's organization emphasized having responsibility issues related to the working environment.
- Users' organization: one of the nine working groups and the working committee discussed work issues related to the environment. The working environment committee forwarded its comments to the project group through the facility supervisor.

The document analysis also showed that post-occupancy evaluation was not included in the required scope of work during procurement of the refurbishment project. As a result of this failing none of the consultants had the opportunity or the funding to undertake an evaluation. Neither was a post-occupancy evaluation undertaken after the refurbishment by the client or the tenant. Consequently, no lessons could be learnt for future projects. Additionally, no evaluation of the users' working environment was undertaken by the facility manager during the facility management.

Interviews

The analysis of the interviews was done in concordance with the twofold aim of the interviews as stated earlier.

Identification of eventual deficiencies in the briefing and design process

A lack of interest for the refurbishment was expressed by one of the facility supervisors.

> "…a meeting in the house where you would explain how this renovation would go and building plans… what surprised me a lot was that there were so few people and when you came to the information meetings, it was always the same people. The house has… what can there be 250–300 people… there are many guest teachers and research students… that do not have the same interest, but you could expect more [participants]" (Interview, facility supervisor #3).

The interviews also indicated that the cleaning personnel had experienced limited involvement in the planning of the refurbishment.

With regard to formalities, the interviews also revealed weaknesses. One interview indicated that no risk analysis of future users' working environment was undertaken although was required in accordance with legislation.

> "…work environment risks associated with office staff… it was no more than that we followed the recommendations contained in the "Requirements and Advice" for the university, so I do not think that any special risk analyses were made... not that I remember" (Interview, facility supervisor #1).

In the interviews, the facility supervisors and users pointed out the lack of support regarding the checking of drawings as a cause of problems.

> "...when there were referral rounds and such like, we had access to basically all kinds of drawings, but it was possible that we were too passive. We should have asked more, but we did not really understand everything that was on those drawings… we would have liked to have had a little clearer explanation or, at some point, a review or something like that" (Interview, researcher).

To make matters worse, the users' limited response on drawings and descriptions was noted by the project leader and interpreted as lack of commitment, resulting in conflict between users and the project management.

> "I am not impressed with the users' involvement during the planning... if there is no commitment from the users then it is difficult..." (Interview, project leader).

In the interviews, the facility supervisors also pointed out the need for guidelines on financial consequences and the assignment of responsibilities among the participating parties. These were generally missing. An example of this can be existing fittings (i.e. window blinds and water installations) which were expected by the users to remain in place but were dismantled and not replaced. The users had to pay to reinstall them.

> "...no one had said they should remain… I think that is simply because people were not aware of how important it was to really go into detail and check all the drawings that it actually stated that they would be left" (Interview, facility supervisor #2).

Furthermore, the opportunity to evaluate the refurbishment by undertaking a post-occupancy evaluation was not included in the tender for the refurbishment neither undertaken voluntarily by the consultants or the facility manager during operation and use.

> "I think we talked about this [to do a post-occupancy evaluation] at a very early stage because we did… surveys before we renovated to find out what the status was like and then we also said that it should be done afterwards too; but then I do not know to what extent someone did or did not do so." (Interview, facility supervisor #1).

> "…we usually go back but we have not really had the time and then there is the question of who to ask, but we don't do it in an overall way. We go and ask some people "how did it work" and maybe most likely we [ask] those who have been dissatisfied [with a suggested solution]." (Interview, architects).

Explanations that could increase the understanding of the results reported in the survey questionnaire

Building performance and Functionality

The interviews revealed that prioritization was not unanimous. Consultants prioritized the *macro level* while users prioritized the *micro level.* The interviews revealed that the architects' focus was typically threefold: (1) creation of the artefact; (2) users' needs; and (3) future users' needs. The priority was the creation of the artefact, behind which came the needs of users including their working environment; but, the architects prioritized lines and space above users' working environment.

> "…understand the place, in this case a refurbishment, the existing facility and its conditions, especially its structure. Thus, step one is to work with structure; that is, connections within a facility and at the same time try to understand the users' needs… those that are present in the building… try to understand future needs, for it is very easy that the users of today who can make themselves heard today decide; but those decisions must not lead to sub-optimizations that have consequences for future opportunities…" (Interview, architects).

> "…our competence is to see the meeting… finding the meeting between the potential/conditions and the needs of users. Find that meeting, see the potential, see unexpected opportunities; it is our cutting-edge expertise..." (Interview, architects).

While, users prioritized the micro level, as the following examples show:

- The lecturers' specific way of teaching in two lecture rooms at the same time during students' project teamwork, by walking around answering questions in both rooms and the need, therefore, to have an open door between the rooms, was not captured during the design of the ventilation system. This resulted in noise in the lecture rooms and difficulty opening the entrance doors to the lecture rooms due to differential air pressure.
- Interviewees showed higher dissatisfaction with the standard room layouts as they were experienced to be inconsistent with the way users would furnish their work rooms after the refurbishment. Problems such as poor positioning of luminaries were highlighted in the interviews.
- Flooring material was a question of central importance in the design of a large laboratory. A specific area for discussion was the treatment of the floor, which was constructed of timber with pre-drilled holes to be used for securing equipment during experiments but sealed with plugs when not used. The users wanted a specific treatment of the floor, but their views were not accepted and another treatment was chosen. This resulted in the plugs not sealing against water leakage to the floor below. The problem lasted until it was resolved, during operation and use, with additional payment met by the users.

- Sound reduction in manager's rooms was emphasized by users during the design process as a key requirement, to allow conversations of a sensitive nature to take place without being overheard. This requirement was actively considered with respect to the doors and walls; however, it was completely overlooked when vents were installed above the doors. This lack of coordination has resulted in a lasting lack of privacy.

The interviews showed that when prioritization was needed, those aspects of the working environment impacting on the cleaning personnel were not considered or downgraded. Some specific examples of areas in which deficiencies were experienced by the cleaning personnel, as a result of this prioritization, can be mentioned.

- Lobbies are complex, with several requirements having to be fulfilled (e.g. fire safety regulations). In particular, functional requirements for electronic card readers involve precision and heavy doors with remote opening should be adapted for the transportation of cleaning carts and scouring machines. Not all requirements could be fulfilled and, as a result, the remote-opening capability was not installed. This increased the workload for the cleaning personnel due to unnecessary hopping on and off when driving their scouring machines.
- Installation of thresholds instead of door-mounted fire and smoke barriers to lecture rooms. Door-mounted barriers could have been an alternative but were not specified. The decision to install thresholds has a direct influence on the working environment of the cleaning personnel as they have to lift the cleaning carts over the thresholds or leave them outside the lecture rooms.
- The choice of fixtures and fittings in the toilets (e.g. lavatory pans, hand dryers and waste bins). Floor-mounted lavatory pans were chosen instead of wall-hung pans; however, floor-mounted lavatory pans result in awkward postures for cleaning personnel. Installation of electric hand-dryers and the absence of waste bins resulted in toilet paper littering the floor as toilet paper was used for drying hands. Often, it was thrown in the small sanitary bag holders, increasing workload for the cleaning personnel.
- The facility owner's interest in reducing the amount of water installations and unresolved conflicts among the cleaning personnel concerning cleaning methods (i.e. dry or wet methods) also occurred during the design. This resulted in some fixtures and fittings, which were expected by some of the cleaning personnel to remain, being dismantled and not replaced. They included water fountains and floor drains in rooms for cleaning equipment on different floors and in toilets. This created difficulties when replacing water in the scouring machines.

Considerations concerning particulate matter (i.e. pollution in the form of small particles) and chemical emissions and their eventual influence on the users' working environment were limited to the regulations and findings published in the technical press. Research results, which have not been incorporated in regulations, were not taken into consideration.

> Question: "When choosing materials such as flooring materials, do you consider emissions and health risks?"
>
> Answer: "Yes, we take in from... well we rely on the knowledge of others, it is not that we directly make our own explorations... but we have our ears open, so absolutely and the research reports that are reflected in our technical press" (Interview, architects).

Comfort and Personal Control

Additionally, the interviews with the users' showed that the experience of the thermal climate and the ventilation was unsatisfactory for office work. The room climate during summer was experienced as too warm to work in due to solar radiation. At the same time, the room climate was experienced as cold during winter and separate radiators was used by the users to make it acceptable. The ventilation was also experienced as unsatisfactory for office work and the users experienced a lack of fresh air.

> "This summer was extremely hot, but I know I contacted [the facility owner] once because it was hot and then they announced that they had increased the ventilation or whatever it was they expressed but I did not notice any difference, so I sat at home quite often because it was too hot here and I sit on the side where the sun rises and fry quite a long time of the day… I think that it was almost too hot to work in" (Interview, research student).
>
> "It is almost never in my room that any air enters" (Interview, researcher).

The argument for not improving external insulation or installing external sun-shading can be found in the interview with the project leader.

> "… we have tried to insulate by adding additional insulation on the outside to cope with the energy requirement better, but… we have had to let it go …there is a lot that we have not been allowed to do because it is a [name of the famous architect] house" (Interview, project leader).
>
> "…it was very, very important that this is a [name of the famous architect] house, so we must not make any external changes" (Interview, project leader).

4.4.4 Discussion

Legislation

The case study revealed through document analysis and interviews how *context-specific control embodied in legislation* can influence briefing and design and, indirectly, prevent an optimal working environment for users. Two Acts with different forms of impact on the projects' influence on the users' working environment were found. Both Acts restricted the results but in different ways.

The Act on copyright in literary and artistic works, SFS 1960:729 (Swedish Code of Statutes, 1960) could have been disputed or its effects taken into consideration when requirements were identified during procurement. However, they were not and this resulted in a negative influence on the users' working environment on both the general and specific levels.

- On the general level, the Act on copyright limited the possibilities to insulate the external walls and install external sun shading, which equated to adverse effects on the users' thermal climate and, as a result of this, the building could reach the silver certification level only.
- On the specific level, the Act on copyright resulted in the exclusion of design considerations on the size of the toilets and the sloping lecture halls. This resulted in unsatisfactory working positions for cleaning personnel in the toilets and continued to limit access to the lecture halls for users with mobility restrictions.

The Work Environment Act, SFS 1977:1160 (Swedish Code of Statutes, 1977) resulted in an unsatisfactory outcome in several areas by distributing work tasks during briefing and design to persons unskilled in such matters.

These findings, not earlier found in the literature, underscore the importance of evaluating general legislation within areas other than construction for their potential influence on users' working environment.

The refurbishment project organization

The composition of the project organization is important, especially the inclusion of all working groups. The document analysis showed that the project organization created to handle the refurbishment consisted of three organizations working in parallel coordinated by a project group with four representatives: 2 client, 1 tenant and 1 user. The organizations were: (1) the client's organization; (2) the tenant's organization; and (3) the users' organization. Greater value might have been created if the organizations had been built with consideration of how different groups believe transmission of project culture takes place (Samaraweera, Senaratne &

Sandanayake, 2018). The users' organization was intended to augment the value of the project in the expectation of co-creating value (Bettencourt, Lusch & Vargo, 2014; Fuentes, 2019). The users' organization had significant representation including around 10% of the researchers and administrative staff but just 1% of the students. However, the cleaning personnel as well as the main safety representative were not represented in any of the users' working groups for the refurbishment project. Moreover, the interviews showed that neither the consultants nor the users' organization considered the workspace or the work environment of the cleaning personnel as part of the whole building. As a result, the ability for the cleaning personnel to influence requirements was mainly restricted to the opportunity to comment on drawings and related documents restricted to their own few areas, namely the washroom, store room, rest room and changing room. Cleaning personnel were not involved in commenting on the design of other areas despite those areas having an influence on their working environment. This affected them directly in the form of an unnecessarily heavy workload continuing into the future because any changes to the services installations, materials or colour schemes are likely to be too costly to change.

The questionnaire responses and interviews indicated that working groups can have quite different interests concerning requirements. Researchers and administrative personnel highlighted both in their responses to the questionnaire and in the interviews: thermal climate, air quality, lighting, noise and location of equipment as relevant to their working environment. On the other hand, the cleaning personnel in the interviews highlighted choice of materials and pigmented wall finish, choice of equipment and location of equipment as relevant to their working environment. One single area, the location of equipment, was mentioned as important by all working groups, researchers and administrative personnel as well as cleaning personnel. This further underlines the importance of inclusion of all working groups.

The case study revealed organizational shortcomings as follows: first, through interviews, where the assignment of responsibilities for financial aspects were unclear for several users and, second, the limited contact areas between the clients' organization and the users' organization. Third, document analysis revealed the separate handling of working environment issues across the three organizations. Together, these shortcomings underline the need to have responsibilities assigned in the project start up, according to both the working environment and available finance. The use of RACI (responsible, accountable, consulted and informed) charts could assist in this regard. The study pointed out the importance of contact times and places where consultants (e.g. architects) and users could meet. However, the practical matter of cooperation between consultants and users was not considered in the project governance or in the users' organizational plan for the users' working groups involved in the refurbishment. This was especially so in regard to the working environment since the organizations involved (i.e. client, tenant and users)

all dealt separately with working environment issues for intended users instead of through cooperation among the organizations. This meant that professional support from the consultants was not accessible for most of those participating in the users' groups dealing with the refurbishment.

This lack of support limited the learning process between the consultants and users. No thought was given to the possibility of users' groups being unable to understand drawings and so check the working details. Drawings are a symbolic language and technical descriptions are built upon technical terms. Importantly, the case study showed that both drawings and technical descriptions require interpretation to be understood by users. The study emphasized the need for representatives to have the requisite skills and competence to represent the users' interests.

The decision not to include post-occupancy evaluation in the scope of the refurbishment limited the learning process since one of the purposes of post-occupancy evaluation is to collect information to help improve procurement (Hadjri & Crozier, 2009). Zimmerman and Martin (2001) noted that architects are not normally paid to go back and review the outcomes. Moreover, designers seldom review the outcome of their design options. This case study lends support to these findings as it has shown that no lessons were learnt from the refurbishment since no post-occupancy evaluation was undertaken by either the facility owner or any of the consultants because the task of undertaking a post-occupancy evaluation was not assigned in the tender to any specific party.

Collectively these findings, indicate that there were several organizational shortcomings that influenced the result of the refurbishment.

Building performance

The interviews with the architects showed that the consultants prioritized the macro level within the area of building performance, while the influence on the working environment is both on the macro and the micro level. The frequency analysis showed that this prioritization resulted in the respondents finding the building as acceptable after refurbishment regarding their requirements for office/lecture work within building performance. The first of the factor analysis of the group of questions on building performance as well as the interviews indicated that the users evaluated their working environment on the micro level. The first factor analysis on building performance showed that one new factor *the micro level* relating to the users' working environment could explain most of the result. It comprised the variables of: your workspace in relation to the surrounding workspaces; privacy of your workspace; current personal workspace, amount of space available for individual work and storage; personal computer facilities; and ease of interactions with co-workers. The fourth, factor analysis on building performance, further underlined this result by indicating that the four variables (your workspace in

relation to the surrounding workspaces; privacy of your workspace; current personal workspace; and, amount of space available for individual work and storage) could explain most of the experience of the refurbishment.

The other new factor generated within the first of the factor analysis for building performance, *the macro level* of the users' working environment could explain a minor part of the result only. It comprised the variables of: security in the building; hygiene and cleanliness in the building; overall quality of the building; safety in the building; and general building layout. The variables within this factor all relate to the macro level of the users' working environment, namely the design.

The interviews confirmed the results of the statistical analysis for building performance, namely that the users' evaluation of the working environment was mainly focused on the micro level. The interviews further indicated the importance of the micro level within building performance, for example, services installations, choice of material and choice of wall colour. Together these findings indicate that users' value both the macro and micro level. However, the users' experience on the micro level explains to a large extent the users' experience of the refurbishment. This is a new finding not earlier seen in the literature.

Functionality

The frequency analysis showed that the respondents found the building as acceptable after refurbishment concerning their requirements for office/lecture work within functionality for 12 of 15 variables. The shortcomings relating to functionality occurred in the areas of laboratories/workshops (non-computer), waste collection entrances and speed of service recovery. The factor analysis of the group of questions for functionality (which did not include premises intended for teaching, see appendix A2) showed that one new factor, *living space*, comprising the variables kitchen and eating places, foyer/common areas, outside areas within the boundary of the building and individual/shared workspace could explain most results. The other new factor generated within the factor analysis for functionality, namely *necessity functions*, which comprised the variables of toilets, elevators/lifts and accessibility could explain just a minor part of the result. But, in the interviews there were no findings regarding functionality.

Comfort

Evaluation of the as-built conditions with regard to comfort is usually based on technical measures (e.g. air flows in ducts). However, another way to evaluate the facility is to measure users' senses (i.e. visual, auditory and thermal) (Szokolay, 2004). This form of evaluation takes into consideration experience of the indoor climate, recognizing that it depends on the intersection of physiological,

psychological and social factors (Chappells & Shove, 2005; Cole et al., 2008) and concepts of comfort that emphasize indoor environments grounded in cultural satisfaction rather than technically optimal factors (Shove et al., 2008). This latter form of evaluation of comfort was used in the survey questionnaire. The frequency analysis revealed that respondents found the building, as acceptable after refurbishment concerning their requirements for office/lecture work within comfort for three of eight variables. The shortcomings concerning comfort occurred in the areas summer indoor temperature, winter indoor temperature, thermal comfort of your workspace, air quality of your workspace and visual comfort from the lighting in your workspace. Further, the factor analysis of the group of questions on comfort showed that one new factor, *thermal climate*, comprising the variables of winter indoor temperature, thermal comfort of your workspace, air quality of your workspace, draught in your workspace and summer indoor temperature could explain most results. The other new factor generated within the factor analysis concerning comfort, namely *other comfort areas*, which comprised the variables of noise level in the building in general, visual comfort from the lighting in your workspace, and noise level within or immediately surrounding your workspace, could explain just a minor part of the result. These findings have support in Choi, Loftness and Aziz (2012) who showed that 33% of workers were slightly dissatisfied, dissatisfied or very dissatisfied with the air quality at their workstations. The findings from the statistical analysis were further strengthened by the interviews with the users, who expressed dissatisfaction with the indoor temperature during summer and winter as well as with air quality.

Together these findings reveal that comfort, identified in earlier research as resulting in unfulfilled aims, remains but also that much of the dissatisfaction with the refurbishment to a large extent can be explained by users' experience of unsatisfactory thermal comfort.

Personal control

The frequency analysis revealed respondents finding the building as acceptable after refurbishment concerning their requirements for office/lecture work within personal control for one of eight variables. The shortcomings with regard to personal control occurred in the areas of heating, ventilation, daylight lighting, noise, privacy, waste disposal and waste recycling. The questionnaire also included a question concerning speed of service recovery in the group of questions on functionality, as the opportunity to respond to unsatisfactory functionality can also be regarded as some sort of personal control. Speed of service recovery (F15) was rated as acceptable by <80% of the respondents: the actual figure was 63%.

The factor analysis for personal control showed that one new factor, *low operation costs* variables, which comprised the variables of control waste disposal, control

waste recycling, control privacy, control artificial lighting and control noise could explain most of the results. The other new factor generated within the factor analysis for personal control, *high operation costs* variables, which comprised the variables of control heating, control ventilation and control daylight lighting could explain just a minor part of the result. The findings were supported within the interviews.

Altogether, these findings show how important users consider personal control with respect to thermal climate. The importance of having personal control over the climate and ventilation find support in earlier research. Steamers and Steane (2004, in Cole et al., 2008, p.325) emphasized that variation in environmental conditions are desirable and Brager, Paliaga and de Dear (2004) underlined the importance of personal control over the indoor climate. The inclusion of service recovery in post-occupancy evaluation is supported by Yasamis, Arditi and Mohammadi (2002).

Productivity

The survey questionnaire included a question on the refurbishment's impact on productivity. This question resulted in 30 responses (out of 103 respondents), which corresponded to a response rate of 29.1%, which was low. Nonetheless, an analysis of the 30 responses was undertaken. It indicated that 19.4% of respondents experienced increased productivity as a result of the refurbishment, which was in line with earlier studies. This finding has support in earlier research. Ulrich et al. (2004) and Parish, Berry and Lam (2008) showed that the design of the facility can have an effect on job satisfaction and employee commitment, and that the design of a specific place used for intense service work can be especially important. Niemelä et al. (2002) showed that the renovation of a storage facility with an emphasis on thermal conditions, air quality and lighting could increase labour productivity by 9%. More recently, Al Horr et al. (2016b) found that thermal comfort, indoor air quality, layout, noise and acoustics affected users' productivity in offices. The physical environment's impact on productivity is further strengthened by the methods used to measure productivity developed by Clements-Croome and Baizhan (2000) and Geng et al. (2017). However, further research is needed to confirm this finding.

4.4.5 Conclusions

The findings in the case study showed that the use of post-occupancy evaluation can create generic information about options taken during briefing, design and facility management and those options' influence on users' working environment. Although post-occupancy evaluation has been available as a method for many years, albeit used infrequently, the study emphasized the need for it.

The study revealed two new areas:

1. the importance of evaluating general legislation, within areas other than construction, with regard to their potential influence on users' working environment; and,
2. the micro level's importance for how the users evaluate their working environment.

In conclusion, the study is in agreement with earlier findings with regard to the importance of comfort when users evaluate their working environment and the need for personal control over it.

4.5 Case study IV – Project governance

4.5.1 Aim

The purpose of this case study was, to a large extent, driven by the results of the previous studies. As the research progressed, it became increasingly clear that governance, in particular project governance, was poorly understood and managed. This study therefore addressed how project governance has been managed to include users' working environment.

4.5.2 Methods

A case study was chosen as the method since stakeholder and organizational satisfaction is mainly subjective and in-depth studies of cases is a way to capture these subjective values. Project 1 and Project 2 were studied. The analysis has been evaluated in relation to the model that summarized the theoretical framework within project governance (see figure 5).

4.5.3 Results and analysis

The analysis from Project 1 and Project 2 were built on document analysis centred on project governance as well as previously conducted interviews in case studies II and III.

Project 1

There were no general governance regulations that applied to this project. The refurbishment was a rather small project to be implemented during a limited period of time of design and construction and the governance process seems never to have been discussed. Instead, it seems to have been a sort of simplified structure-based standard governance process with limited passive service provision in the form of input from the stakeholders decided by the facility owner and tenant. The governance process seems to have been built on the design and construction meetings. During the design and construction meetings, with users represented by two persons, there were no discussions concerning further stakeholder involvement. The project did not map different stakeholder groups (e.g. administrators, lecturers, researchers and cleaning personnel); neither did it take into consideration the stakeholders' organizational culture, i.e. hierarchical or developmental. Central issues in the project governance process were time and cost.

Scope management included no formal change management plan to control change, inform stakeholders and ensure that the stakeholders understood the consequences of change. In the first design meeting, the entire request for the refurbishment was summarized as a need for "50 working rooms". In the second design meeting, there was a change of this request to a specification of working rooms and conference rooms. At the fourth design meeting, it was decided that the designers must work with the construction document during the system document referral stage not to lose time as "the changes that the referral may lead to are considered small". In the sixth design meeting, there was a major change of the project scope: a third building was to be included in the refurbishment. However, this was not formally approved until the eighth design meeting. No formal review of previous design decisions was made as a result of this change in the project scope statement. The scope management included no certification schemes.

No discussions concerning how to communicate information was performed and no formal communication plan was established. The tenant's communication process was built on formal documents. It started with a "room function program" document which was summarized in a "premises program" – a formal document describing functions needed in different rooms. This premises program was tentative and included mainly demands in the form of possible functions/requests marked with question marks (e.g. conference room – audio visual equipment, image projection equipment). In the premises program for work rooms, just the term work rooms is noted; not a single remark concerning equipment or how the room is expected to function or the sort of work that will be performed in the room was covered. After this formal start, communication with the stakeholders was built on feedback from the representative attending the design meetings and a few separate meetings with the tenant's representatives around, for example, sketches of the distribution of rooms. During the initial part of the project around the room function program the communication was

built on upward communication. Then, communication changed to be downward during the design meetings. Central in the design meetings was construction issues (e.g. options for fan rooms and alternative positioning of ventilation channels). Communication during the construction meetings was also downward.

Working environmental issues were not central in the project governance. Existing deficiencies in the facility to be refurbished, at the outset of the refurbishment project, in form of draught from walls and windows and high U-values, as well as the effects of this in form of poor working environment for users, were not captured by the consultants in the documents. Furthermore, working environmental problems were not a central concern in the design meetings. However, in the tender documents, several working environmental issues for consideration were described. These were in the form of environmentally friendly choice of materials such as lead-free and halogen-free cables, halogen-free boxes, avoidance of bromating flame retardants, low emitting colours and shielding from electromagnetic fields emitted from a switchgear room. The thermal climate to be achieved was also described in detail. These documents also described working environment issues to be considered during the refurbishment (e.g. external sound disturbance in the form of a maximum dBA measurement). All these requirements were the results of consultants' input. The knowledge from users about their working methods was not elicited and captured by the consultants and included in the documents.

Working environmental issues frequently noted in the documents referred to cold and draughts, heat, external noise, drinking water, mixed traffic and foul odour. Working environmental issues still remaining at the end of the case study referred to: non-divided radiator circuits; absence of solar shielding, inadequate noise reduction in interior glass walls; under-sized elevator; absence of wind catchers and fixed entrances mats; inadequate floor material, small and tight toilet space; top kitchen cabinets placed too high; and, low height for staircase. The working environmental shortcomings mentioned in the documents were with regard to office work mainly regarding the thermal climate and noise. However, in the interviews it was also mentioned disturbance through interior glass reducing concentration. The main shortcomings with regard to office work was solved at the end of the case study. The working environmental shortcomings with regard to cleaning personnel posed the risk of repetitive strain injury due to inadequate flooring material. This main shortcoming with regard to cleaning personnel was not solved at the end of the case study.

The governance process can in concordance with the table 2 on project governance be summarized as: structure based with no adaptation to the specific project. The governance process can, in concordance with the generated model on the relationships between the central concepts in project governance (see figure 5), be summarized as: incomplete identification of stakeholder groups and their organizational structure; passive service provision; established scope; no established change management plan; no implementation of certification schemes; no established communication plan; and communication form downward/upward.

Project 2

The project's governance by which the organization made and implemented decisions in the refurbishment project (e.g. principles, policies and procedures) was mainly built on two general governance documents applied at the time for the main period of the project, one from the client (Project guide for tenants 2012) and one from the tenant (Construction project procedure 2010). The refurbishment was an extensive project to be implemented during several years of design and construction. The decision-making governance process seems never to have been discussed. Instead, it seems to have been a form of simplified structure-based standard governance process with limited passive service provision in form of input from the stakeholders, decided by the facility owner and tenant and built on the referral rounds, as well design and construction meetings. The project did not map different stakeholder groups (e.g. administrators, lecturers, researchers and cleaning personnel); neither did it take into consideration the stakeholders' organizational culture, i.e. hierarchical or developmental. While at the same time, the users implemented a relationship-based informal governance process with several working groups. This informal relationship-based governance process was non-hierarchical, it included the involvement of stakeholders and was built on communication. This informal governance process implemented by the users was only advisory. The formal responsibility for economic and working environmental issues were still on the departments and the tenant's central authority. Central issues in the project governance process were time and cost.

In the client's general governance document it was stated that:

> "In connection with the architect starting to sketch the new premises: it is time for the tenant to establish a so-called room function program (RFP). The room function program is one specification for each room based on the overall functional the requirements. In addition to the room area (already specified in the local met) contains the RFP various hygienic requirements such as daylight requirements, requirements for air volumes, temperature etc. It also contains technical requirements for the supply of equipment or information on disturbances to be taken care of, for example, heat or noise. In addition to specific requests prompted by the activity, there are several legislative requirements to take into account, among other things regarding the work environment" (Project guide for tenants, Client, 2012).

In the tenant's general governance document, it was stated that:

> "The tenant is responsible through the local planner that:
> - the design meets the requirements set by the tenant
> - all necessary documentation and information for the design is obtained from the users, quality assured and taken into account by the consultants in the design" (Construction project procedure, Tenant, 2010).

The tenant's project governance process was described in vague terms with the process concentrated on the preparation of documents describing the business and the business' need for space and connections within the building. There was no emphasis on the operational phase. Furthermore, the process made no provision for value creation. This aspect was mentioned by the architects alone and then the focus was on value creation for students and connections between the departments. The division of responsibilities between the tenant and users was also unclear as no organizational plan that clarified the responsibilities was discussed and established. It can be presumed that this lack of clear documentation contributed to uncertainty in the allocation of responsibilities. The project organization plan was criticized in the referral rounds by the users.

> "There has been some ambiguity in the process. It is unclear who owns different issues and the schedule... it is difficult to conduct constructive discussions based on unclear conditions" (Building technology).

Later, after the project ended, this was clarified in advisory documents in 2017 and again in 2019 as the tenant's new general governance document (i.e. The construction process in nine steps, 2019). In this general governance document most of the responsibility for the project-related processes is imposed on the users (e.g. development of the premises program and communication plan, as well as risk analysis).

The general governance document states that, for example, the businesses (i.e. users) are responsible for:

- "specifying their vision and goals for the business and the premises
- describing their needs for premises
- answering questions about functional requirements
- communicate the project within the faculty
- review the documents produced during the project" (The construction process in nine steps, Tenant, 2019).

During the project the users' refurbishment organization and the departments handled a mix of questions which potentially had short and long-term impacts on the refurbishment, namely 1) the requirements for the refurbishment; 2) the requirements for interior design in the form of furniture; and, 3) the decanting of personnel during the refurbishment. This mix of short and long-term questions influenced the prioritization of requirements negatively.

The need for stakeholder involvement in the project was highlighted in a document.

> "Use the knowledge that is in the buildings. It creates frustration not to be asked. It would be good to map the expertise that is in the buildings" (Energy matters and cultural values, 30/08/13).

Despite the above, just one representative from the users was formally assigned to participate in the project, namely the facility supervisor – an administrative role rather than technical role. The project did not map different stakeholder groups.

The governance process seems to have been concentrated on the approval process and formal roles (structure based) The focus on the approval process built on the referral rounds confirms that the service provision was passive, i.e. the users informed the project management about their needs. No evidence has been found that supports relationship-based governance (i.e. discussions were on a central level concerning the leadership, informal relations and communication).

No scope management plan seems to have been communicated to the users. The facility owners' certification schemes which had an influence on the project's governance were "Environmental building", Manual 2.2 [Miljöbyggnad, Version 2.2], (Sweden Green Building Council, 2014) and ISO 14001 (International Organization for Standardization, 2015c). The facility owners' certification schemes that influenced the project's governance only covered the working environment for the facility owner's employees and their subcontractors. The tenant had no certification schemes of its own to cover refurbishments.

No discussions concerning how to communicate information was performed and no formal communication plan was established; neither was communication adapted to include aspects of the organizational culture of the users (e.g. question and discussion-based feedback). The tenant's communication process was built on formal documents. It started with a room function program document which was summarized in a premises program – a formal document describing functions needed in different rooms. During the initial part of the project around the room function program the communication was built on upward communication. After this formal start of the project communication, the communication with the stakeholders was built on another form of upward communication, i.e. referral rounds and downward communication in form of formal decisions. Any communication with the stakeholders that followed was built on downward communication based on referral rounds, concerning the program document and system document regarding the refurbishment. The documents were distributed to the central steering group, the departments and the health, safety and environment committee. However, not all relevant stakeholders had access to all the documentation.

The referral rounds built on drawings; however, the ability of personnel to read construction drawings was not established. Instead, there was a presumption that everyone in a building accommodating construction sciences personnel would be able to read drawings.

> "Once moved in, there will be a period for adjusting ventilation, responding to comments arising from inspections etc., which we believe you in the building are well aware of and about which you have some understanding" (Missive, Premises planner, 21/11/13).

In the interviews, several users voiced their concerns about being expected to read construction drawings, with was hardly surprising because construction sciences include specialisms (e.g. fire safety and geology). Each request presented during the referral rounds was formally answered by the words "to be considered, to be investigated or not taken into account". When the answer was "not taken into account", sometimes an explanation was added. The referral rounds resulted in a project statement on a detailed level.

No formal time schedule was agreed and both major referral rounds were sent out to the users close to the end of a semester break, with responses requested directly after the break. Furthermore, the effectiveness of communication was not evaluated and adapted during the project's four years.

Working environmental issues were not central in the project governance. The legislation with regard to working environment was to be found in "Systematic Work Environment, provisions", AFS 2001:1 (Sweden Work Environment Authority, 2001). This act states that working environment perspectives shall include working environment perspectives during both the construction stage and the operational phase. However, any mention of the working environment became the operational working environment during refurbishment, not after handover.

Furthermore, working environment aspects for users were not mentioned in the referral requests, as something that the users should consider in their referral answers. Instead, the referral rounds urged users to concentrate on some restricted areas of interest.

> "Look through what the refurbishment means to you.
> Is the space enough for your organization?
> Is there enough room for storage?
> Is the daylight enough?
> Do the connections and the mood work for your organization?" (Referral round, 15/12/11).

To guarantee that the working environment issues were approved, it was mandated that the referral rounds answers were signed by each department's safety representative. The project statement derived from the referral rounds was finally approved by the central safety representative, but not by the local safety representatives at each department. The handling of working environmental issues was in accordance with the central working environment agreement which delegated responsibility concerning the working environment to the health, safety and environment committee and the local safety representatives of each department.

Nonetheless, the governance process was criticized by one of the union organizations for not being negotiated under the "Act on Co-Determination in the Workplace", SFS 1976:580 (Swedish Codes of Statutes, 1976) which regulates the relationship between employer and employee.

> "First, I wonder if there has been any negotiation about the reconstruction of the building? If this has happened, we wonder when it happened and wish to see the documents that exist for this [purpose]. If this has not happened, we wonder how it was reasoned that it was not needed and wish to see relevant documents that have been prepared, such as possible risk and impact assessments, protocols from security rounds and the like" (Missive, Union at the University, 17/09/13).

In the "Energy matters and cultural values" documents it was stated that:

> "work environment problems such as draughts and cold walls have not been properly taken into account in the investigations" (Energy matters and cultural values 30/08/13).

Even accessibility questions were not considered, and it was noted in the same document that:

> "[there] will soon be a conference on the accessibility of the buildings; it will be interesting to see how the building copes" (Energy matters and cultural values, 30/08/13).

Here, the users' tacit knowledge concerning activities in the work rooms and the need for concentration was never discussed or captured during design; instead, these needs were downgraded when expressed in the referral rounds. Examples included the need to be undisturbed (i.e. sound reduction between spaces and that room doors should not be glazed) and to have a good thermal climate (e.g. insulation and window shields).

The main working environmental shortcomings noted in the survey questionnaire about office work mainly concerned the thermal climate and the lack of personal control. This was further underlined in the interviews, which also mentioned noise. While the working environmental shortcomings noted in the interviews with regard to cleaning personnel were heavy workload due to choice of material and insufficient installations.

The governance process can in concordance with the table on project governance and adaptation as in table 2 be summarized as: structure based with no adaptation to the specific project. The governance process can, in concordance with the generated model on the relationships between the central concepts in project governance (see figure 5), be summarized as: incomplete identification of stakeholder groups and their organizational structure; passive service provision; established scope;

implementation of certification schemes; no established communication plan; and communication form downward/upward and asymmetric.

4.5.4 Discussion

The theoretical position of project governance in construction and its formal elements, i.e. stakeholder involvement, scope definition and project management in managing scope and controlling scope change can be summarized as follows. Project governance should concentrate on the value creation of the delivered project's use, include the whole project lifecycle as well as the operational phase and assess the achievement of project management success (tactical level) and project success (strategic level). All stakeholders, even minority groups, should be identified and involved at the front-end of the project to capture their requirements including tacit knowledge. A communication plan for involving stakeholders should be developed and formalized with the intention of achieving consensus, satisfaction and realistic stakeholder expectations. The communication plan should take into account the project's as well as the stakeholders' normal organizational culture, include two-way communication and be evaluated and updated during the project to take into account the evolution of the project. The project scope should build on an analysis of the requirements to reduce the complexity and determine priorities. The final project scope statement should be complete, comprehensive, documented and agreed. Scope management, when divided into strategic and operational management, should establish guidelines for the project's management, including development of a change management plan intended to keep control over the project's scope and scope change and prevent scope creep. Crucially, all affected stakeholders should be informed about a proposed scope change and understand the consequences if that change were to be approved, as well as ensuring compliance with any applicable certification scheme and, therefore, conformity with the relevant management system standard. Project governance needs to include identification and fulfilment of occupational health and safety issues for the whole project lifecycle and beyond, i.e. construction workers during the construction stage as well as users during the operational phase.

The governance form that was used in both case studies was built on generic advisory documents – structure based and with passive service provision (Farok & Garcia, 2016; Hjelmbrekke, Klakegg & Lohne, 2017). The alternatives, relationship-based governance and active service provision, which could have increased the information flow, were never considered. Furthermore, in both the projects, no consideration was given to find information about the users in order to adapt the organizational plan to the specific context; specifically, the number of organizations involved, the normal culture of the organizations, different working groups of stakeholders in the organizations, any earlier experience of refurbishment and the normal schedules of the individual organizations. Information that could

have increased understanding and acceptance of the governance process as well as increased the opportunities to participate in the process in an adequate way was unavailable. The studies show that this has influenced the stakeholders' acceptance of the project as well as their opportunities to participate in the process and experience of the achieved purpose of the project. These findings gain support from earlier research (Mirza, Pourzolfaghar & Shahnazari, 2013; Alami, 2016; Badewi, 2016; Farok & Garcia 2016; ul Musawir, Abd-Karim & Mohd-Danuri, 2020).

In Project 1, no formal change management plan was developed. This had a very high impact on the results achieved from the refurbishment, as a major change of the project scope was taken half-way through the project without reconsideration of earlier decisions or the inclusion of new information (e.g. in form of building envelope with shortcomings and close situation to heavy traffic). The stakeholders were aware of the change and agreed to it; however, they did not understand the impact the change would have on the working environment. In Project 2, only smaller changes were undertaken, and these were restricted mainly to the dismantling of existing services installations (e.g. water taps, automatic door opening equipment and blinds). Yet, information with regard to these changes was never communicated in a way that was fully understood by the stakeholders and, in this project, consent on the part of affected stakeholders was not obtained. Even these changes affected experiences in the project and resulted in a worsening working environment. The importance of information concerning change and stakeholders' understanding of the consequences of change has been earlier emphasised (Butt, Naaranoja & Savolainen, 2016).

In both projects, no communication plan for involving the stakeholders was formalized or developed in cooperation with the stakeholders for the purpose of achieving consensus, satisfaction and realistic expectations. Communications were mainly one way. Furthermore, there was no evaluation and updating of the way communication was performed during the project to take into account the evolution of the project. In both the projects, there was no analysis of requirements that might have reduced complexity and made the information more accessible for stakeholders; instead, it was communicated in the form of drawings with detailed information. A result of this was that in Project 2, the information was not fully understood and accepted by the stakeholders even though the final project statements were complete and documented. Furthermore, in Project 2, the opportunity for the inclusion of stakeholders and access to their information decreased as communication took place on the terms of the project management. This did not take into account the stakeholders' normal schedule with semesters. Project 1 did not suffer from these problems as the refurbishment was smaller and less complex. However, the result from Project 2 underlines the importance of the communication plan (Sharma & Lutchman, 2006; Fageha & Aibinu, 2013; Butt, Naaranoja & Savolainen, 2016; Waheed & Ogunlana, 2019).

Design considerations in both studies, concerning users' working environment during the operational phase, were mainly built on general knowledge about requirements relating to the working environment in the form of regulations or standards. This shortcoming resulted in specific requirements not being documented in regulations or standards, for example, the need for the workspace to be supportive of cognitive work and for it not to generate stress was missed in both cases. Mismatch between the demands placed on users and their personal control over the working environment in which they perform their work has been mentioned as generating stress (McCoy & Evans, 2005). Furthermore, noise and visual privacy are two factors mentioned as generating workplace stress (Vischer, 2007). Both cases included complaints with regard to the thermal climate and personal control over the thermal climate, as well as complaints with regard to noise and visual privacy. Furthermore, both showed that ergonomics aspects (e.g. repetitive strain injury) (Hale, Kirwan & Kjellén, 2007; Fadier, 2008; Horberry et. al., 2016; Jones et al., 2019; Fan, Zhu, Timming, Su, Huang & Lu, 2020) concerning cleaning personnel had not been captured. All the mentioned requirements could have been captured through adequate stakeholder involvement and communication. The purpose of the governance process is to keep control of the project and guide and control the flow of information during design and construction. To achieve this, the governance process needs to be adapted to accommodate and communicate the needs of users as a key stakeholder group through the organizational plan, change management plan and communication plan.

4.5.5 Conclusions

In the governance process attention should be directed to information exchange between the project and its stakeholders. This is necessary to achieve full commitment from stakeholders and gain access to important knowledge with impact on the working environment. Specific knowledge of which the project management and consultants were unaware turned out to be of the utmost importance to achieve a good working environment after the refurbishment. Information plans must cater for stakeholders and should be adapted to each project's context. The recommended information plans are the organizational plan, communication plan and change management plan.

4.6 Summary of case studies findings

The studies of Project 1 and Project 2 show that the working environment for office work was acceptable with regard to building performance. At the same time, through case study II and III, it was found that for both Project 1 and Project 2 the working environment for office work was unacceptable with regard to comfort, i.e. thermal climate, noise and privacy.

Case studies II and III also showed that personal control over the thermal climate and noise was almost zero for Project 1 and Project 2. Case study II revealed that repeated complaints over several years were needed before rectification occurred; even then, some deficiencies remained up to eight years after handover to be resolved.

The studies also showed that the working environment for cleaning work was sufficient with regard to comfort. Case studies II and III indicated that the working environment was unacceptable for cleaning work with regard to building performance and functionality in both Project 1 and Project 2. Case studies II and III revealed that in neither Project 1 nor in Project 2 were any rectifications done after handover to improve building performance and functionality for cleaning work.

The deficiencies uncovered in case studies II and III regarding the users' working environment, both rectified and not rectified, had created discomfort that can lead to stress for users and repetitive strain injury for cleaning personnel.

The causes of these shortcomings with regard to users' working environment are to be found in the governance process and can be summarized as follows.

- The scope of the projects was consciously delimited before the briefing process started and before the participation of users and consultants. Examples were the exclusion of the building envelope (case study I), exclusion of elevators (case studies I and III), unchanged floor area for toilets (case studies I and III), no possibility of personal control over the thermal comfort (case studies I and III), exclusion of accessibility requirements to second floor (case study I) and limited accessibility to sloping lecture halls (case study III).
- On the other hand, existing conditions both in the building and the surrounding environment were overlooked during briefing. Examples include the existing building envelope regarding thermal climate and noise reduction (case study I), close frequent traffic (case study I), mixed traffic at the entrance (case study I), water quality (case study I), size of elevator (case study I) and existing sun-shading (case studies I and III).
- The project's stakeholders were not fully identified at the beginning of briefing and their requirements were not captured in both Project 1 and Project 2.

- The project's influence on users' working environment during operation and use was not discussed or fully understood during briefing. It was never established if users fully understood the initial limitations and their probable impact on the future working environment (case studies I and III). The reason could be lack of a communication plan.
- Facility management was not designed to take account of defects and deficiencies influencing users' working environment (case study II).
- The decisions taken during briefing and design with regard to users' working environment was mainly built on applicable regulations or standards, resulting in specific requirements being overlooked in briefing and design. Examples can be cognitive work and the need to limit sound and visual disturbance (case studies I and IV). This shortcoming was caused by not capturing users' requirements (case studies I and IV).
- Cleaning personnel were not identified as users of the whole building and their axiomatic knowledge was not captured during briefing and design. This resulted in insufficient understanding of the huge influence that small design decisions can have on their working environment. Examples include installation of thresholds (case study III), no installation of remote control of door opening (case study III), choice of pigmented wall finish (case study III), choice of flooring material (case study I) and choice of floor-mounted toilets (case studies I and III).
- Communication with users was not adapted to their ability to understand the governance process and to assimilate information on drawings (case study III). There was no consideration of how conflicts between different user groups would be solved during briefing and design (case study III).
- The governance process did not assign responsibilities to different groups (case study III) or include a change management plan (case study I).

5 Conclusions

5.1 Review of research questions

The aim of the research was to understand the conditions and decisions that influence users' working environment in refurbishment projects.

The research questions were threefold.

1. How do decisions taken as part of project governance, briefing and facility management influence users' working environment during operation and use?
2. Can single post-occupancy evaluations make a meaningful contribution to understand and improve users' working environment?
3. How could increased attention addressing users' working environment improve the outcomes of refurbishment projects?

5.1.1 Project governance, briefing and facility management's influence on users' working environment

In both Project 1 and Project 2, governance was structure based and not adapted to the individual project. Stakeholders' organizational culture (developmental) was not considered in either project. Project governance was centralized around the iron triangle (i.e. cost, time and quality) and not around stakeholders' needs. The projects showed that all stakeholders were not identified before defining requirements and those that were did not have equal opportunity to articulate needs and expectations. In both projects, passive service provision was adopted. Project governance could have been used to close the strategy-to-performance gap and thus increase the performance of the projects; however, this opportunity was not taken. In neither project was the project scope defined, agreed and understood by all stakeholders. Change management plan was not established in project 1 and no communication plans were agreed in project 1 and project 2. In summary, the case studies revealed that the impact of governance on stakeholders' working environment was not considered at all.

The main deficiency in briefing was that the users were not fully identified. This meant that there was no common understanding of the projects. Additionally, users'

axiomatic knowledge and absorptive capacity were not captured and this contributed to users' needs and future use of the buildings not being incorporated in the project scope. Instead, the focus was on traditional construction, with delivery on time and within budget. The result of these shortcomings was that the scope was insufficiently defined. Case study III revealed that communication through drawings can result in final project statements that are not fully understood even though they are considered to have been agreed. A communication plan could have included analysis of requirements and reduction of complexity resulting in the information being more accessible for stakeholders. Case study IV showed that the governance process needs to be adapted to accommodate and communicate the needs of users as a key stakeholder group through the organizational plan, change management plan and communication plan.

The limitations in Project 1 in terms of the location, the existing deficiencies in the facility and their impact were not captured and proved to have major consequences for the users' working environment (case study I). These shortcomings have led to the formulation of a new definition of briefing for refurbishment projects (case study I). This definition comprises two parts, one generic and one intended specifically for briefing with respect to refurbishment. The generic definition is "the process by which the requirements for a facility are captured at the outset, interpreted, implemented and evaluated at key decision points", where "requirements" include users' wants, needs and acceptance criteria taken into account during briefing. A specific definition for refurbishment is "the process by which the requirements and constraints for a refurbished facility are captured at the outset, interpreted, implemented and evaluated at key decision points".

Another finding was the negative impact that the lack of a change management plan had on the users' working environment (case study I). Change management is expected to keep track of changes and their impact on the project scope and on operational health and safety, which the case study underlined.

The opportunity to change procurement from considering the facility as a physical object to regard it as a means to achieve a defined purpose by the inclusion of a post-occupancy evaluation was not exploited in either project. The lack of emphasis on the users' working environment was further underlined by technical evaluation (case study I and III), thereby omitting user's total experience of the facility. Overall, case studies I and III revealed that the users' working environment was not central to the briefing process.

Case studies II and III uncovered unexpectedly long-lasting effects during operation and use, resulting from shortcomings in briefing and design. Case study II also highlighted the large number of complaints that were received before deficiencies were rectified. The inadequate implementation of facility management, in terms of economy, organization and service regarding users' working environment, was also revealed (case study II).

The mismatch between the findings and earlier recommendations concerning facility management resulted in development of the EOS model in case study II to emphasize the importance of appropriate facility management with regard to economy, organization and service around the users' working environment. The model underscores the need for an adequate level of facility management directly after handover, which might then be expected to reduce during operation. The EOS model could help to increase understanding of the need to adapt the implementation of facility management to match the requirements for the facility in question.

5.1.2 Single post-occupancy evaluation's contribution to understand and improve users' working environment

No post-occupancy evaluation was undertaken for either Project 1 or Project 2. The inclusion of a post-occupancy evaluation based on occupant feedback instead of technical evaluations (e.g. airflow in ducts and temperature measurements during winter/summer) could have contributed to an awareness of users' experienced shortcomings.

Case study III demonstrated that a single post-occupancy evaluation based on a survey questionnaire and interviews can contribute to both single- and double-loop learning. The case study also lends support to earlier findings which show that post-occupancy evaluations remain beneficial and can have a positive impact on the users' working environment. Shortcomings found in case study III, which influence users' working environment have support in earlier research, notably thermal climate, personal control and service recovery. The statistical analysis of the results of the post-occupancy evaluation in case study III uncovered new variables influencing users' working environment. Furthermore, the post-occupancy evaluation highlighted the influence of legal requirements on users' working environment. Case study III also indicated that inclusion of post-occupancy evaluation, based on occupant feedback in the rating systems of certification schemes, should be considered. The inclusion of post-occupancy evaluation could increase the likelihood of future design decisions being based on empirical evidence.

5.1.3 Increased attention to users' working environment improves the outcomes of refurbishment projects

The findings in case studies I-IV show that the working environment achieved through the refurbishment projects did not satisfy users' expectations. Case studies I-III showed that for both Project 1 and Project 2, the working environment was deficient in regard to comfort (especially thermal climate during both summer and winter case) and sound reduction. Case studies II and III showed that office workers experienced a lack of influence over their own working environment with regard to

the thermal climate due to lack of personal control over the indoor environment. The findings in case studies II and III further revealed that the inadequate working environment with respect to deficiencies persisted for several years in Project 1 (for some deficiencies it was up to eight years after handover) and at least two years after handover in Project 2 regarding thermal comfort. Case studies II and III revealed that the refurbishment projects increased the likelihood of repetitive strain injury for cleaning personnel; moreover, no action was taken remedy this situation after handover. Several shortcomings in case study II, which influence office workers, were also left without remedy. Together, these shortcomings can lead to stress for users and repetitive strain injury for cleaning personnel. Interestingly, case studies II and III also showed that the experience of thermal climate was very different between working groups, office workers and cleaning personnel.

The users' main expectations from the refurbishment of facilities for office work and education were an improved working environment and improved productivity. Facilities are production factors that have an impact on productivity directly and indirectly through facility management. For employees to reach peak performance, self-actualization is needed (i.e. realization of the employees' full potential and abilities). The findings have shown that users' ability to achieve self-actualization was severely restricted by the refurbishments in Project 1 and Project 2. Nonetheless, case study III indicated that productivity could have increased on the part of office workers in Project 2 as a result of the refurbishment. If increased attention addressing users' working environment had been prevalent in the projects' governance process, it could have generated further increased user productivity, which might be seen as an improved outcome from a refurbishment.

5.2 Contributions

5.2.1 Theoretical contribution

Refurbishment projects and their influence on users' working environment is a relevant but neglected area in research. Such projects are regarded as more complex than new-build projects. They also attract higher risks and are more difficult to govern. Together, these prerequisites can result in negative impact on the users' working environment as well as on their productivity. This research contributes to this theoretical gap within construction science with regard to refurbishment projects and their influence on users' working environment after handover.

Case study I highlighted the importance of mapping both the external factors (that depend on the location of the building) as well as the buildings' condition prior to refurbishment. To be able to inform the design, thereby avoiding negative subsequent impacts on the users' working environment, a modified definition of briefing, which

emphasizes the difference between briefing for new-build projects and refurbishment, has been proposed.

Case study II revealed that a realistic plan with regard to facility management and its possibilities to correct deficiencies after handover is necessary to avoid negative impact on users' working environment. In the case study, the EOS model has been developed to help in planning the facility's management by establishing a balanced economy, organizational and service capability at the front end of projects. The model underscores the importance of allocating resources immediately after handover to deal with deficiencies with respect to the users' working environment. If facility management has been correctly implemented at the point of handover, or in the coming term, these resources can be successively reduced. Interestingly, the model is not confined to deficiencies arising post-handover of a facility following refurbishment and can be applied to new-build projects to determine the steps to be taken to eradicate them.

Case study III demonstrated that single post-occupancy evaluations undertaken after handover can contribute to the learning process in general. The case study also demonstrated that the practice of undertaking post-occupancy evaluation remains valid and can contribute to improvement in the users' working environment. Furthermore, the case study revealed new variables with regard to users' experience of the refurbished facility within the areas of building performance, functionality, comfort and personal control. These variables can be used in future research to capture new information. Collectively, these findings from case study III could encourage project teams to base design decisions on empirical evidence.

Case study IV revealed several shortcomings with regard to the governance process with influence on users' working environment after handover. The shortcomings can be summarized as: delimitation of the project scope before briefing, inadequate identification of stakeholders and their requirements; inadequate recording of existing conditions in the building and surrounding environment; lack of communication (resulting in users not fully understanding the information they have been given); limited consideration of established and emerging regulations and standards on the working environment; and insufficient assignment of responsibilities to different groups. Arguably, the most compelling message is that governance is critically important and must be firmly in place before the project starts. The project's governance must mandate the early engagement of users, as a key stakeholder group with wholly legitimate interests in the project's outcomes, and ensure it is followed by accurate scope definition, control over scope change and explicit communication plans.

5.2.2 Methodological contribution

The main methodological contributions are as follows.

- Case study II showed how longitudinal research can increase understanding of a phenomenon in terms of causes and effects on users' working environment, which might not occur when analysed at a single point in time.
- Case study III showed how a deep statistical analysis of the results from a single survey can increase understanding of complex problems.

5.2.3 Practical contribution

The findings contribute to practice in several ways by:

- emphasizing that the building, from the perspective of users, is not an artefact but a production aid with an impact on the working environment and productivity;
- showing how several shortcomings in the users' working environment are a direct result of limitations in the governance and organizational structure of refurbishment projects;
- demonstrating how important it is to map and communicate the existing building's condition, characteristics and constraints;
- highlighting the importance of spending time on eliciting the kind of work that will be performed in the refurbished facility, how users will undertake their work and the requirements that must be fulfilled to facilitate it;
- showing that the risks in office environment are not the same as those in industrial premises – whilst not life-threatening, there are still risks that can cause damage in the long run (e.g. stress and repetitive strain injury);
- underscoring the importance of considering requirements with respect to facility management early in the project;
- focusing on prioritizing decisions about the facility's design that would be costly and difficult to change after handover (e.g. size of building and spaces, thermal envelope, users' opportunities to influence their working environment during operation, and choice of wall and floor finishes);
- emphasizing the importance of ensuring that users are provided with help to interpret design information, especially drawings;
- designing a communication plan for stakeholders; and
- providing evidence that a single post-occupancy evaluation can contribute to an improvement in general learning about refurbishment projects.

5.3 Future research

Potential topics for future research include the following.

- Assessing the usefulness of the EOS model in different facility management organizations within other owner organizations.
- Investigating the influence of project governance on users' working environment in other types of refurbishment project (e.g. healthcare).

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Appendices

Appendix A1:
Survey questionnaire about Building Performance

Table A1/BPI: Definition of variables from questions about building performance (BP)

Variable	Questions about
BP1	General building layout
BP2	Current personal workspace
BP3	Your workspace in relation to the surrounding workspaces
BP4	Privacy of your workspace
BP5	Personal computer facilities
BP6	Amount of space available for individual work and storage
BP7	Shared workspaces (if applicable)
BP8	Ease of interaction with co-workers
BP9	Safety in the building
BP10	Security in the building
BP11	Hygiene and cleanliness in the building
BP12	Overall quality of building

Table A1/BPII: Alternative response in all variables for building performance (BP)

Alternative response	Meaning	Code for response
Unacceptable	Falls below my minimum requirements	1
Inadequate	Does not meet my essential requirements	2
Adequate	Meets my essential requirements	3
Delighted	Exceeds all my requirements	4
No answer	Missing value	0

Table A1/BPIII: Responses for building performance (BP)

Variable	Number of responses per code				
	1	2	3	4	0
BP1	0	4	80	18	1
BP2	2	9	57	33	2
BP3	0	6	65	30	2
BP4	2	13	52	34	2
BP5	1	8	54	39	1
BP6	1	11	57	33	1
BP7	2	12	47	12	30
BP8	1	6	66	29	1
BP9	0	4	73	26	0
BP10	0	15	69	18	1
BP11	3	13	67	19	1
BP12	1	6	73	20	3

Table A1/BPIV: Responses for building performance (BP), summary of codes 1+2 and 3+4 (%)

Variable	Number of responses per code		
	∑1+2	∑3+4	0
BP1	4 (4%)	98 (96%)	1
BP2	11 (11%)	90 (89%)	2
BP3	6 (6%)	95 (94%)	2
BP4	15 (15%)	86 (85%)	2
BP5	9 (9%)	93 (91%)	1
BP6	12 (12%)	90 (88%)	1
BP7	14 (19%)	59 (81%)	30
BP8	7 (7%)	95 (93%)	1
BP9	4 (4%)	99 (96%)	0
BP10	15 (15%)	87 (85%)	1
BP11	16 (16%)	86 (84%)	1
BP12	7 (7%)	93 (93%)	3

Analysis of data

The analysis started with general evaluation of the material. The analysis results in variable BP7 (shared workplace if applicable) being excluded, due to 30 missing values. A table summarizing the different codes of the responses was compiled (see table A1/BPIV). First, a frequency analysis was undertaken and evaluated for the established 80% level of occupant satisfaction, for the result of the refurbishment in the case study to be evaluated as acceptable. The analysis shows that the respondents that rank Building Performance (BP) as 3 or 4 out of 4 possible is ≥ 80% for all variables (BP1, BP2, BP3, BP4, BP5, BP6, BP8, BP9, BP10, BP11 and BP12). This shows that the users' experience of the refurbishment is acceptable for Building performance (BP) for all evaluated variables.

Further analysis of the responses (see table A1/BPIII) shows that for example, variables BP2, BP3 and BP4 have similar response patterns. This can indicate that it is possible there is an internal correlation between variables. The finding motivates testing a factor analysis on the data to clarify the connections.

Factor analysis 1

The first analysis 1 is undertaken including variable BP1, 2, 3, 4, 5, 6, 8, 9, 10, 11 and 12. To measure the inter-correlation, the correlation between the different variables, two tests are performed. Both tests indicate that a factor analysis can contribute to increase the understanding of the material.

1. The Bartlett's test of sphericity was used to test the null hypothesis that is if the correlation matrix is an identity matrix (unrelated and not ideal for factor analysis). A significant statistical test (less than 0.05) indicate that the correlation matrix is not an identity matrix and rejects the null hypothesis. The actual significance value of Bartlett's test of sphericity is 0.000.
2. The Kaiser-Meyer-Olkin test (KMO) is a test conducted to examine the strength of the partial correlation between the variables. Kaiser characterizes measures in the 0.8's a meritorious measure (Kaiser 1974, in Norušis, 1993). The actual KMO value is 0.780.

Figure A1/BP1 shows in the generated Scree plot that two factors have an Eigenvalue above 1, which indicates that they can explain the variation in the material. Factor 1 has an Eigenvalue of 4.4 and Factor 2 has an Eigenvalue of 1.5. It means that Factor 1 explains most of the variation in the data (see figure A1/BP1).

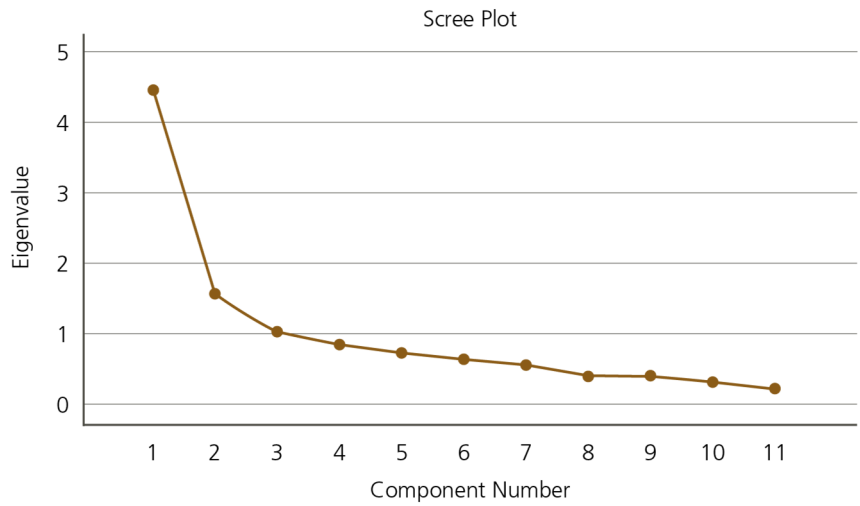

Figure A1/BP1: Factor analysis 1 BP (Scree plot)

The result of the factor analysis is shown in figure A1/BP2, the rotated component matrix. After the rotation the factors are orthogonal.

- Factor (Component) 1 in analysis 1 consists of the following variables BP in decreasing order of importance: BP3, BP4, BP2, BP6, BP5 and BP8.
- Factor (Component) 2 in analysis 1 consists of the following variables BP in decreasing order of importance: BP10, BP11, BP12, BP9 and BP1 (see figure A1/BP2).

Rotated Component Matrix[a]

	Component	
	1	2
BP3	,853	,084
BP4	,733	,035
BP2	,724	,256
BP6	,721	,215
BP5	,526	,418
BP8	,468	,244
BP10	,029	,803
BP11	,061	,784
BP12	,271	,712
BP9	,385	,636
BP1	,260	,540

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
[a] Rotation converged in 3 iterations.

Figure A1/BP2: Factor analysis 1 BP (Rotated component matrix)

Findings of factor analysis 1

Factor 1 in analysis 1 consists of the following variables in decreasing order of importance: your workspace in relation to the surrounding workspaces; privacy of your workspace; current personal workspace, amount of space available for individual work and storage; personal computer facilities; and ease of interaction with co-workers. These variables all relate to the *micro level* of the users' working environment, the individual user's closest working area, probably only a few square metres surrounding each individuals working place.

Factor 2 in analysis 1 consists of the following variables in decreasing order of importance: security in the building; hygiene and cleanliness in the building; overall quality of building; safety in the building; and general building layout. These variables relate to the *macro level* of the users' working environment, the overall structure and design, that shapes the building.

To find out if the exclusion of some variables can increase the understanding of the material, further factor analysis are undertaken.

Factor analysis 2 – exclusion of BP5 and BP11

In factor analysis 2, BP5 (personal computer facilities) and BP11 (hygiene and cleanliness in the building) are excluded. The exclusion is motivated by the fact that these variables can depend on other decisions than the refurbishment.

The result of the factor analysis is shown in figure A1/BP3, the rotated component matrix. After the rotation the factors are orthogonal.

- Factor 1 in analysis 2 consists of the following variables BP in decreasing order of importance: BP3, BP4, BP2, BP6 and BP8.
- Factor 2 in analysis 2 consists of the following variables BP in decreasing order of importance: BP10, BP9, BP12 and BP1.

Rotated Component Matrix[a]

	Component	
	1	2
BP3	,856	,146
BP4	,781	-,018
BP2	,721	,295
BP6	,716	,256
BP8	,399	,297
BP10	-,068	,806
BP9	,307	,713
BP12	,275	,693
BP1	,188	,618

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

[a] Rotation converged in 3 iterations.

Figure A1/BP3: Factor analysis 2 BP (Rotated component matrix)

Factor analysis 3 – exclusion of BP5, BP8 and BP11

In factor analysis 3 and 4 the variables that have the lowest importance within Factor 1 and 2, in the rotated component matrix are successively excluded. In analyses 3, BP8 (ease of interaction with co-workers) with the value 0.399 within Factor 1 in analysis 2 was excluded.

The result of the factor analysis is shown in figure A1/BP4, the rotated component matrix. After the rotation the factors are orthogonal.

- Factor 1 in analysis 3 consists of the following variables BP in decreasing order of importance: BP3, BP4, BP2 and BP6.
- Factor 2 in analysis 3 consists of the following variables BP in decreasing order of importance: BP10, BP9, BP12 and BP1.

Rotated Component Matrix[a]

	Component	
	1	2
BP3	,852	,155
BP4	,805	,007
BP2	,718	,305
BP6	,706	,261
BP10	-,079	,805
BP9	,295	,716
BP12	,273	,701
BP1	,201	,632

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
[a] Rotation converged in 3 iterations.

Figure A1/BP4: Factor analysis 3 BP (Rotated component matrix)

Factor analysis 4 – exclusion of BP1, BP5, BP8 and BP11.

In analysis 4, BP1 (general building layout) with the value 0.632 within Factor 2 in analysis 3 was excluded.

The result of the factor analysis is shown in figure A1/BP5, the rotated component matrix. After the rotation the factors are orthogonal.

- Factor 1 in analysis 4 consists of the following variables BP in decreasing order of importance: BP3, BP4, BP2 and BP6.
- Factor 2 in analysis 4 consists of the following variables BP in decreasing order of importance: BP10, BP9 and BP12.

Rotated Component Matrix[a]

	Component	
	1	2
BP3	,866	,103
BP4	,797	,044
BP2	,728	,301
BP6	,708	,276
BP10	-,056	,880
BP9	,311	,749
BP12	,311	,669

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
[a] Rotation converged in 3 iterations.

Figure A1/BP5: Factor analysis 4 BP (Rotated component matrix)

Result of factor analysis 1-4

The result of factor analysis 1, 2, 3 and 4 are summarized in table A1/ BPV. The analysis shows that highest value of KMO is achieved in analysis 4 (0.797), analysis 3 (0.788) and analysis 1 (0.780) after exclusion of different variables.

Table A1/BPV: Matrix over undertaken factor analysis with regard to building performance (BP)

Factor analyse, nr.	1	2	3	4
Bartlett's test	0.000	0.000	0.000	0.000
KMO	0.780	0.763	0.788	0.797
Eigenvalue Factor 1	4.4	3.6	3.4	3.3
Variables in Factor 1	3,4,2,6,5,8	3,4,2,6,8	3,4,2,6	3,4,2,6
Eigenvalue Factor 2	1.5	1.4	1.4	1.3
Variables in Factor 2	10,11,12,9,1	10,9,12,1	10,9,12,1	10,9,12

The further factor analysis contributed to increase the understanding of the material, especially factor analysis 4 as it resulted in an increased KMO value.

- Factor 1 in analysis 4 consists of the following variables in decreasing order of importance: your workspace in relation to the surrounding workspaces; privacy of your workspace; current personal workspace; and amount of space available for individual work and storage. These variables all relate to the *workspace level* of the users' working environment, the individual user's absolute closest working area, the individual working place.
- Factor 2 in analysis 4 consists of the following variables in decreasing order of importance: security in the building; safety in the building; and overall quality of building. The two dominant variables in this factor relate to the *personal safety* of the users' working environment.

Appendix A2:
Survey questionnaire about Functionality (Facilities/Services)

Table A2/FI: Definition of variables from questions about functionality (facilities/services) (F)

Variables	Questions about
F1	Individual/shared workspace
F2	Accessibility
F3	Classrooms
F4	Lecture theatres
F5	Laboratories/workshops (non-computer)
F6	Computer laboratories
F7	Foyer/common areas
F8	Kitchen and eating places
F9	Toilets
F10	Elevators/lifts
F11	Goods delivery entrances
F12	Waste collection entrances
F13	Library
F14	Outside areas within the boundary of the building
F15	Speed of service recovery (remedial actions taken after reporting of complaints)

Table A2/FII: Alternative response in all variables for functionality (facilities/services) (F)

Alternative response	Meaning	Code for response
Unacceptable	Falls below my minimum requirements	1
Inadequate	Does not meet my essential requirements	2
Adequate	Meets my essential requirements	3
Delighted	Exceeds all my requirements	4
Not applicable		5
No response	Missing value	0

Table A2/FIII: Responses for functionality (facilities/services) (F)

	Number of responses per code					
Variable	**1**	**2**	**3**	**4**	**5**	**0**
F1	2	7	59	31	3	1
F2	0	3	68	24	8	0
F3	2	7	54	19	21	0
F4	1	7	58	20	17	0
F5	2	15	30	12	43	1
F6	1	7	37	14	44	0
F7	1	4	68	23	6	1
F8	2	5	57	33	6	0
F9	2	3	77	19	1	1
F10	2	2	72	21	6	0
F11	1	11	40	11	40	0
F12	4	21	38	10	30	0
F13	1	2	49	30	20	1
F14	0	6	69	23	3	2
F15	5	25	38	14	20	1

Table A2/FIV: Responses for functionality (facilities/services) (F), summary of codes 1+2, 3+4 (%) and 5+0

	Number of responses per code		
Variable	**∑1+2**	**∑3+4**	**∑5+0**
F1	9 (9%)	90 (91%)	4
F2	3 (3%)	92 (97%)	8
F3	9 (11%)	73 (89%)	21
F4	8 (9%)	78 (91%)	17
F5	17 (29%)	42 (71%)	44
F6	8 (14%)	51 (86%)	44
F7	5 (5%)	91 (95%)	7
F8	7 (7%)	90 (93%)	6
F9	5 (5%)	96 (95%)	2
F10	4 (4%)	93 (96%)	6
F11	12 (19%)	51 (81%)	40
F12	25 (34%)	48 (66%)	30
F13	3 (4%)	79 (96%)	21
F14	6 (6%)	92 (94%)	5
F15	30 (37%)	52 (63%)	21

Analysis of data

The analysis started with general evaluation of the material. A table summarizing the different codes of the responses was then compiled (see table A2/FIV). First, a frequency analysis was undertaken and evaluated for the established 80% level of occupant satisfaction for the result of the refurbishment in the case study to be evaluated as acceptable. The analysis shows that the respondents that rank Functionality (F) as 3 or 4 out of 4 possible is ≥80 % for 12 variables (F1, F2, F3, F4, F6, F7, F8, F9, F10, F11, F13 and F14). This shows that the users' experience of the refurbishment is acceptable for Functionality (F) for: individual/ shared workspace, accessibility, classrooms, lecture theatres, computer laboratories, foyer/common areas, kitchen and eating places, toilets, elevators/lifts, goods delivery entrances, library and outside areas within the boundary of the building. Although, the respondents that rank Functionality (F) as 3 or 4 out of 4 possible is < 80% for three variables (F5, F12 and F15). This shows that the users' experience of the refurbishment is unacceptable for Functionality (F) for: laboratories/ workshops (non-computer), waste collection entrances and speed of service recovery (remedial actions taken after reporting of complaints).

The further analysis of the responses (see table A2/FIII) resulted in the following.

- Exclusion of variables F3, F4, F5, F6, F11, F12, F13 and F15, due high values on the response not applicable (21, 17, 43, 44, 40, 30, 20 and 20).
- The exclusion of these variables is grounded on the basis that the question was incorrectly formulated. It is presumed that the value not applicable, are generated by administrative personnel for variables F3, F4, F5, F6 and F13 as those variables refer to classrooms, lecture theatres, laboratories/ workshops (non-computer), computer laboratories and the library. However, the number of not applicable answers also varies in between the variables, which can depend on the difference in the type of teaching personnel.
- Variable F11 and F12 refer to goods delivery entrances and waste collection entrances, from which it is presumed that the value, not applicable, depends on some groups of users' not having goods or waste of such an amount that those entrances have to be used.

These exclusions result in a severe restriction, as the factor analysis will not include premises intended for teaching.

Table A2/FII:I: Alternative response in all variables for functionality (facilities/services) (F) after recoding the response not applicable as a missing value

Alternative response	Meaning	Code for response
Unacceptable	Falls below my minimum requirements	1
Inadequate	Does not meet my essential requirements	2
Adequate	Meets my essential requirements	3
Delighted	Exceeds all my requirements	4
Not applicable/No response	Missing value	0

Table A2/FIII:I: Responses for functionality (facilities/services) (F) after recoding the response not applicable as a missing value

	Number of responses per code				
Variable	**1**	**2**	**3**	**4**	**0**
F1	2	7	59	31	4
F2	0	3	68	24	8
F7	1	4	68	23	7
F8	2	5	57	33	6
F9	2	3	77	19	2
F10	2	2	72	21	6
F14	0	6	69	23	5

To be able to undertake further analysis of the material with regard to functionality the response not applicable for the remaining variables (F1, F2, F7, F8, F9, F10 and F14) is recoded as a missing value (see table A2/FII:I and table A2/FIII:I). Further analysis of the recoded responses shows that for example variables F2, F7 and F14 have similar response patterns. This can indicate that it is possible that there is an internal correlation between variables. The finding motivates testing factor analysis on the data to clarify the connections.

To measure the inter-correlation, the correlation between the different variables, two tests are performed. Both tests indicate that a factor analysis can contribute to increase the understanding of the material.

- The Bartlett's test of sphericity was used to test the null hypothesis that is if the correlation matrix is an identity matrix (unrelated and not ideal for factor analysis). A significant statistical test (less than 0.05) indicate that the correlation matrix is not an identity matrix and rejects the null hypothesis. The actual significance value of Bartlett's test of sphericity is 0.000.

– The Kaiser-Meyer-Olkin test (KMO) is a test conducted to examine the strength of the partial correlation between the variables. Kaiser characterizes measures in the 0.8's a meritorious measure (Kaiser 1974, in Norušis, 1993) The actual KMO value is 0.796.

Figure A2/F1 shows in the generated Scree plot that two factors have an Eigenvalue above 1, which indicates that they can explain the variation in the material. Factor 1 has an Eigenvalue of 3.0 and Factor 2 has an Eigenvalue of 1.1. That means that Factor 1 explains most of the variation in the data (see figure A2/F1).

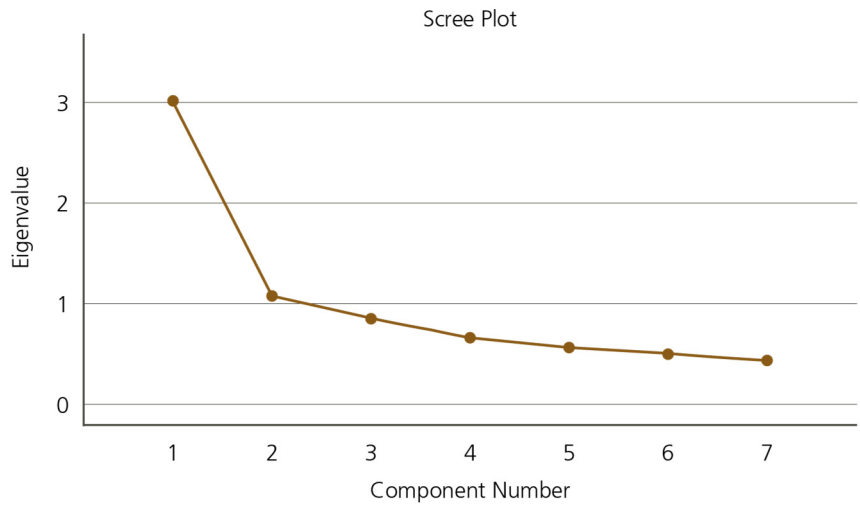

Figure A2/F1: Factor analysis F (Scree plot)

The result of the factor analysis is shown in figure A2/F2, the rotated component matrix. After the rotation the factors are orthogonal.

– Factor (Component) 1 consists of the following variables F in decreasing order of importance: F8, F7, F14 and F1.

– Factor (Component) 2 consists of the following variables F in decreasing order of importance: F9, F10 and F2.

Rotated Component Matrix[a]

	Component	
	1	2
F8	,856	-,082
F7	,761	,329
F14	,592	,347
F1	,553	,480
F9	,054	,790
F10	,200	,736
F2	,218	,623

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

[a] Rotation converged in 3 iterations.

Figure A2/F2: Factor analysis F (Rotated component matrix)

Findings of factor analysis

Factor 1 consists of the following variables in decreasing order of importance: kitchen and eating places; foyer/common areas; outside areas within the boundary of the building; and individual/shared workspace. These variables all relate to areas that can be seen as *living space*, social areas for recovery during the working day.

Factor 2 consists of the following variables in decreasing order of importance: toilets; elevators/lifts; and accessibility. These variables relate to areas that can be seen as *necessity functions*, basic functions without which the building does not work.

Appendix A3:
Survey questionnaire about Comfort

Table A3/CI: Definition of variables from questions about comfort (C)

Variables	Questions about
C1	Summer indoor temperature
C2	Winter indoor temperature
C3	Thermal comfort of your workspace
C4	Air quality of your workspace
C5	Draught in your workspace
C6	Noise level within or immediately surrounding your workspace
C7	Noise level in the building in general
C8	Visual comfort from the lighting in your workspace

Table A3/CII: Alternative response in all variables for comfort (C)

Alternative response	Meaning	Code for response
Unacceptable	Falls below my minimum requirements	1
Inadequate	Does not meet my essential requirements	2
Adequate	Meets my essential requirements	3
Delighted	Exceeds all my requirements	4
No answer	Missing value	0

Table A3/CIII: Responses for comfort (C)

	Number of responses per code				
Variable	**1**	**2**	**3**	**4**	**0**
C1	6	25	52	20	0
C2	6	22	58	16	1
C3	5	29	55	13	1
C4	3	33	53	12	2
C5	2	9	67	21	4
C6	3	15	61	23	1
C7	1	7	76	16	3
C8	4	17	68	13	1

Table A3/CIV: Responses for comfort (C), summary of codes 1+2 and 3+4 (%)

	Number of responses per code		
Variable	∑1+2	∑3+4	0
C1	31 (30%)	72 (70%)	0
C2	28 (27%)	74 (73%)	1
C3	34 (33%)	68 (67%)	1
C4	36 (36%)	65 (64%)	2
C5	11 (11%)	88 (89%)	4
C6	18 (18%)	84 (82%)	1
C7	8 (8%)	92 (92%)	3
C8	21 (21%)	81 (79%)	1

Analysis of data

The analysis starts with general evaluation of the responses. The analysis of the responses shows that no exclusion of variables is needed. A table summarizing the different codes of the responses was compiled (see table A3/CIV). First, a frequency analysis was undertaken and evaluated for the established 80% level of occupant satisfaction, for the result of the refurbishment in the case study to be evaluated as acceptable. The analysis shows that the respondents that rank Comfort (C) as 3 or 4 out of 4 possible is ≥ 80% for three variables (C5, C6 and C7). This shows that the users' experience of the refurbishment for Comfort (C) is acceptable for draught in your workspace, noise level within or immediately surrounding your workspace and noise level in the building in general. The respondents that rank Comfort (C) as 3 or 4 out of 4 possible is < 80% for five variables (C1, C2, C3, C4 and C8). This shows that the users' experience of the refurbishment is unacceptable for Comfort for: summer indoor temperature, winter indoor temperature, thermal comfort of your workspace, air quality of your workspace and visual comfort from the lighting in your workspace.

The further analysis of the responses (see table A3/CIII) shows that variables C1 and C2 as well as the variables C3 and C4 have similar response patterns. This can indicate that it is possible there is an internal correlation between variables. The finding motivates testing factor analysis on the data to clarify the connections.

To measure the inter-correlation, the correlation between the different variables, two tests are performed. Both tests indicate that a factor analysis can contribute to increase the understanding of the material.

- The Bartlett's test of sphericity is used to test the null hypothesis, that is, if the correlation matrix is an identity matrix (unrelated and not ideal for factor analysis). A significant statistical test (less than 0.05) indicates that the

correlation matrix is not an identity matrix and rejects the null hypothesis. The actual significance value of Bartlett's test of sphericity is 0.000.

– The Kaiser-Meyer-Olkin test (KMO) is a test conducted to examine the strength of the partial correlation between the variables. Kaiser characterizes measures in the 0.8's a meritorious measure (Kaiser 1974, in Norušis, 1993). The actual KMO value is 0.792.

Figure A3/C1 shows in the generated Scree plot that two factors have an Eigenvalue above 1, which indicates that they can explain the variation in the material. Factor 1 has an Eigenvalue of 4.0 and Factor 2 has an Eigenvalue of 1.1. That means that Factor 1 explains most of the variation in the data (see figure A3/C1).

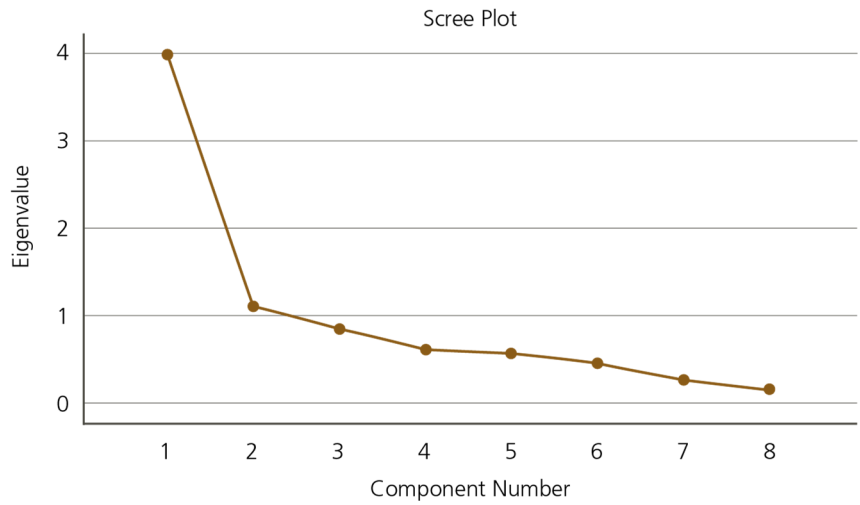

Figure A3/C1: Factor analysis C (Scree plot)

The result of the factor analysis is shown in figure A3/C2, the rotated component matrix. After the rotation the factors are orthogonal.

– Factor (Component) 1 consists of the following variables C in decreasing order of importance: C2, C3, C4, C5 and C1.

– Factor (Component) 2 consists of the following variables C in decreasing order of importance: C7, C8 and C6.

Rotated Component Matrix[a]

	Component	
	1	2
C2	,873	-,030
C3	,868	,287
C4	,723	,420
C5	,710	,230
C1	,618	,484
C7	,192	,752
C8	,122	,699
C6	,194	,688

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

[a] Rotation converged in 3 iterations.

Figure A3/C2: Factor analysis C (Rotated component matrix)

Findings of factor analysis

Factor 1 consists of the following variables in decreasing order of importance: winter indoor temperature; thermal comfort of your workspace; air quality of your workspace; draught in your workspace; and summer indoor temperature. These variables mainly relate to *thermal climate* of the users' working environment.

Factor 2 consists of the following variables in decreasing order of importance: noise level in the building in general; visual comfort from the lighting in your workspace; and noise level within or immediately surrounding your workspace. These variables relate to *other comfort areas* of the users' working environment.

Appendix A4:
Survey questionnaire about Personal Control

Table A4/PCI: Definition of variables from questions about personal control (PC)

Variables	Questions about
PC1	Control-Heating
PC2	Control-Ventilation
PC3	Control-Daylight lighting
PC4	Control-Artificial lighting
PC5	Control-Noise
PC6	Control-Privacy
PC7	Control-Waste disposal
PC8	Control-Waste recycling

Table A4/PCII: Alternative response in all variables for personal control (PC)

Alternative response	Code for response
No control	1
Little control	2
Some control	3
Almost full control	4
Full control	5
No answer/Missing value	0

Table A4/PCIII: Responses for personal control (PC)

	Number of responses per code					
Variable	**1**	**2**	**3**	**4**	**5**	**0**
PC1	52	28	10	8	4	1
PC2	65	22	8	2	4	2
PC3	13	13	22	32	22	1
PC4	4	14	22	34	27	2
PC5	21	23	24	23	11	1
PC6	7	17	24	28	26	1
PC7	12	21	32	20	17	1
PC8	21	19	27	22	11	3

Table A4/PCIV: Responses for personal control (PC), summary of codes 1+2 and 3+4+5 (%)

	Number of responses per code		
Variable	∑1+2	∑3+4+5	0
PC1	80 (78%)	22 (22%)	1
PC2	87 (86%)	14 (14%)	2
PC3	26 (25%)	76 (75%)	1
PC4	18 (18%)	83 (82%)	2
PC5	44 (43%)	58 (57%)	1
PC6	24 (24%)	78 (76%)	1
PC7	33 (32%)	69 (68%)	1
PC8	40 (40%)	60 (60%)	3

Analysis of data

The analysis starts with general evaluation of the material. The analysis of the responses shows that no exclusion of variables is needed. A table summarizing the different codes of the responses is then compiled (see table A4/PCIV). First, a frequency analysis is undertaken and evaluated with regard to the established 80% level of occupant satisfaction, for the result of the refurbishment in the case study to be evaluated as acceptable. The analysis shows that the respondents that rank their Personal Control (PC) in the workplace after refurbishment as 3, 4 or 5 out of possible 5 is ≥ 80% for one variable (PC4). This shows that the users' experience of the refurbishment is acceptable for Personal Control (PC) for artificial lighting. Although, the respondents that rank their Personal Control (PC) in the workplace after refurbishment as 3, 4 or 5 out of a possible 5 is < 80% for seven variables (PC1, PC2, PC3, PC5, PC6, PC7 and PC8). This shows that the users' experience of the refurbishment is unacceptable for Personal Control (PC) for: heating, ventilation, daylight lighting, noise, privacy, waste disposal and waste recycling.

The further analysis of the responses (see table A4/PCIII) shows that variables PC1 and PC2 have similar response patterns. This can indicate that it is possible there is an internal correlation between variables. The finding motivates testing factor analysis on the data to clarify the connection.

To measure the inter-correlation, the correlation between the different variables, two tests were performed. Bartlett's tests indicate that a factor analysis can contribute to increase the understanding of the material, while Kaiser-Meyer-Olkin test indicate that a factor analysis can contribute a little to increase the understanding of the material, which means that it is worthwhile to undertake a factor analysis.

- The Bartlett's test of sphericity is used to test the null hypothesis that is if the correlation matrix is an identity matrix (unrelated and not ideal for factor

analysis). A significant statistical test (less than 0.05) indicates that the correlation matrix is not an identity matrix and rejects the null hypothesis. The actual significance value of Bartlett's test of sphericity is 0.000.

– The Kaiser-Meyer-Olkin test (KMO) is a test conducted to examine the strength of the partial correlation between the variables. Kaiser characterizes measures in the 0.6's a meritorious mediocre (Kaiser 1974, in Norušis, 1993). The actual KMO value is 0.687.

Figure A4/PC1 shows in the generated Scree plot that two factors have an Eigenvalue above 1, which indicates that they can explain the variation in the material. Factor 1 has an Eigenvalue of 3.0 and Factor 2 has an Eigenvalue of 1.6. That means Factor 1 explains most of the variation in the data (see figure A4/PC1).

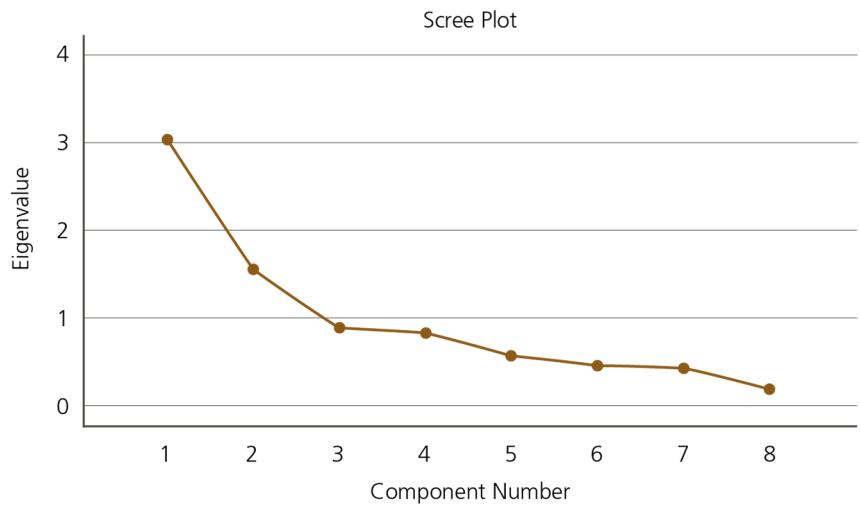

Figure A4/PC1: Factor analysis PC (Scree plot)

The result of the factor analysis is shown in figure A4/PC2, the rotated component matrix. After the rotation the factors are orthogonal.

– Factor (Component) 1 consists of the following variables PC in decreasing order of importance: PC7, PC8, PC6, PC4 and PC5.

– Factor (Component) 2 consists of the following variables PC in decreasing order of importance: PC1, PC2 and PC3.

Rotated Component Matrix[a]

	Component	
	1	2
PC7	,907	-,077
PC8	,837	-,041
PC6	,568	,389
PC4	,508	,421
PC5	,491	,447
PC1	-,059	,805
PC2	,002	,743
PC3	,351	,620

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

[a] Rotation converged in 3 iterations.

Figure A4/PC2: Factor analysis PC (Rotated component matrix)

Findings of factor analysis

Factor 1 consists of the following variables in decreasing order of importance: control waste disposal; control waste recycling; control privacy; control artificial lighting; and control noise. These variables all relate to *low operation costs* variables, i.e. variables that the users can control by their own behaviour with small impacts in the form of increased costs (in the case studied, users pay for their own consumption of electricity).

Factor 2 consists of the following variables in decreasing order of importance: control heating; control ventilation; and control daylight lighting. These variables mainly relate to *high operation costs* variables i.e. variables that are controlled by the facility management function and associated with increased costs. (Heating and ventilation are mainly centralized systems since the client has limited the users' ability to regulate the radiators' thermostat. Users' ability to control daylight lighting was also limited since the blinds were taken away in the refurbishment).

Appendix A5:
Survey questionnaire about Work Productivity

Question: "In what ways, if any, has the renovated building either improved or decreased your work productivity?"

The question resulted in 30 responses (out of 103 respondents), which correspond to a response rate of 29.1%. This is a low response rate. To be able to draw conclusions from this question, it would have been necessary to formulate it as a mandatory question with fixed response options in the form of increased/unaltered/ decreased productivity. Nonetheless, analysis of the 30 responses was undertaken.

In 17 of the answers the word "productivity" was used. The answers were distributed as follows:

- 11 increased productivity;
- 4 no influence on productivity; and
- 2 decreased productivity.

The remaining 13 answers described the result of the refurbishment without using the word productivity. The answers were distributed as follows:

- 9 described improvement;
- 3 described both improvement and deterioration or had nothing to compare the refurbishment with; and
- 1 described deterioration.

If the answers with regard to improvements/deterioration are interpreted as influencing productivity the distribution would be as follows.

- 20 increased productivity;
- 7 no influence on productivity; and
- 3 decreased productivity.

The analysis indicates that 19.4% of respondents experienced increased productivity because of the refurbishment.

Appendix B1:
Cover letter and survey questionnaire

Post-occupancy evaluation (POE) is the process of systematically comparing actual building performance, i.e. performance measures, with explicitly stated performance criteria. The division of Construction Management (Byggproduktion) is conducting a POE to ascertain users' satisfaction with the refurbished [X-house].

The goal of this evaluation is to determine the extent to which the refurbished building meets users' requirements in performing their daily work. It is hoped that the results will help to improve understanding of functional performance requirements and indoor environmental design of workplaces. The evaluation forms part of a doctoral research project investigating, *inter alia,* design and construction for operability.

We kindly ask you to complete this survey questionnaire related to your experiences. By completing it, we assume you have given your consent to participate in this study and have your answers included in the project data set. The estimated time to complete this survey is 20 minutes. Anonymity will be observed throughout.

The questionnaire contains a series of questions about your satisfaction regarding the following:

- Building performance
- Facilities and services
- Indoor environment.

We thank you for your cooperation.

Radhlinah Aulin, Docent

Brian Atkin, Prof

Elna Jönsson, Doktorand

Byggproduktion, Bygg- och miljöteknologi, LTH

Age (years)

< 30	30–40	40—50	50—60	> 60
○	○	○	○	○

Nature of employment (A)

- ☐ Full time
- ☐ Part-time

Nature of employment (B)

- ☐ Permanent
- ☐ Fixed term
- ☐ Temporary

To what extent do the following building performance attributes match your needs:
(Unacceptable = falls below my minimum requirements; Inadequate = does not meet my essential requirements; Adequate = meets my essential requirements; Delighted = exceeds all my requirements)

	Unacceptable	Inadequate	Adequate	Delighted
General building layout	○	○	○	○
Current personal workspace	○	○	○	○
Your workspace in relation to the surrounding workspaces	○	○	○	○
Privacy of your workspace	○	○	○	○
Personal computer facilities	○	○	○	○
Amount of space available for individual work and storage	○	○	○	○
Shared workspaces (if applicable)	○	○	○	○
Ease of interaction with co-workers	○	○	○	○
Safety in the building	○	○	○	○
Security in the building	○	○	○	○
Hygiene and cleanliness in the building	○	○	○	○
Overall quality of building	○	○	○	○

Please add any comments that would help to qualify your responses

To what extent do the following facilities/services match your needs:
(Unacceptable = falls below my minimum requirements; Inadequate = does not meet my essential requirements; Adequate = meets my essential requirements; Delighted = exceeds all my requirements; NA = not applicable)

	Unacceptable	Inadequate	Adequate	Delighted	NA
Individual/shared workspace	○	○	○	○	○
Accessibility	○	○	○	○	○
Classrooms (övningssalar)	○	○	○	○	○
Lecture theatres	○	○	○	○	○
Laboratories/workshops (non-computer)	○	○	○	○	○
Computer laboratories	○	○	○	○	○
Foyer/common areas	○	○	○	○	○
Kitchen and eating places	○	○	○	○	○
Toilets	○	○	○	○	○
Elevators/lifts	○	○	○	○	○
Goods delivery entrances	○	○	○	○	○
Waste collection entrances	○	○	○	○	○
Library	○	○	○	○	○
Outside areas within the boundary of the building	○	○	○	○	○
Speed of service recovery (remedial actions taken after reporting of complaints)	○	○	○	○	○

Please state if there is a facility or service that you miss and which is necessary

Please add any comments that would help to qualify your responses

To what extent do the following indoor environment match your needs:
(Unacceptable = falls below my minimum requirements; Inadequate = does not meet my essential requirements; Adequate = meets my essential requirements; Delighted = exceeds all my requirements)

	Unacceptable	Inadequate	Adequate	Delighted
Summer indoor temperature	○	○	○	○
Winter indoor temperature	○	○	○	○
Thermal comfort of your workspace	○	○	○	○
Air quality of your workspace	○	○	○	○
Draught in your workspace	○	○	○	○
Noise level within or immediately surrounding your workspace	○	○	○	○
Noise level in the building in general	○	○	○	○
Visual comfort from the lighting in your workspace	○	○	○	○

Please add any comments that would help to qualify your responses

How much control do you have in your workspace over the following aspects? (with 1 being no control and 5 being full control):

	1	2	3	4	5
Heating	○	○	○	○	○
Ventilation	○	○	○	○	○
Daylight lighting	○	○	○	○	○
Artificial lighting	○	○	○	○	○
Noise	○	○	○	○	○
Privacy	○	○	○	○	○
Waste disposal	○	○	○	○	○
Waste recycling (källsortering)	○	○	○	○	○

Please add any comments that would help to qualify your responses

How long have you been working in this building?

Before refurbishment (years)	
After fully refurbishment–post 2016 (years)	

On average, how many hours do you spend in the building daily? (hours/day)

1-2	3-5	6-8	> 8
○	○	○	○

On average, how many hours do you spend in your workspace per day? (hours/day)

1-2	3-5	6-8	> 8
○	○	○	○

On average, how long do you spend working at a computer each working day in the building? (hours/day)

1-2	3-5	6-8	> 8
○	○	○	○

In what ways, if any, has the renovated building either improved or decreased your work productivity?

If you would be happy to elaborate upon any of your responses in a short discussion with one of us, please add your name and email below

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