RESEARCH PAPERS FOR

THE 18TH EUROFM RESEARCH SYMPOSIUM

EFMC 2019

12-15 JUNE 2019 IN DUBLIN, IRELAND

MATTHEW TUCKER (EDITOR)

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EUROPEAN FACILITY MANAGEMENT NETWORK

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EuroFM
Boeing Avenue 215
1119 PD Schiphol-Rijk
Netherlands
www.eurofm.org

Published 2019

ISBN: 978-94-90694-10-4

Cover logo by CIFMERS GLOBAL

Edited by Matthew Tucker

Published by
EuroFM
Boeing Avenue 215
1119 PD Schiphol-Rijk
Netherlands
www.eurofm.org

TABLE OF CONTENTS

PREFACE

EuroFM exists to create a platform for opportunities for the facilities management (FM) community. The flagship event for EuroFM is the European Facilities Management Conference (EFMC) and the Research Symposium.

For the second year, the EFMC conference organisation has taken a fresh approach by consolidating the EFMC with the EuroFM Research Symposium, creating one holistic platform for all FM researchers, practitioners and educators to share their work. This will mark the 27th Edition of the EFMC and the 18th Edition of the Research Symposium, all engaging together in one collective space, in the wonderful city of Dublin, Ireland.

The theme for this year is *"One Place, One Voice, One FM"*. The theme symbolises the impact that FM has globally, to which the research papers presented are not only relevant in a European Context, but a wider global context.

The research journey for this year's conference started in November 2018, where the call for abstracts was first announced. All together 24 abstracts were received and a Scientific Committee was assembled to ensure that all abstracts undertook a double-blind review process. A total of 20 papers were finally submitted and approved for publication in this year's proceedings.

Each paper is produced in a standardised format. You will see a structured abstract at the beginning outlining the purpose, methodology, findings and impact of the work. You will also see the type of paper that is presented, to which there are 15 research papers, three case study papers, one conceptual paper, and one viewpoint paper. I would like to commend all the authors that have worked hard to get their papers to an excellent standard for this final submission.

I would also like to express my sincere thanks to the Scientific Committee who have given up their valuable time to undertake a very rigorous exercise. It is the work of this committee, and all the other 17 committees that have previously stood, that ensures that the research proceedings for our EFMC's are consistently kept to a high quality standard.

EuroFM creates a network of professionals that advances knowledge in FM and ensures its effective application in practice, research and education. EFMC 2019 is testament to this, and I hope you all enjoy the experience.

Dr Matthew Tucker

Research Chair

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The benefits of building information modelling (BIM) to facility management (FM) over built assets whole lifecycle

Simon Ashworth
Liverpool John Moores University (LJMU) and Zurich University of Applied Sciences (ZHAW)
ashw@zhaw.ch

Carsten Druhmann
Zurich University of Applied Sciences (ZHAW)
dhnn@zhaw.ch

Tenny Streeter
Zurich University of Applied Sciences (ZHAW)
streeten@students.zhaw.ch

ABSTRACT

Purpose: This paper evaluates benefits of building information modelling (BIM) to facility management (FM). The process of identifying and categorising benefits is explained and how interviews with FM and BIM experts were used to evaluate how they might help clients and facility managers during the operational phase of built assets.

Methodology: a literature review identified 95 relevant sources highlighting benefits of BIM to FM. After further review, 68 were selected for further analysis and categorisation. Interviews with nine BIM and FM experts were then used to validate practitioners' views regarding the importance of the benefits and their application in practice.

Findings: 373 benefit occurrences were categorised into nine types of benefit; 1) business values, 2) collaboration/communication, 3) cost savings, 4) data accuracy/quality, 5) energy performance, 6) interoperability, 7) productivity, 8) safety and 9) time efficiency. Each benefit was further categorised as tangible/quantifiable or intangible/qualitative. Experts indicated that benefits should be made transparent in order to be achievable: In doing so the benefits could deliver significant value to FM over the whole life of built assets.

Intended impact of the study on either research, education or practice: The findings make more transparent how the benefits will impact on FM in the operational phase. The full "*Benefits of BIM to FM Catalogue*" can be found at https://www.researchgate.net/publication/332655772_The_Benefits_of_BIM_to_FM_Catelogue_Version_2542019. It can be used by practitioners when constructing business cases for the adoption/use of BIM and planning BIM projects. Research suggests clients and operators are the stakeholders who stand to benefit the most from BIM. However, in the literature there has been little coordinated attempt to bring the benefits together in one place. The research provides a practical list of specific benefits to FM and validates their viability using feedback from FM practitioners.

Paper type: Research Paper

Keywords: facility management (FM), building information modelling (BIM), benefits of BIM, return on investment (ROI), Whole Life Cycle (WLC)

1. INTRODUCTION

BIM has become a necessity for modern construction projects. Its rapid adoption rate is well demonstrated in the UK, which has seen a rise from 10% in 2011 to 70% of companies using BIM in 2018 (NBS, 2018). New digital trends and associated software developments have resulted in a revolution of innovation driving change in the built environment. What BIM can, and will be able to deliver to various stakeholders is something that until recently was often unachievable. Schley (2011) and others have observed, BIM has the potential to deliver significant benefits in the operational phase of built assets. However, there has been a lack of documented evidence about the benefits and if they can be demonstrated in the operational phase. As a result, the proactive adoption and use of BIM in the operational phase has yet to become the norm. In order to realise the full potential value of BIM the benefits need to be considered over the whole life cycle (WLC) in order to ensure the effort put into creating *digital twins* of built assets not only delivers significant value for the design and construction phases, but even more value over the much longer operational phase. The research argues that if the benefits can be made transparent and are realistic there is more chance they will be achieved and make a significant contribution to improving the long-term performance, efficiency and sustainability of built assets as well as improving the wellbeing of the people using them.

2. LITERATURE REVIEW

Estimates for the proportion of operational cost over the WLC of built assets vary significantly. Eastman et al. (2018) puts the percentage at 57.5%, Broadbent (2018) at 75% and Miettinen et al. (2018) even higher up to 85%. The percentages can be debated however, there is general agreement in the literature that costs incurred during operation are significantly larger than during design and construction. The many stakeholders involved all stand to benefit from the BIM process by being able to share relevant and accurate information. For FM it is especially important to ensure that none of the valuable data accumulated during the design and construction phase is lost during the handover phase and that there can be a seamless transfer of the information into FM management systems e.g. Computer Aided Facility Management (CAFM). Historically the process of information handover has been poorly handled and much information was often lost. This creates significant problems for the operational teams who need to be able to quickly find important information in order to run and optimize built assets. NIST (2004) estimated an annual cost burden of $15.8 billion due to inadequate interoperability in the capital facilities segment of the U.S. construction industry. Broadbent (2018) estimates the FM industry might achieve possible savings in annual operation expenditures between 5-10%. Estimates as to the value of the European FM market vary considerably. Teichmann (2009) estimated the value in 2008 at approximately 655 billion euros, whereas the Global FM (2018) put the figure at 272 Billion. However, whichever figure is used even a small percentage saving due to BIM would amount to significant savings to many countries' economies.

The benefits of BIM to operational teams is a hot topic of discussion among academic researchers. Findings from the *FM Awareness of BIM survey* (Ashworth and Tucker, 2017, p5) indicated 74% of respondents believe "*BIM will have a significant impact on the FM industry*". Research by McGraw Hill Construction (2014) on the perceived value by owners of BIM for FM predicted that 98% of UK building owners would perceive high value from BIM. Other literature focuses on how BIM can deliver significant benefits both in financial terms, but also other ways which are often very important. There has been a shift of focus from thinking about

benefits purely from a CAPEX (capital expenditure) perspective and more to an OPEX (operational expenditure) perspective in order to deliver more value and sustainable outcomes. Schley (2011) argues facility managers need to access to information that is current, accurate, and relevant to demonstrate this value. However, Mari and Poggesi (2014) note this is only possible if the information is fully transparent, accessible and can be used in everyday FM CAFM and other management systems. McGraw Hill Construction (2014) argue when this is achievable, practitioners will perceive BIM as an innovation which helps reduce wasted time finding information, reduces project durations and rework, improves project costs, and positively impacting productivity and the efficiency of the project delivery process.

The role of FM in the BIM process is increasingly recognized as critical to realising the benefits of BIM (Ashworth & Tucker, 2017). However, their findings indicate that FMs knowledge and awareness about the BIM process, the possible benefits of BIM and how FMs could benefit from engaging and using BIM to their advantage is lacking. They argue FMs need to have a clear and transparent understanding of the benefits, and how the resulting data, documents and 3D models can provide significant value over the whole life of built assets. Other research by Ashworth et al (2016) indicates early engagement of FMs during the early stages of projects is likely to significantly improve the project outcomes and empower people to better operate facilities throughout their lifecycle. Yalcinkaya and Singh (2014) observe there is often a lack of clear requirements for the implementation of BIM in FM in the early stages of projects. However, Codinhoto and Kiviniemi (2014) observe a lack of evidence of the benefits of BIM being achieved in the operational phase. Pouriya and Johannes (2014) highlight three possible major obstacles; 1) IT provisions, 2) business processes and contracts, and 3) effective FM and operations using BIM-based integrated information systems. These challenges are not surprising as there is not yet a wealth of BIM projects which have been handed over to operation with sufficient time to document evidence of the operational benefits. Another issue hampering proof of the benefits is highlighted by McGraw Hill Construction (2014) who note there is currently no standard metric for measuring ROI on BIM.

A key challenge in the BIM process is data overload. If lots of valuable data is provided but which is unorganized it can be overwhelming to unprepared recipients and often ends in people feeling BIM has not delivered what they expected. To have high-performance built assets processes need to be put in place to acquire data in a way which is well structured for easy use and transfer to FM management systems. This should ideally include common open data schema e.g. Industry Foundation Classes (IFC) and Construction Operations Building Information Exchange (COBie). as well as Model View Definitions (MVD). These are all explained at the buildingSMART website www.buildingsmart.org (buildingSMART, 2019). Krämer and Besenyōi (2018) argue BIM will increase building information accuracy and reduce the cost and the time required to collect and build FM systems. Gerber et.al, (2012) also argue people will be able to use BIM to provide the much talked about *single source of truth* by using BIM-FM interoperability software, whilst Stowe et al (2014) argue data capture, storage and accessibility is critical to FM and Life Cycle Costs (LCC) and that BIM can help owners understand the benefit of investing in materials and systems that may cost more initially but have a better return over the life of the built assets. It is not possible to list all the benefits reviewed but a few of the key benefits of BIM to FM are shown in Table 1:

Table 1: Examples of key benefits of BIM to FM (from literature review)

Benefit	**Details of specific benefit**	**References**
Time and efficiency	BIM can reduce project execution time, improve faster & more effective processes, information is more easily shared, can be value-added and reused.	(CRC Construction Innovation, 2007)
Performance analysis	BIM can enable analysis for improving building performance.	(Aziz et. al, 2016)
Cost savings	BIM can reduce down time and associated costs by providing faster response times to emergency work orders.	(Brinda & Prasanna, 2014)
Energy efficiency	BIM can be used to help reduce annual energy use and minimize environmental risks.	(Shoubi, Shoubi, Bagchi, & Barough, 2015)
Increase business value	BIM can help reduce the probability of asset downtime due to more accurate understanding of asset condition and avoiding unpredictable component failure due to timely maintenance.	(PwC, 2018)
Data accuracy / quality	BIM can empower better management and organization of information, reduce inaccuracy and incomplete information, empower the improvement of life cycle planning and improve durability and sustainability.	(Mohanta & Das, 2016)
Interoperability	BIM exchange and transfer, reduces the need for major repairs and alterations, increasing the efficiency of work orders and decision-making process by access to real-time as well as previously stored graphical and non-graphical data.	(Yalcinkaya & Singh, 2014)

As well as delivering benefits which can be seen as clearly tangible, there are also many that are intangible in nature, but which may still deliver significant value to operational teams. Broadbent (2018) argues for example visualizations of the 3D models will allow employees to assess workplaces in a virtual context before any work commences which can greatly assist planning operations and improving health, safety and risk assessments. Broadbent goes on to argue this may also increase employees motivation and satisfaction in being able to easily and successfully complete essential operations and maintenance work in a safe way. However, achieving the benefits of BIM in operation is not without its challenges as highlighted by Kassem et al. (2015). They note; there is a lack of methodologies that demonstrate the tangible benefits of BIM in FM, as well as limited knowledge of implementation requirements including BIM for FM modelling requirements, the interoperability between BIM and FM technologies, the presence of disparate operational systems managing the same building and finally, the shortage of BIM skills in the FM industry. The authors believe all of these challenges need to be overcome if the FM industry, clients, owners and users and wider society is to realize the full potential of BIM.

3. METHODOLOGY

The following research questions were addressed:

1) *Is there compelling evidence from literature that BIM will deliver significant benefits for FM?*
2) *What are the potential benefits of BIM specifically to FM?*, and
3) *How can the benefits be categorized?*

In order to answer the research questions an initial in-depth literature review was undertaken to establish if the potential benefits of BIM to FM were a topic significantly reported on in the literature as well as identifying a list of possible benefits of BIM to FM. This involved using online databases containing a variety of FM and BIM related publications. Initially 95 sources were identified and then narrowed down to 68 following a review process which highlighted; some benefits were not so relevant to FM from an operational perspective, older publications, or simply a repetition of a particular subject. A wide variety of sources were found highlighting the complexity and diversity of the subject. The focus was on literature published within the last ten years. Table 2 shows a summary of the sources used.

Table 2. Sources of data making specific reference to benefits of BIM

Type of Resources	**Total**
Books	4
Conference papers	20
Case study reports	3
Industry reports	8
Journal articles	18
Presentations	1
Project reports	4
Thesis	1
Webpages	4
Whitepapers	3
Total	**68**

The aim of the categorization process was to assess each benefit using certain criteria and to group them according to similarities. The process included setting up a **Catalogue of Benefits of BIM to FM**. This was set up to record each *reference source* used from the literature review, the *general benefits* identified and extracted from the source. These were broken down into more *detailed benefits* and categorized by the *type of benefit* which indicates in more detail how and when each benefit occurs. The *context* of how the benefit could be applied was categorized as well if the benefit could be considered to be *tangible* or *intangible* in monetary or time terms. An example of one line of the 373 identified benefits is shown in Table 3.

Table 3. Example entry: Catalogue of Benefits of BIM to FM

No	Reference Source	General Benefits	Detailed Benefits	Type of Benefits	Context	Tangible	Intangible
1.	*Schley (2011) "Making Sense of BIM for FM"*	Preventive maintenance	1.regular inspection and upkeep 2. periodic modification	Cost savings	BIM for FM	X	

In order to develop a deeper understanding of which stakeholders would benefit most from the individual benefits each one was also categorized indicating which individual or group of stakeholders would benefit from each benefit. This enabled the *type of benefits* to be reduced to nine key categories as follows; 1) business values, 2) collaboration / communication, 3) cost savings, 4) data accuracy/quality, 5) energy performance, 6) interoperability, 7) productivity, 8) improving safety and risk management, and 9) time efficiency.

Following the literature categorization process, nine semi-structured interviews with BIM and FM experts were used to validate the catalogue of benefits and assess the practitioners' perception with respect to the importance of the benefits and their application in practice. The interview questions were designed to get feedback from the interviewees and validate the findings from the literature review and also to have insightful discussion and inputs regarding the topic. The interview questions were structured to reflect the benefits identified during literature analysis.

The interviewees were selected on the basis of their engagement and experience of FM and BIM. Nine experts who were selected from different geographical locations in order to get a wider perspective of BIM and its current trends. Table 4 shows the diversity of roles including: BIM consultant, (BIM) project manager, BIM (data) specialist, BIM&FM service manager and a lecturer. All of them work and have experience in BIM related projects. This combination is a reflection of the complexity of BIM and its application. The responses therefore were very diverse and rich in regards to their perspective of the reality of BIM implementation from different regions and expertise.

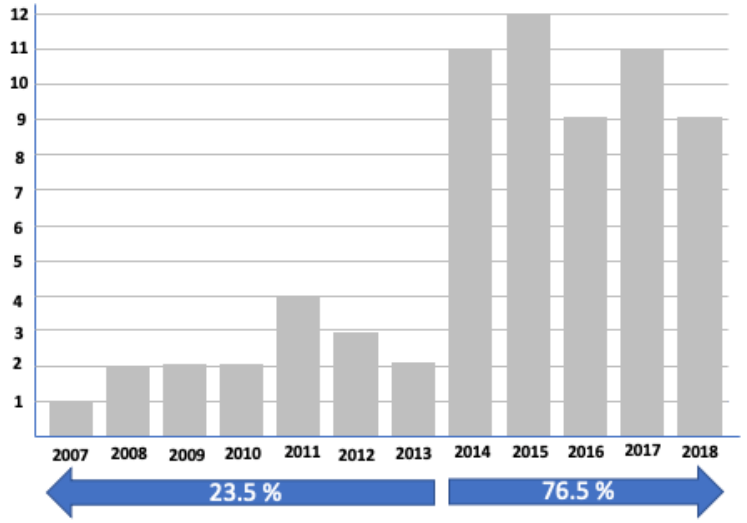
Table 4: List of FM and BIM experts interviewed

Function	Region
Property Manager	UK
BIM Manager / Consultant	Switzerland
BIM Consultant	UK
BIM Manager	USA
BIM – FM service Manager	Switzerland
Lecture / Professor	UAE
Lecturer	UK
BIM Manager	USA
BIM Consultant / Data Specialist	USA

4. FINDINGS

Level of interest in the potential benefits of BIM to FM: Figure 1 indicates how the popularity of the BIM topic and specifically literature about the benefits of BIM to stakeholders in the operational phase has increased over recent years in the scientific and practice communities. There appears to have been a significant increase in the period 2014 through to 2018. From the 68 references used 76.5% were authored between 2014 and 2018, with only 23.5% between 2007 and 2013. This indicates a general trend with respect to increased interest of how BIM might impact on and be beneficial to stakeholders in the operational phase of a built asset's life. The authors believe this might be linked to the paradigm change in thinking about BIM more from a whole life perspective and the need to make the benefits of BIM more transparent. There might also be a link to the general increased adoption of BIM and introduction of BIM mandates around the world (e.g. 2016 in UK). The increase in interest in the benefits of BIM led the authors to merit the topic some more attention.

Figure 1. Distribution of citation sources by year



Findings about benefits of BIM to FM from literature: 68 selected resources were reviewed to identify benefits of BIM which were directly relevant to FM and operations teams. A total of 373 individual benefits were identified, categorized and 'summarized'. Table 5 shows the percentage by "*type of benefit"* category and also ranked by frequency:

Table. 5 Key benefit categories ranked by frequency of occurrence

Ranking of frequency	Type of benefits category	Percentage
1	Time savings	21.98%
2	Productivity	18.23%
3	Cost savings	16.62%
4	Business Values	14.21%
5	Data Accuracy / Quality	11.26%
6	Communication / Collaboration	7.77%

7	Energy Performance	4.02%
8	Improving safety and risk management	3.75%
9	Interoperability	2.14%
	Total	**100%**

The ranking does not necessarily indicate that one category can be said to be more important than another, rather the intent is to show how frequently the type of benefit was mentioned in the literature. With respect to nature of each of the benefits to FM and how quantifiable they were the research categorised 42.35% of the benefits as quantitative (tangible) in nature and 57.64% of the benefits as being more qualitative (intangible) in nature.

Findings from the interviews: all interviewees were in general agreement that BIM currently and, in the future, will provide significant benefits to FM and organizations. They also concurred the nature of the benefits can be tangible or intangible based on an individual's perception and personal experience. Common benefit themes that occurred during interviews included; **collaboration:** "*collaboration and coordination are significantly improved",* **visualisation:** "*clients having accurate 3D digital twins or representation is crucial",* **optimisation:** *"BIM allows the tracking of data and analysis of relationships to optimize building systems",* **marketing:** *"BIM is very beneficial for organisations marketing strategy",* **accurate data:** "*BIM allows easy access to updated information, can help operating buildings efficiently and can result in cost saving over the long term",* and **knowledge management**: *"BIM will help access to update information effectively*".

5. DISCUSSION

The discussion reflects on benefits from literature and the expert practitioners` perspective. The nine ranked category **types of benefits** are used to present interesting findings. Quotes from interviewees are shown using inverted commas/italics.

1) Time savings

The most mentioned benefit in the literature; e.g. Kassem et al. (2015) debate how good quality BIM data and information will reduce the cost and time required to populate good data in FM systems. This aligned with expert's view; "*A significant benefit of BIM is to improve the handover process and the time needed to populate FM systems*". Interestingly many time saving examples were highlighted in the literature, however during interviews, experts did strongly agree or disagree with these.

2) Increased productivity

Examples from the literature discuss increased productivity in a variety of ways; e.g. Krämer and Besenyői (2018) argue that BIM has the potential to reduce labour-intensive activities by providing easy access to data over a long period using digital BIM models. This aligns with expert's view *"productivity with BIM is a lot higher compared to traditional ways of doing things, improving the end result, avoiding mistakes and therefore improving quality*". Another expert said "*BIM will definitely add value to organisations, especially for maintenance, from paper base to electronic*".

3) Cost savings

Often discussed in literature is if cost saving benefits can be measured in monetary terms. Examples include estimating monetary benefits across the asset lifecycle; e.g. (PwC, 2018), (Li, et al., 2014). Nical and Wodynski (2016) also describe benefits using maintainability studies. Although cost savings are often discussed in the literature and experts tended to agree that BIM should be able to save costs, they said it was hard to point to specific examples. However, they mostly agreed "*long-term WLC cost saving can be achieved using BIM*" and that "*BIM can help reduce operational costs*". The authors believe this gap between literature and practice may be due to relatively low numbers of BIM projects currently having a WLC as a focus from the outset, a lack of well-documented case studies and difficulties in comparing a "build with BIM vs without BIM comparison".

4) Business values

Most experts agree that BIM will add value to business and organisations but note "*you have to have the desire to work with BIM to maximize the benefits*". Another benefit from literature is using BIM as an investment tool to increase ROI and for marketing business to new clients; e.g. Hill (2009) discusses how BIM can be used as a tool for competitive advantage in the business organization, helping maintain company repeat business with past clients and to offer new services. This benefit was repeatedly mentioned and supported by the experts; "*BIM is very beneficial for an organisation's marketing strategy*" and "*BIM can be used as a marketing and change management tool to help people selling and renting buildings and informing tenants about their building*".

5) Data accuracy/quality

Often mentioned in the literature this benefit was of primary interest to the experts; "*data from BIM is the most beneficial aspect for FM*" and "*BIM empowers FM to make sure we are operationally ready with soft landing, and have a single source of truth*". This aligns with literature findings; e.g. Broadbent (2015) who argues BIM is extremely beneficial because it can capture data for asset management system, and Nical and Wodynski (2016) who argue BIM can provide a digital asset with real-time data access, knowledge-based system supporting O&M activities.

6) Communication /collaboration

This benefit was found important in literature and also to experts. Gerber et al (2012) emphasis the value of BIM as a visualization tool to facility managers. The experts view this as crucial; "*BIM facilitates FMs to engage in early phase of building lifecycle and also will allow collaboration among stakeholders involved in the whole process*" Another expert said "*BIM empowers collaboration between stakeholders saving a lot of time in decision making*".

7) Energy performance

This benefit occurs often in literature; e.g. Stumpf et al (2011) who discuss using BIM to conduct energy modelling early in design phase. Autodesk (2010) argue BIM will help organisations meet sustainability and energy-efficiency goals such as reducing water consumption, improving air quality and increasing on-site. renewable opportunities. However, experts had no specific examples from their experience that they could specifically point to.

8) Improving safety and risk management

Wetzel and Thabet (2018) ague BIM increases safety during operation by having safety relevant data (safety inputs) transferred into the BIM Model and SBEnrc (2018) argues BIM can reduce risk shown the reduction of the likelihood of adverse outcomes arising across the life-cycle of the asset. Experts tended to agree; "*BIM can improve safety in terms of information for safety and evacuation strategy*". BIM data can also help identifying possible hazards; "*BIM will help quickly find specifications and hazard sheets for products, improving faster assessments and safety".*

9) Interoperability

Yalcinkaya and Singh (2014) observe BIM is capable of increasing interoperability, facilitates the information exchange and transfer, automates data process and information transfer from the early stages of the project to the operation and maintenance phases. Aziz et al (2016) argue BIM can increase job satisfaction through good software / ICT interfaces and can improve work productivity. However, experts had no specific examples from their experience that they could specifically point to.

6. CONCLUSION

Reflecting on the research question "*1)Is there compelling evidence from literature that BIM will deliver significant benefits for FM*?; the findings showed an increased frequency of literature highlighting the benefits of BIM specifically to FM. (especially from 2014 onwards). This aligns with Ashworth and Tucker (2017) who surveyed FM practitioners and 74% believe that "*BIM will have a significant impact on the FM industry*" and 83.5% believed "*BIM will help support the delivery of facilities management*". Golabechi and Akula (2013) describe benefits in a wider context arguing BIM can be seen as a value creating processes that involves the generation, management and exchange of knowledge of a facility forming a reliable basis for decision making throughout its life cycle from the conceptual, design and construction phases through its operational life and subsequent closure.

With respect to "*How can the benefits be categorized in terms of those which are tangible & intangible?*" the research indicated 42.35% of benefits can be broadly categorised as tangible (quantifiable) and 57.64% as intangible (qualitative) in nature. Nine main benefit categories were established as shown in Table 3 and both literature and experts allowed the identification of significant benefits of BIM to FM. Five key examples are:

1. Improving FM service delivery by having instant access to accurate data.
2. Streamlining business process across the life-cycle of the asset.
3. Visualizations to increase collaboration, improve marketing and improve decision making.
4. Building performance monitoring/analyses and improving control of FM operations.
5. Reducing LCC, operating and maintenance costs and improved asset management.

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Quantitative improvement in workplace performance through biophilic design: a pilot experiment case study

Julia Ayuso Sanchez
CB Richard Ellis Real Estate Consultancy. Madrid, Spain
julia.ayuso@cbre.com
+34 600433390

Sergio Vega Sanchez
Department of Construction and Architectural Technology. High Technical School of Architecture of Madrid. Universidad Politécnica de Madrid, Spain.
sergio.vega@upm.es

Enrique Carrero Alvaro
CB Richard Ellis Real Estate Consultancy. Madrid, Spain
enrique.carrero@cbre.com

ABSTRACT

Purpose: Humans spend an average of 90% of their time indoors, so the health impacts of the spaces we create and occupy are significant. Buildings can influence our productivity, creativity, and health both inside and outside the office. Workplace management and the improvement of productivity-creativity performance and well-being are key drivers for Facility Managers. The improvement in well-being and performance in the workplace are economic and critical social factors since the decrease in productivity for companies means a cost of up to $US 550 billion per year (Sorenson and Garman, 2013). On the other hand, several studies affirm that biophilic design, defined as a response to human beings' inherent need to be in contact with nature, improves productivity and user's well-being in the workplace. However, by how much? How do we measure the improvement? It is not that easy.

Methodology: In response to this challenge of how to measure productivity and well-being performances, we have conducted a scheduled pilot experiment, as a small-scale version done in preparation for a major study. It quantifies the impact of biophilic design features on productivity-creativity and well-being, to assess the influence of different variables on improving workplaces, and examine biophilic design knowledge in greater depth.

Findings: The results highlight an improvement in health and well-being, and productivity-creativity performances, through the incorporation of biophilic design features in workplace design.

Intended impact of the study on either research, education or practice: The development of the pilot experiment opens new ways to measure workplace capabilities fostering key drivers to improve facility managers' performance.

Paper type: Research Paper.

Keywords: Facility Management, Workplace, Productivity, Health, Well-being.

1. INTRODUCTION

According to 2015 report, Japan passed the tipping point at which its population began to decline in 2011 (Ministry of Health, Labor and Welfare 2012). By 2040, more than one-third of its population will be 65 years old or older (Marutschke 2017). The implications of this shift can be felt already economically and socially. With its working-age population shrinking, Japan has to focus on productivity as the primary catalyst for economic momentum.

Numerous studies endorsed by the scientific community, affirm that biophilic design, defined as a response to the inherent need of human beings to be in contact with nature (Wilson, 1984), in the workplace improves productivity and user well-being (Human Spaces, 2015), (Human Spaces, 2011). The first challenge applied to architecture is to increase contact with nature in spaces through an optimal design. If you cannot measure it, you cannot improve it (Willcocks and Lester, 1996), so the second challenge that arises is how to objectify and quantify rigorously the features that improve productivity and well-being in biophilic-design spaces.

The United Nations predicts that by 2030, 60% of the world's population will live in urban environments (Un-Habitat, 2008). It is therefore imperative that we consider how the connection between people residing in cities and nature can be maintained, and what are the most impact parameters in human's well-being, health, and performance. Relevant authors have stated that the answer to this challenge is biophilic design (Brioni, 2017).

Previous studies have shown that the relationship between indoor building design and wellbeing of occupants are complex (Bluyssen et al., 1995). There are many indoor stressors, such as excessive thermal factors, lighting aspects, moisture, noise and vibration, radiation, chemical compounds, and particulates fluctuations that can cause their effects additively or through complex interactions. It has been shown that exposure to these stressors can cause both short-term and long-term effects. In the workplace, a whole range of effects has been associated with these stressors such as Sick Building Syndrome (SBS), building-related illnesses and productivity loss.

Although previous studies have shown associations between indoor stressors and comfort, health and productivity in an office environment, relevant relations between lighting and greenery combination as biophilic design and effects have been difficult to establish. Lighting and greenery are selected in the pilot experiment because they are features included in the WELL certification within the category of Biophilia (International WELL Building Institute, 2017) and because in the State of the Art is possible to find few examples of pilot experiments that combine these two characteristics (Bluyssen et al., 1995).

With well-being and productivity at the workplace as economic and social critical factors, a tool has been designed to quantify the influence of the use of biophilic design on intellectual performance, creativity, and well-being, following a methodology developed in Keio University, tested by a pilot experiment carried out through physiological tests, psychological tests, and simulated work tasks.

Users' perceptions are examined using a questionnaire and measuring physical and physiological parameters, administered to two experimental groups and a control group before and after the installation of greenery and daylight. The results are analyzed to determine any statistically significant differences between the three groups and between the pre- and post-test subjective. Furthermore, daily tests are undertaken for temperature, relative humidity, CO2, and luminance.

2. HYPOTHESIS AND OBJECTIVES

The improvement in well-being and performance in the workplace are economic and social critical factors since the loss of productivity for companies means a cost of up to US$ 550,000 million per year (Sorenson and Garman, 2013).

Based on the above, it is possible to establish the hypothesis that an appropriate methodology could be used to create a tool that would make it possible to compare work environments, quantifying the difference in metrics thrown by users relating to productivity and well-being.

The objective of this article is to test a tool through a pilot experiment to quantify objective variables and to assess how much greenery and daylight influence users' perceptions, and its effect on performance, creativity, well-being, and health.

3. THE METHODOLOGY

A pilot experiment was designed with both subjective and objective evaluation, to quantify the subjects' performance. User perceptions were examined using the NASA TLX questionnaire, Subjective Assessment of Workplace Performance questionnaire, and the Jikuko-sho questionnaire. The combination of these three methods provides a holistic view of the subjective human perception.

For the objective assessment, the physical and physiological parameters have been measured, from two experimental pilot groups and a control group, before and after the installation of greenery and daylight. The results were analyzed to determine any statistically significant differences between the three groups and between the pre- and post-test subjects. Furthermore, daily tests were carried out for temperature, relative humidity, CO_2, and light. Table I summarizes all the items measured.

Table I: Pilot experiment measurement items.

	Item	Method	Time
Physiological measurements	Autonomic nerves	Heart rate	Continuous
	Activity level	Activity meter	
	Sleeping latency and efficiency	Sleep gauge	At home
	Saliva amylase concentration	Saliva amylase activity monitor	Before and after work
Psychological measurements	Fatigue - drowsiness	Questionnaires	
	Indoor environmental satisfaction		
	Subjective working efficiency		
	Subjective workload		
	Objective work efficiency: typing (information processing work), mind map (knowledge creation work)	Tasks	During work
Environmental measurements	Light (lx)	Environmental measurement station	1-minute interval
	Temperature (ºC)		
	HR (%)		
	Radiation temperature (ºC)		
	Wind speed (m/s)		
	CO_2 concentration (ppm)		30-minute interval
	Noise (dB)		

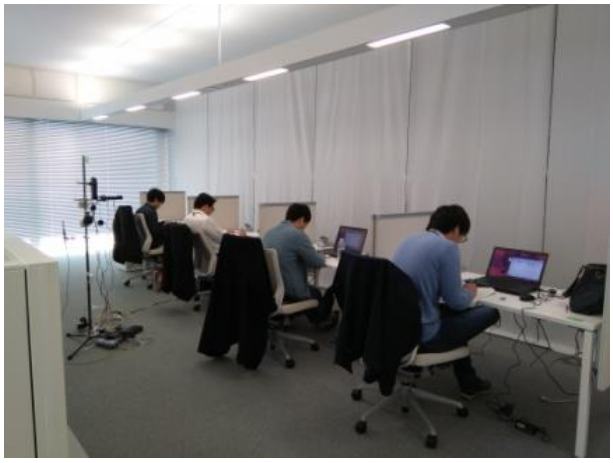
4. EXPERIMENT OUTLINE

4.1 Outline of the subject experiment

The experiment with subjects was carried out in a laboratory environment of Taisei Company (Fig. 1 and 2) for a total of five days. One control group and two experimental groups were characterized as follows: subjects were a total of eight male, college students, with a standard body type (18.5 < Body Mass Index (kg/m2) < 25.0) without smoking habits. In this study case, a series of tasks simulating office work were performed, with a total of three task set in the morning and three in the afternoon (Fig. 3). During simulation work, text typing was done as information processing work, and mind map as knowledge creation work. This study was done under the protocol approved by the bioethics research committee of Faculty of Science and Technology, Keio University (No.28-19).

Figure 1: Interior of the experimental place with greenery.

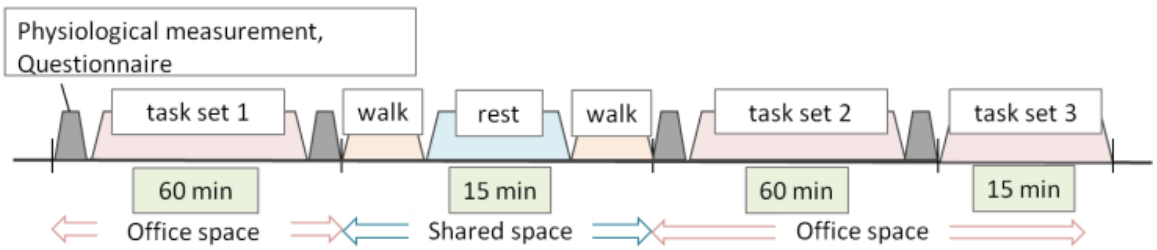
Figure 2: Interior of the experimental place without greenery.



The typical daily experimental schedule is shown in Figure 3. The subjects were set in the simulated environment at 9:00. Firstly, they responded a questionnaire on the eve-morning activities. After that, a 60 minutes' session started, with physiological measurement, questionnaire and simulated work with two different tasks, performed in 25 minutes each one. Before and after the experiment subjects enjoyed free time, however, strenuous exercise or drinking alcohol were prohibited.

It has been demonstrated that productivity decreases when the end time is close. Task Set three was added with the aim of not compromising the results of Task Set one and two, and results of Task Set three were not considered, eliminating the "end time effect" (Diehl 1991).

Figure 3: Morning and afternoon schedule.



4.2 Case setting

As shown in Table II, during the five days in which the experiment was developed, three cases were established, combining the presence of daylight and greenery.

Table II: Experiment cases setup combining the total of three cases. Each case combines greenery and daylight as variables.

		2/13（M）	2/14（T）	2/15（W）	2/16（T）	2/17（F）
Group A	Subject 1	CASE 1 No Daylight No Greenery	CASE 1 No Daylight No Greenery	CASE 2 No Daylight There is Greenery	CASE 3 There is Daylight There is Greenery	CASE 3 There is Daylight There is Greenery
	Subject 2					
	Subject 3					
	Subject 4					
Group B	Subject 5	CASE 3 There is Daylight There is Greenery	CASE 3 There is Daylight There is Greenery	CASE 3 There is Daylight There is Greenery	CASE 1 No Daylight No Greenery	CASE 2 No Daylight There is Greenery
	Subject 6					
	Subject 7					
	Subject 8					

In Case 2 and Case 3, were placed four units of Dracaena Lemon Lime, four units of Sansevieria Trifasciata (Snake plant) and four units of Aloe Vera. Figure 4 shows the exact location of the greenery. The plants were selected according to the classification made by the NASA study of plants with particular qualities regarding air purification (Wolverton 1989). Table III summarizes the main characteristics of the selected plants.

Figure 4: Experiment place layout.

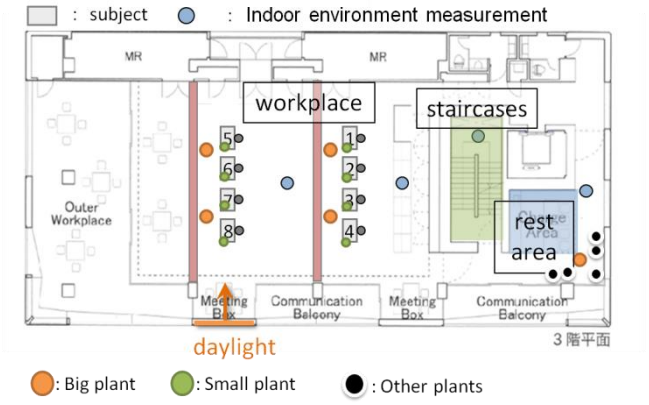


Table III: Selected greenery.

Name	Dracaena Lemon Lime	Sansevieria Trifasciata	Aloe Vera
Size	Large	Large	Small
Contaminants it eliminates	Trichloroethylene, Formaldehyde,	Trichloroethylene, Formaldehyde, Benzene,	Formaldehyde, Benzene

	Xylene	Ammonia	
Picture			

About the rest time area, two cases were set: a case in which students rested at the desk for 15 minutes and another instance where students went for a walk from the workspace to the rest area for repose (Saurabh 2015), and which was provided with greenery and daylight.

In the analysis of the results of the experiment, daylight and greenery were not combined, in order to study the effect of both variables separately.

4.3 Measurement item: indoor environment

A continuous measurement of the ambient temperature, relative humidity, globe temperature and wind speed was made at the height of 1.1 meters from the floor plane. Likewise, the noise and CO_2 concentration were measured at 20-minute intervals and the luminance on the work surface and vertical surface at the beginning of each work session. The average value of the CO_2 concentration was 886 (±105) [ppm], the noise was 49.9 (±1.2) [dB], the luminance at the horizontal plane was 503.5 (±15) [lx]. According to Hygienic Environment in Buildings regulations, the interior of the office was in standard condition. Table IV shows the results obtained.

Table IV: Indoor Environment Measurement results during the experiment (± Standard Deviation).

	Morning		Afternoon	
Group	A	B	A	B
1.1m Temperature [°C]	24.4±0.4	25.0±0.4	24.6±0.5	24.6±0.4
Humidity [%]	38.1±2.7	37.5±3.0	40.0±2.0	40.5±2.3
Wind speed[m/s]	0.13±0.08	0.15±0.07	0.13±0.08	0.14±0.06
Globe Temperature [°C]	24.1±0.4	24.9±0.4	24.2±0.4	24.4±0.3
CO_2 concentration[ppm]	832±100	842±105	939±109	954±127
Noise[dB]	50.1±1.5	48.6±0.9	49.7±0.9	48.6±1.2
Horizontal plane Luminance [lx]	455±22	1032±303	425±8	477±57
Vertical plane Luminance [lx]	232±122	603±117	211±106	321±39

4.4 Measurement item: physiological measurement

Heart rate, salivary amylase concentration, tympanic membrane temperature and activity level were measured during the experiment. Continuous measurement of heartbeat was carried out to ascertain the change of autonomic nerve state which is an index of stress at work and the relaxation state and the sympathetic activity during work. The salivary amylase concentration was measured to grasp the stress state before and after work. Also, the tympanic membrane temperature was measured for physical condition control of subjects. Also, intending to seize

the subjects' routine that was out of the experimental time, the activity amount was continuously measured.

4.5 Measurement item: psychological measurement.

The indoor environment satisfaction degree was evaluated in six-grade scale: thermal comfort, light, noise, air quality and space environment of workplace and rest area. Physical condition, fatigue, drowsiness, subjective work efficiency before and after work were also studied. Therefore, subjective symptoms investigation was also used for evaluating fatigue perception. Finally, subjective workload evaluation was performed using the Japanese version of NASA Task Load Index (Hart 1988).

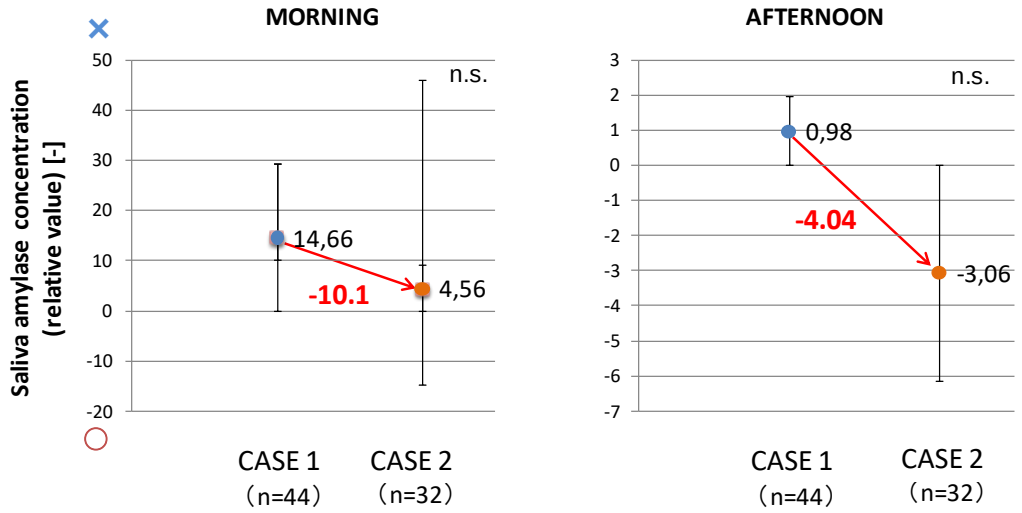
5. THE RELATIONSHIP BETWEEN GREENERY AND PRODUCTIVITY

For the unification of conditions, according to the questionnaire of the morning, the data collected from those who were in severe physical condition, those who had drunk the night before and those who did not take breakfast were excluded. A positive correlation was found for physical health, drinking alcohol, and breakfast with tasks results. Also, since the influences of hunger and fatigue in the morning and afternoon were different, each result was analyzed separately.

5.1 Influence of utilization of Greenery on stress condition

The results of the saliva amylase concentration after working in space with greenery and in the space without greenery are shown in Figure 5. By measuring the saliva amylase concentration was possible to understand the stress state at that time. There was a significant difference between cases in the morning and afternoon. The result suggested that the use of greenery in the office space would affected the stress condition.

Figure 5: Saliva amylase concentration in each case.



5.2 Psychological influence on the use of Greenery

Before the experiment, during the recruitment period, students were asked about possible allergies to plants, selecting only people who did not present any pathology. During the five days in which the experiment was carried out, the groups of people who occupy the workspace with greenery were asked about their satisfaction with them. Figure 6 shows that 71.4% of the people said they were satisfied or very satisfied with greenery.

Figure 6: Satisfaction about greenery questionnaire

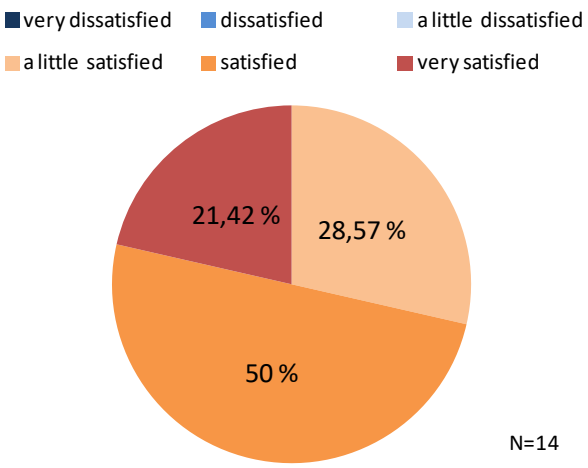
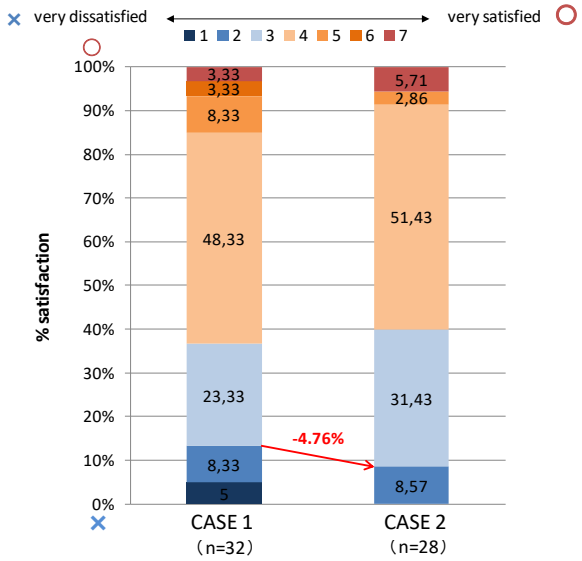


Figure 7: Answer percentages to the question: "Did you feel thermal sensation adequate?"



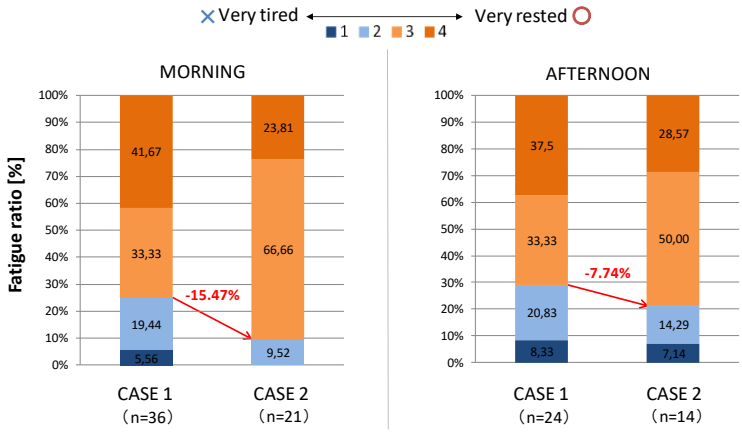
5.3 The relationship between Greenery and thermal satisfaction

The thermal sensation was strongly correlated with the presence or not of greenery in the workplace. It is important to note that the two groups are under the same ambient temperature conditions. According to the answers obtained in the questionnaire, mention should be made of the decrease in the percentage of "dissatisfied" and "very dissatisfied."

5.4 The relationship between Greenery and fatigue

There was a significant correlation between the presence of greenery and the subjective feeling of tiredness manifested in the Jikaku-sho Shirabe questionnaire. The percentage of people who felt "tired" or "very tired" descended significantly in the case with the presence of greenery, highlighting the decrease of that percentage by 15.5% in the morning.

Figure 8: Fatigue reporting ratio.



5.5 The relationship between Greenery and intellectual productivity

The results of the tasks were analyzed, noting that none of the eight subjects showed abnormal productivity results.

Figure 9 shows the erroneous batting typing rate with and without greenery use in the workplace, and Figure 10 illustrates the number of valid responses in the mind map task. Results were normalized and analyzed to eliminate individual ability differences. Furthermore, the results of the first day were excluded, taking into consideration the effect of the inexperience.

The task results were not significantly different between cases in the morning or afternoon. Although the presence of greenery in the workplace did not contribute to the enhancement of the work efficiency, it was necessary to point out that other factors could affect the result, such as the lack of space illumination.

Figure 9: Results of typing task in each case.

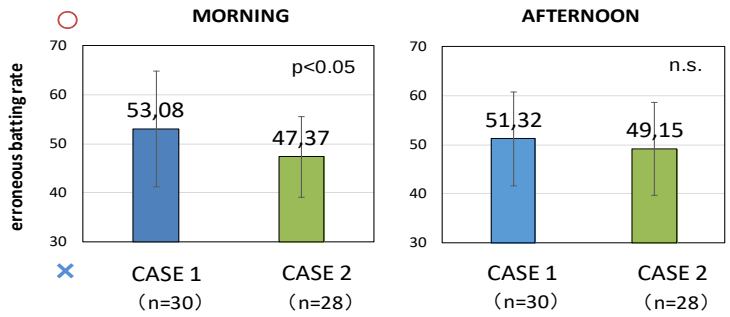
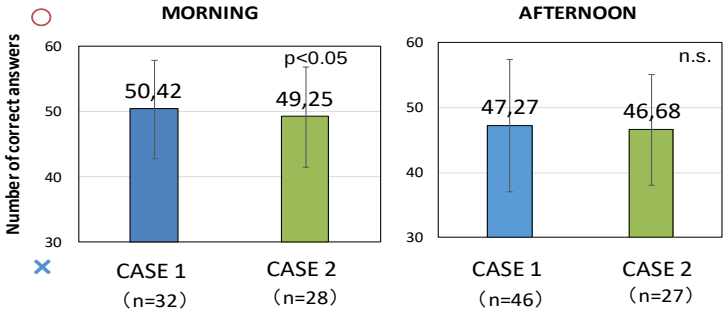


Figure 10: Results of mind map task in each case.



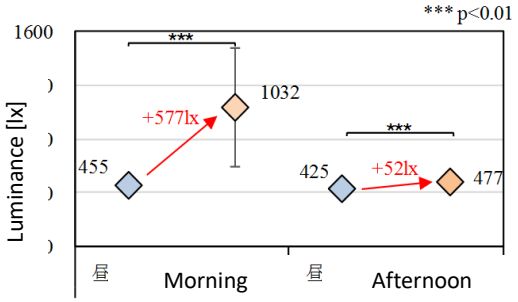
6. THE RELATIONSHIP BETWEEN DAYLIGHT AND PRODUCTIVITY.

In this paper, the relationship between daylight utilization and fatigue feeling, sleepiness and intellectual productivity was quantitatively verified. Following the same criteria as in the analysis of the relationship between the presence of greenery and productivity, for the unification of conditions, according to the questionnaire of the morning, the results from those who are in severe physical condition, those who had drunk the night before and those who did not take breakfast were excluded. Also, since the influences of hunger and fatigue in the morning and afternoon are different, each result was analyzed separately.

6.1 The relationship between Daylight and luminance

According to the results shown in Table 3, it was confirmed that there was no difference in thermal, air quality and sound environment in the presence or absence of daylight. Similarly, it was confirmed that the light environment (horizontal surface and vertical surface luminance) was brought to high luminance by using daylight. Furthermore, Fig. 11 shows the desk top luminance which was thought to affect the work performance. It was 577lx higher in the morning and 52lx higher in the afternoon ($p < 0.01$) in daylight utilization space compared with no daylight use space. It was confirmed that the luminance on the desk top surface was significantly higher than usual, especially on morning.

Figure 11: Measurement result of desk top luminance during experiment

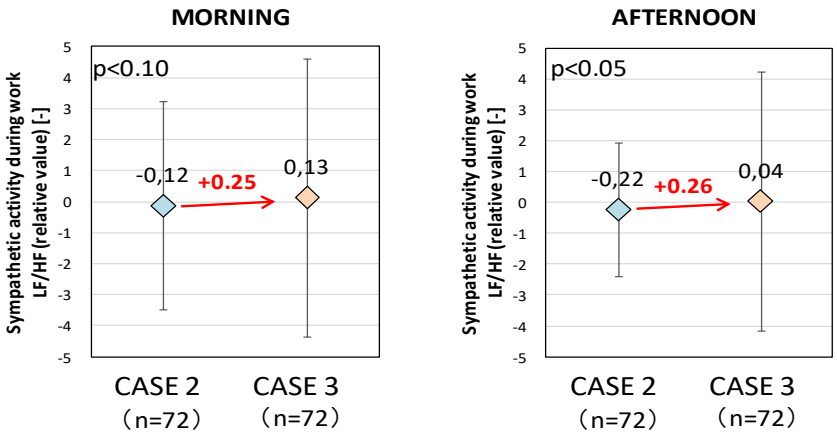


6.2 Effect of utilization of Daylight on the Sympathetic nerve

The relationship between the Sympathetic Activity Low Frequency (LF) / High Frequency (HF) during working and the workspace with and without daylight was analyzed. The difference from the resting value of each day for each subject was calculated and taken as a

relative value to eliminate individual differences between days. Moreover, the results where the sympathetic state at rest is abnormal were excluded. It was thought that it was desirable that sympathetic nerves be active and in a state of awakening during work (Oyama 2015). As Figure 12 shows, sympathetic activity was 0.25 points higher ($p < 0.10$) in the morning and 0.26 points higher in the afternoon ($p < 0.05$) than in the case without daylight, compared to the case without daylight. From this, it was shown that the use of daylight to the office space could activate the sympathetic nerve during work and bring about the arousal state.

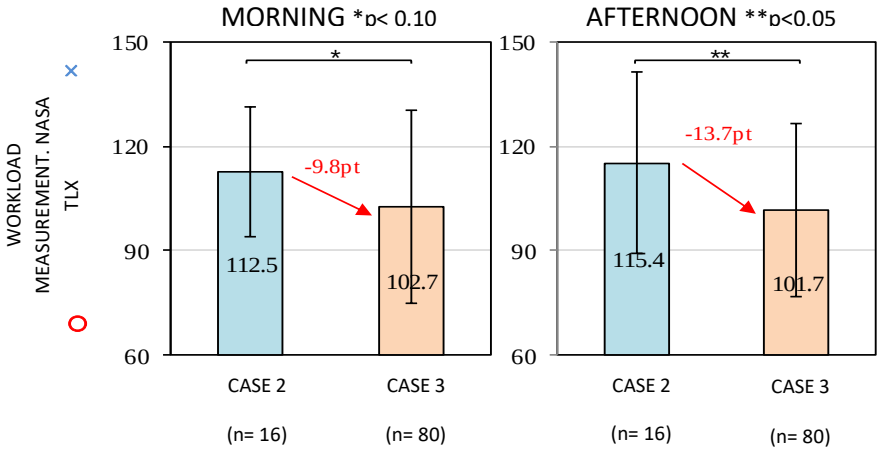
Figure 12: Sympathetic activity during work LF/HF



6.3 Influence of Daylight presence on subjective workload.

In the case of daylight utilization, the subjective workload scores were lower by 9.8 points ($p < 0.10$) in the morning and by 13.7 points in the afternoon compared with the case without daylight ($p < 0.05$). From this, it was shown that the score of the subjective workload evaluation decreases due to the use of daylight to the office workspace, and the possibility of suppressing the workload was shown.

Figure 13: Evaluation of subjective workload in each case (NASA-TLX)



6.4 The relationship between Daylight and intellectual productivity.

To eliminate individual capacity differences, typing and mind map results were normalized and analyzed. Additionally, the results on the first day were excluded, considering the effects of unskilled work.

The erroneous batting rate of typing, which was a simple task, was not significantly different between cases in the morning and afternoon. From this, it was shown that there was no influence of the use of daylight to the office space for simple work.

Meanwhile, the number of effective responses of the mind map, which was a creative work, is 5.4 points higher ($p < 0.05$) in the morning and 1.6 points higher in the afternoon ($p < 0.15$). From this, it was shown that the use of daylight to the office space in the creative work could contribute to the improvement of work performance. Although the use of daylight to the office workspace did not contribute to the enhancement of the work efficiency of simple work, the possibility of contributing to the work performance of the creative work was shown from the above.

Figure 14: Results of typing task in each case.

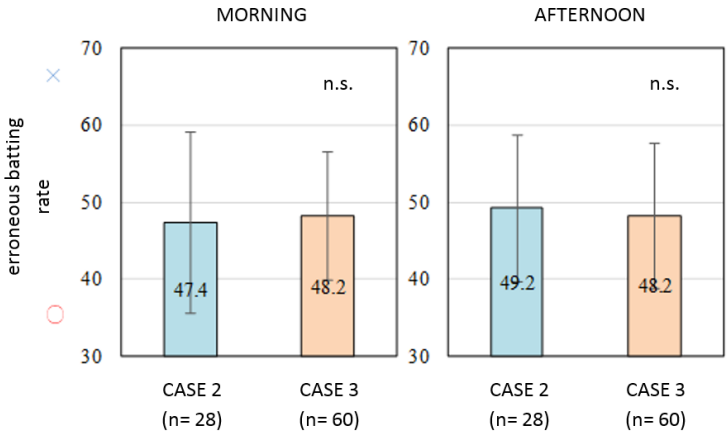
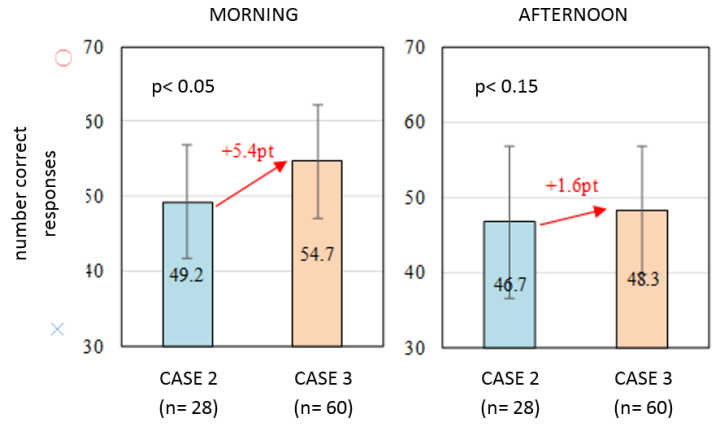


Figure 15: Results of mind map task in each case.



7. CONCLUSIONS

In this research, subject experiments were conducted with the aim of quantitatively verifying the influence of utilization of greenery and daylight in the workplace on intellectual productivity. The findings obtained by this experiment are shown below.

The tool tested with this pilot experiment allows the influence of some variables in well-being and workplace performance to be quantified, and it will lead to greater knowledge in productivity and creativity in the workplace, and how it could be improved.

The findings with this pilot experiment, point to additional benefits to performance, creativity, user well-being and health in biophilic designed workplaces, by combining greenery and daylight. In a five-day pilot experiment, participants in biophilic space have 4.92 points more in creative task scores, better environmental perceptions, and fewer symptoms than those in the control space. Findings suggest that the quantifiable benefits of the biophilic workplace go beyond measurable physiological indicators. Greenery and daylight may play a major role in the occupants' health and cognitive function, and both could be assessed through the measurement of subjective and objective parameters.

Based on the application of this tool in the pilot experiment,several lessons were learned; the main one was the positive return of investing enough time and resources in the design of the pilot experiment. Since an adequate design of the scenarios of the pilot experiment is key to the success of it, by exactly defining the variables to measure, it would have been convenient to define the attributes of daylight in more detail.

ACKNOWLEDGMENTS

We would like to thank Erasmus Mundus – Euro Asia Sustainable Energy Development Program (EM-EASED), for the financial support of this pre-doctoral stay. Also, the authors wish to thank all the participants in the study.

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Value adding FM in practice: Using importance analysis at the Technical University of Denmark

Susanne Balslev Nielsen
Oslo Metropolitan University, Norway and NIRAS A/S, Denmark
subals@oslomet.no
+45 60 34 09 25

Jacob Steen Møller
DTU Campus Service, Technical University of Denmark
jsmo@dtu.dk

Tine Berg Krogstrup
Office for Study Programmes and Student Affairs, Technical University of Denmark
tibek@adm.dtu.dk

Line Katrine Harder Clemmensen
DTU Compute, Technical University of Denmark
lkhc@dtu.dk

Christian Bøge Lyndgaard
DTU Compute, Technical University of Denmark
cbly@dtu.dk

ABSTRACT

Purpose: In 2018 Technical University of Denmark (DTU) conducted its third study environment investigation since 2012 to gain insights into the students' experiences at the university. This investigation aimed to give important feedback to the facility management (FM) organisation, DTU Campus Service and others involved in creating an attractive study environment at DTU. The investigation was is to answer the question: What matters the most for the general satisfaction of students and how will FM contribute to maintain and improve the general satisfaction in coming years? These are important insights for an organisation that constantly needs to justify that the value creation is higher than or at least the same as the associated costs.

Methodology: The methodology consists of a mix of methods in a three-step process. The first step was the quantitative survey with 65 statements about the social, physical and aesthetic study environment in the spring 2018 sent to 10.535 students of which 3837 (36%) answered in full. Each statement was assigned a score from 1 (totally disagree) to 6 (totally agree). The second step was a quantitative investigation of the most important aspects in relation with the general satisfaction of the students through a so-called importance analysis. This analysis showed that not all aspects were equally important for the general satisfaction. The third step was the creation of a study environment investment plan based on the strategic direction given by the current student investigation and other relevant information like a similar staff satisfaction.

Key findings: The importance analysis, based on the questionnaire survey conducted, identified the following 10 factors as the most important focus points in value adding management for the university as a whole: absence of loneliness, good contact with fellow

students, availability of lecturers also outside of normal teaching time, easy access to information about one's study lines and the courses followed, tidy and well-kept outdoor areas, tidy and well-kept premises, easy way finding, selection of social events, well-functioning informal learning environments and absence of stress symptoms in everyday life.

Intended impact of the study on research and practice: Of the 10 most important aspects there are aspects, which FM has a direct or indirect influence on. This is reflected in the new action plan, developed by DTU. The DTU approach can give inspiration to others who are conducting user feedback via surveys, in particular the set of questions and the "importance analysis". The case study adds to the growing literature on added value in FM, university FM and FM value creation. The study environment investigation focused only on students, not the researchers and other staff at DTU. Other investigations cover their views; and the FM-organisation might need to balance conflicting views with the results of the student environment survey.

Paper type: Case study

Keywords: action plans, facilities management, study environment, survey, university, campus services

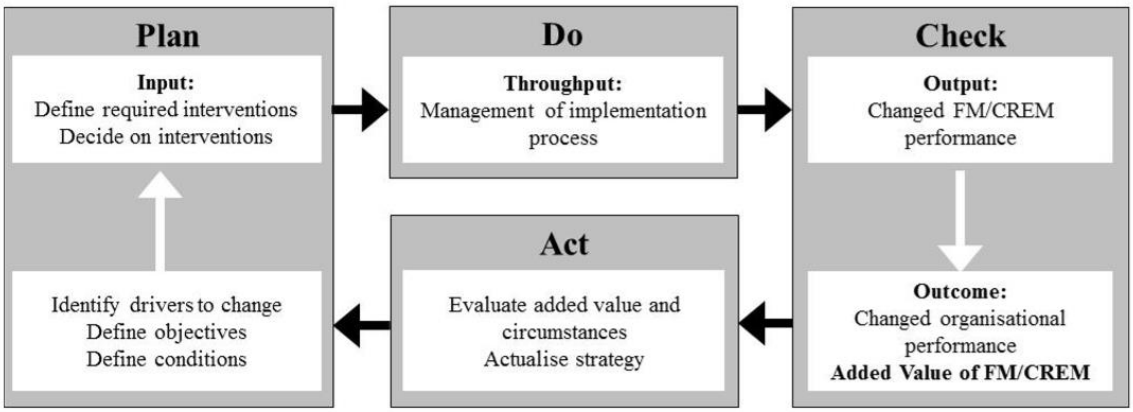
1 INTRODUCTION

In 2018 the Technical University of Denmark (DTU) conducted its third study environment investigation since 2012 to gain insights into the students' experiences at the university. This investigation gives important feedback to the university including the facility management (FM) organisation, DTU Campus Service (CAS). What matters the most for the general satisfaction of students and how will FM contribute to maintain and improve the general satisfaction in coming years? These are important insights for a support organisation that constantly needs to justify that the value creation is higher than or at least the same as the associated costs.

The comprehensive studies of FM and Corporate Real Estate Management (CREM) as Value Drivers by 23 European researchers Jensen and van der Voordt (2016) presents twelve value parameters as most essential in FM value creation. These are satisfaction, image, culture, health & safety, productivity, adaptability, innovation and creativity, risk, cost, value of assets, sustainability and corporate social responsibility. The added value methodology for real estate and FM organizations is summarized in van der Voordt et al (2016) and shown in Figure 1. The management model begins with "Plan" interventions on basis on the given condition and objectives for a future situation. The following phase is "Do", meaning implementing the planned interventions. Next step in the management process is to "Check" if the FM/CREM performance has changed as intended with the intended outcome for the organization. Based on this evaluation the next phase is to "Act" if there is a need for updating the strategy to ensure the planned objectives will be met. This paper focus on this process in the context of the study environment at DTU and in particular the sub process of "Check", "Act" and "Plan" again. The reason for this focus is the novel results of the 2018 study environment survey and the following action plan at DTU and its potential inspiration for other FM organizations.

Figure 1: The Adding Value management model

in Jensen and van der Voordt (2016) and van der Voordt et al (2016).



FM in a university context is a specific context within the general FM theory, and several researchers has studied learning environments and processes of aligning FM practices with current user needs and preferences (Den Heijer, 2011), (Beckers, 2016,) while also embracing scenarios of future learning environments e.g (Nørgård and Bengtsen, 2016) and (Rytkönen, 2016).

After this introduction the following sections present the Case of DTU, the research methodology and the results from the study environment survey as well as the new action plan for further improvements of the study environment at DTU. The discussion focuses on the differences and similarities between the theoretical value adding management model suggested by van der Voort, Jensen et al. The conclusion summaries the findings "what matters the most to DTU students" and DTU learnings from the survey.

2 LEARNING ENVIRONMENTS AT DTU

The Technical University of Denmark is a polytechnic single faculty university in the Capital Region of Denmark with 11.000 students, almost 6000 staff members and an expectation of growth. The FM organization, DTU Campus Service, has an important strategic role as providers of facilities and services. According to the University strategy 2014-2019 "DTU must prioritize beautiful and functional campuses with a visible and versatile social life, including engaging study environments. More specifically, DTU must strengthen and develop formal and informal learning environments for students who support and promote presence and an active study environment on campus". It is thus important for DTU to carry out a thorough mapping of student motivation in order to create a qualified knowledge base for the further development and strengthening of the university's study environment (DTU, 2018) (authors' translation).

The Strategic campus plan (DTU Campus Service, 2018) is the master plan for the physical planning of the main campus DTU Lyngby Campus and the general values regarding campus development. The vision is that DTU´s campuses contribute to DTU value creation by being sustainable, integrating and at elite level. In the meaning that:

- A sustainable campus is resource-conscious, healthy and good for people and the environment. It ensures long-term freedom of action for DTU with the world goals for sustainability in mind.

- An integral campus connects professionals, people, universities and the surrounding community - internationally, nationally and locally.
- An elite-level campus attracts and inspires the best, and creates the best results for society by expanding unique research and learning facilities.

According to the national law of pupil and students learning environments (Undervisningsministeriet, 2017), all Danish universities are obliged to develop the study environments in dialogue with students and to evaluate the study environments at least every three years. However, at the universities there is a methodological flexibility in the focus and phrasing of questions. This is done at DTU by establishing the Board of Learning Environments to ensure a continuous debate about issues relating to the study environment and the more rare study environment surveys. This board is chaired by the dean of bachelor educations and has representatives of students, teachers, study administration and Campus Service. The board can suggest projects to improve the study environment but they do not administer a specific budget, as the university board controls the university investment plan.

DTU Campus Service benefit from the ongoing qualitative dialogue in the study board, and make use of this community to define interventions, plan implementation, and to check new performance of facilities and services. The qualitative dialogue is important for adding value management in DTU Campus Service activities, but the qualitative dialogue also has its limitations. This paper focuses on the quantitative feedback from the study environment survey, which provides feedback from many students about their experiences of the study environment at DTU.

This paper represents a new phase of a longitudinal research-in-practice relationship for almost 10 years. Previous research and information about DTU and the FM organisation Campus Service is available at www.dtu.dk and in the research papers (Nielsen et al, 2012), (Rasmussen et al, 2014) and (Eriksson et al, 2014) (Eriksson et al, 2015), and (Nenonen et al, 2016).

3 THE STUDY ENVIRONMENT SURVEY - METHODOLOGY

The methodology consists of a mixed quantitative and qualitative method conducted in a three-step process on a single case, Technical University of Denmark in 2018-19.

3.1 The Study environment survey

65 statements about the social, physical and aesthetic study environment were sent to 10.536 students at the Technical University of Denmark in spring 2018. This is the third study environment survey (in Danish: Studiemiljøundersøgelse (SMU), the first was conducted in 2013, and the second in 2015. The survey was sent as an electronic survey.

3,837 students (39%) out of the 10.535 students answered the survey in full. 276 students (3%) completed only parts of the survey. Table 1 provides information about the full responses and their representation of the 3 main educations in focus. There was a slight overrepresentation of students on the BSc in general engineering and a slight underrepresentation of the bachelor in engineering. This is considered as minor deviations at an acceptable level. The questions are formulated as positive statements and the students had to answer with a score from 1 (totally disagree) to 6 (totally agree) or “not relevant as I am not using it”. This implies a scale where 1 is the most negative 6 the most positive and the average (neutral) is 3.5. In the analysis 3.0-

3.9 is considered neutral, whereas higher than 3.9 is a good result and lower than 3 is a bad and unacceptable result.

The number of questions has changed slightly over time. Some of the original questions have been reformulated to stay relevant, and the list of questions has been expanded to reflect contemporary study environment debates. The 2018 survey included e.g. four questions addressing bullying and sexual harassment to provide data to document alignment with a non-tolerance policy. Appendix 1 provides all 65 statements/questions in the 2018 survey of which some are primary statements in the evaluation of the study environment and other statements are to provide information about the student or additional specific information if relevant.

Table 1: Responses by main educational direction and total student population (22.02.2018)

Education	Number of responses	Number of responses in %	Number of students	Number of Students in %
BSc in general engineering	1.355	35%	2.772	26%
MSc in general engineering	1.371	36%	3.967	38%
Bachelor of engineering	1.111	29%	3.796	36%
Total	3.837	100%	10.535	100%

3.2 The "Importance analysis"

The second step in the process was an investigation of the survey replies to identify the most important aspects to maintain or improve the general satisfaction of each student. This step is referred to as the "Importance analysis" (Clemmensen & Brockhoff, 2012). This was an additional process to determine if all statements had equal importance for student general satisfaction. A general satisfaction factor was defined by the study environment board as the average of the four key questions:

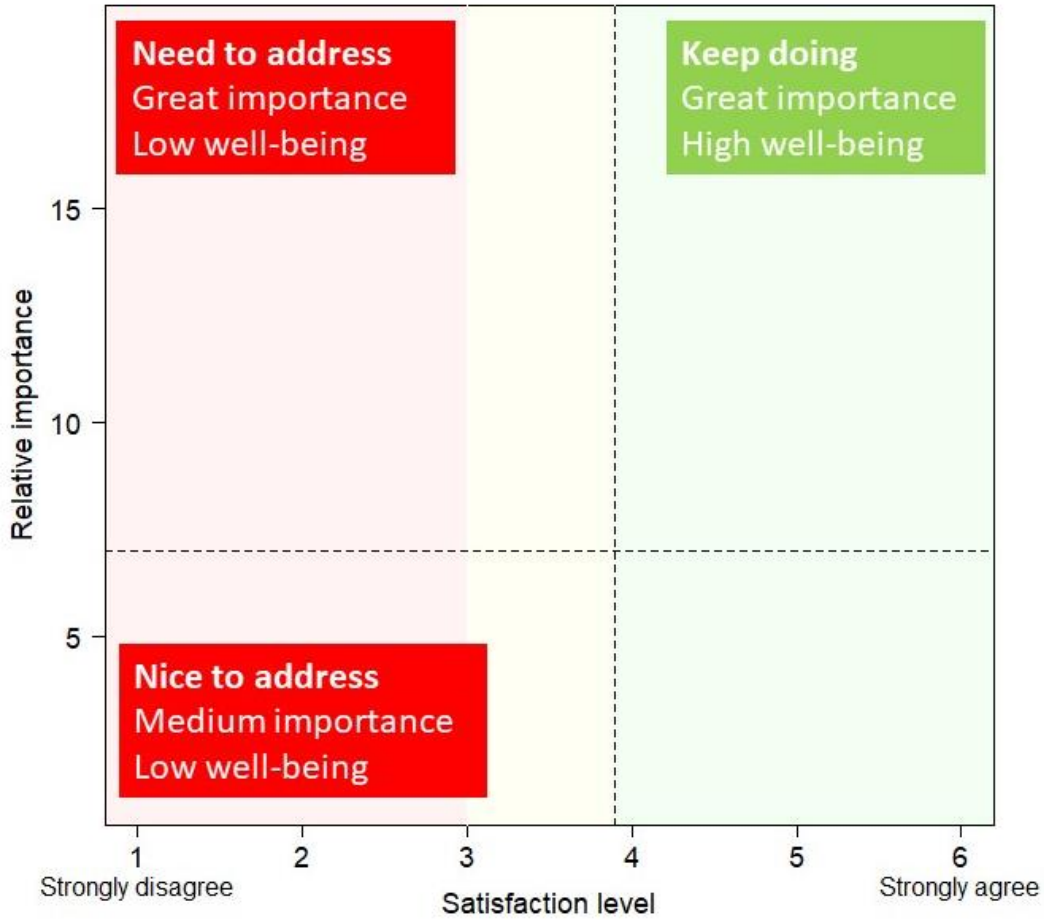
- I consider myself to be generally well informed regarding my studies (statement svg6)
- I generally feel at ease and comfortable at DTU (statement tot5)
- I am overall satisfied with the physical surroundings at DTU (statement lmc21)
- The atmosphere at DTU is generally good (statement amo1)

A regression analysis, Partial Last Squares Regression (PLS), is used on the survey data, to identify the relation between the general satisfaction and each of 47 primary statements, if the statement has high importance for the general satisfaction or no importance. Thus, the PLS regression coefficients of the 47 statements reflect the degree of importance of the statements in relation to the general satisfaction. The PLS was conducted for all students and repeated for various subgroups of students (study, gender, exchange student or not), to see if there were additional lessons to learn in regard of each particular group. As this paper focuses on the overall process, the only results presented here is the results from the PLS for all students. However, the analysis was conducted also for specific groups according to gender, campus, exchange student or not, and study lines.

The importance analysis is used to conclude a range of recommendations to keep or improve the study environment at DTU. The principle is illustrated in figure 2 and further detailed in

Clemmensen & Brockhoff (2012). Statements with high importance and high satisfaction (green: top right corner) should have high attention as well as statements with high importance and low satisfaction (red: top left corner) or statements with medium importance and low satisfaction (red: bottom left corner).

Figure 2: The principle of the importance analysis of student satisfaction survey 2018. The vertical axis shows the importance of a survey statement relative to general satisfaction. The horizontal axis shows the satisfaction level or agreement with statement. The red (left), yellow (in the middle) and green (right) regions are defined as low, medium and high satisfaction levels and the horizontal broken line denotes the average relative importance of statements.



3.3 The follow up action plan

Following the study environment report completed in June 2018, the third step in the process was the creation of a study environment investment-plan. Idea generation and prioritization was a six months long process, starting with generation of ideas in the board of study environment and collection of further ideas from within DTU CAS and across the university study environment community. The study environment coordinator facilitated this process, which led to a suggested investment plan which was finally approved by the university board in March 2019.

4 ANALYSIS AND FINDINGS

4.1 Student satisfaction with the learning environment

To all questions, the students answered that their satisfaction was higher than 3, which was defined as the lowest acceptable satisfaction level. Compared to the SMU2015 the SMU2018 shows a positive development of the general satisfaction with the social, physical and aesthetic study environment. See table 2 for the student satisfaction level regarding the 4 statements used for calculating the general satisfaction and the FM specific questions, 25 statements in total. The first column is the average and the second and third are the shares of respondents who gave a positive score (4-6) in 2018 and 2015. See (DTU, 2018) for a full report on the SMU 2018.

Table 2: Student satisfaction in the Study Environment Survey (SMU) 2018

compared to the previous SMU from 2015

General satisfaction	**SMU 2018 average**	**SMU 2018 (4-6)***	**SMU 2015 (4-6)***
I consider myself to be generally well informed regarding my studies	4,6	85%	82%
I generally feel at ease and comfortable at DTU	5,1	93%	91%
I am overall satisfied with the physical surroundings at DTU	5,0	93%	90%
The atmosphere at DTU is generally good	5,4	97%	96%
FM specific questions			
DTU's facilities generally appear neat and well-kept	5,1	95%	92%
DTU's outdoor areas generally appear neat and well-kept	5,3	98%	97%
DTU's outdoor areas invite both contemplation and active use	4,9	89%	86%
There is generally a good indoor climate in the classrooms	4,0	68%	64%
DTU's lecture halls are generally well-functioning	4,6	84%	76%
DTU's classrooms are generally well-functioning	4,7	85%	82%
DTU's databars (computer class rooms) are generally well-functioning	4,6	72%	71%
DTU's laboratories and workshops are generally well-functioning	4,6	72%	72%
DTU's informal learning environments are generally well-functioning	4,9	87%	83%
The lighting conditions in the classrooms are generally satisfactory	4,6	84%	80%
There are enough workspaces for students at DTU where I can work myself an undisturbed	4,3	61%	55%
There are enough workspaces for students at DTU where I can work with my group	4,3	72%	-
There is generally a good indoor climate in the classrooms	4,0	68%	64%

The lighting conditions in the classrooms are generally satisfactory	4,6	84%	80%
The classrooms have good acoustics	4,6	84%	80%
I am not bothered by noise	4,4	76%	73%
There is sufficient access to power outlets at campus	4,3	74%	70%
The interior design of S-huset and other bars is satisfactory (Student community house)	4,9	80%	86%
I am satisfied with the leisure activities offered at DTU	5,0	81%	81%
I am satisfied with the academic events offered at DTU (excl. lessons)	4,8	77%	75%
The facilities for sport and leisure activities at DTU are satisfactory	4,8	68%	69%
There are good bicycle parking conditions at DTU	5,1	77%	75%
Traffic safety is generally good at DTU	5,0	84%	-
The lavatories are hygienic and well-kept	4,5	79%	77%
It is easy finding your way around DTU	4,8	87%	84%

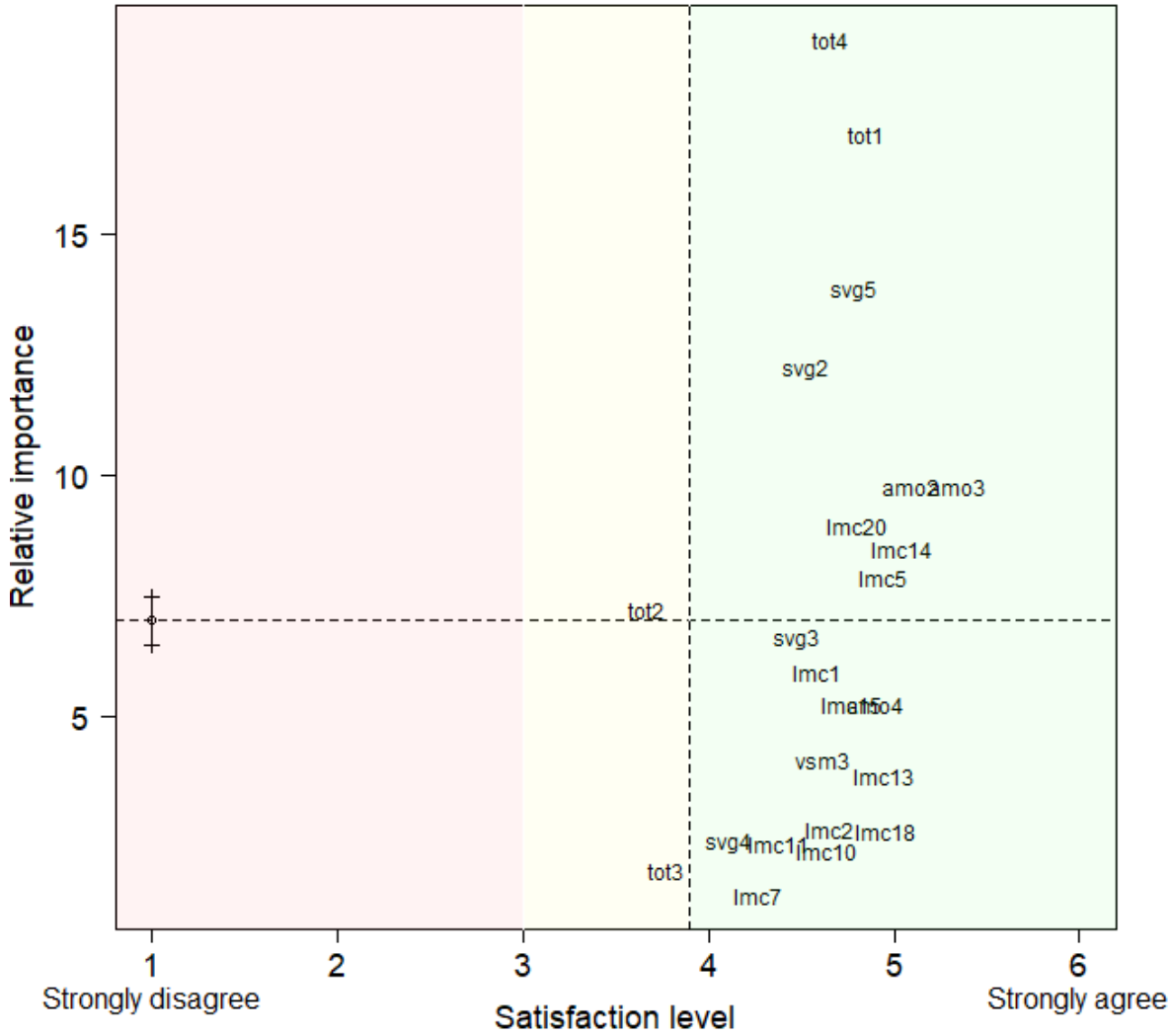
*** Share of respondents who gave a positive score (4-6)**

Despite the fact that the general satisfaction is good and improving, the university knows that the study environment needs ongoing attention. The wishes from students keep coming and DTU Campus service/DTU needs to prioritize limited financial and human resources. If they only prioritize the issues with the lowest relative importance score, they risk investing in facilities and services that are of minor importance to the students.

4.2 This matters the most

22 statements were identified as having significant importance for the general satisfaction. Figure 3 shows the PLS result of all statements that have a significant importance and exclude those that do not. In principle, this means that improving these statements by one satisfaction score increases the general satisfaction level more than improving non-significant statements. The strategy was to focus on issues with high positive impact, as strategic goals that should be maintained or further improved in the future, and negative impacts, which should have a strategic focus as these were issues with high impact and relatively low satisfaction.

Figure 3: Importance plot with 22 statements having significant importance for the general satisfaction.



Top 3 statements with high satisfaction and high importance *(Keep doing)*

1. tot4: I rarely feel lonely or isolated at DTU
2. tot1: I have good social relations with my fellow students
3. svg5: My teachers are available if I have questions or need guidance outside scheduled lessons

Statements with medium satisfaction (average 3-3,9) and medium importance *(Need to address)*

1. tot2: I rarely experience stress symptoms in connection with my study in everyday life, which makes me uncomfortable. Stress symptoms may include stomach ache, headache, anxiety, depression, palpitations, insomnia, difficulty concentrating, etc.
2. tot3: I have knowledge of ways to prevent stress

The 5 statements with high satisfaction and the least importance *(Nice to address)*

1. svg 4: It is easy to find the information that I need regarding leisure activities at DTU

2. lmc2: DTU’s classrooms are generally well-functioning
3. lmc10: The classrooms have good acoustics
4. lmc11: I am not bothered by noise
5. lmc18: Traffic safety is generally good at DTU

The importance analysis was done for the various student groups (gender, study line, exchange student or not, campus) to reveal eventual variations in satisfaction levels. This gave some indications for the focus points in the action plan to come.

The concluding result of the importance analysis identified the following 10 factors as the most important focus points in value adding management for the university as a whole.

For the students the most important is:

1. Absence of loneliness,
2. Good contact with fellow students,
3. Availability of lecturers also outside of normal teaching time,
4. Easy access to information about one's study lines and the courses followed,
5. Tidy and well-kept outdoor areas,
6. Tidy and well-kept premises,
7. Easy way finding,
8. Selection of social events,
9. Well-functioning informal learning environments and finally
10. Absence of stress symptoms in everyday life.

4.3 The follow up action plan

The agreed action plan is structured according to 6 themes and has 23 result goals each with 1-7 process and effort goals, 62 in total. See DTU (2019). The following is an extraction of the action plan with focus on actions where DTU Campus Service has the main responsibility for its realization.

The format of this paper unfortunately does not allow further specification of the planned CAS actions which includes a variation of activities including coordination activities, space management, strategic planning, helpdesk, construction management, end-user dialogue, sports facilities, bike parking, signage, green areas, evacuation plans and safety communication.

Table 3: CAS relevant result goals, Study environment Action plan 2019-2021 (DTU 2019)

The six themes	Result goal (CAS has main responsibility)
Safety and well-being	*No CAS specific goal*
Study guide and general information	*No CAS specific goal*
Learning environment and campus life	• DTU meets the need for study places for concentrated work alone or in groups. • There is a good indoor climate in DTU's teaching rooms • Noise reduction (during construction and renovation activities) • Sufficient power outlet supply on the Ballerup Campus • S-Huset, cafés and Friday bars appear as DTU's students want it • The facilities for sports and leisure activities at Ballerup Campus have a satisfactory level • Covered and locked bicycle parking is available for DTU students • It is easy to orientate and find your way around DTU • DTU's outdoor space supports an attractive learning environment and is comfortable to stay in
Security	• All employees and students know what to do in connection with an emergency or accident at DTU • All students are instructed in relevant safety conditions before work in laboratories and workshops begins
Virtual study environment	*No CAS specific goal*
Blue dot projects etc.	*No CAS specific goal*

5 DISCUSSION OF VALUE CREATION IN FM

The added-value management model suggested by (Jensen and van der Voordt 2016) and (van der Voordt et al 2016) recommend "Check processes" to ensure Changed FM/CREM performance (output) leading to changed organizational performance (outcome) in this case an improved study environment for DTU students. The study environment survey showed a generally high satisfaction with the current situation where as many as 93% gave a positive evaluation. The development since the previous survey was also satisfactory as there was a positive development for all value dimensions. For further improving the study environment the importance analysis was an important process. The "importance analysis" showed that some value dimensions were more important for students' general satisfaction than other and this information was used in the "Act process" where the several university stakeholders reflected on the result of the survey and the need for correcting actions.

Other universities and educational institutions can use the DTU survey as inspiration for their study environment evaluations as the survey contains value dimensions and statements that are relevant for similar learning environments. But the result of the importance analysis should be used with precautions. As the importance analysis reflects the current situation at DTU, and the matter of "high satisfaction and medium importance" like the classroom acoustics, could

have a higher importance, if the satisfaction was lower. The survey data and the importance analysis does not inform about a possibly critical satisfaction level. But in theory there could be a level, once reached, where the additional effort does not give added value.

Despite the focus of this paper being on the role of Campus Service there are many parties responsible for the quality of the study environment. The full action plan identifies as many as 18 various actors to be either main actor or supporting actor for specific actions. This demonstrates that collaboration and coordination is a significant task, when a university as DTU is taking an integrated approach to ensure formal and informal learning environments that support and promotes attendance and an active study environment at campus. The whole process which in the Value Adding Management model is illustrated as three steps, has in practice taken 1 year, from planning and conducting the survey in spring 2018, to the study environment report in June 2018 and the final action plan in March 2019. A long process that has encountered widespread dialogue, processes of idea generation, negotiations and reformulations before the final version was agreed on by the involved stakeholders and approved by the university board, the highest authority at the university.

6 CONCLUSION

The study environment survey provides feedback to the university and in particular to the Board of Study Environment and the FM organization about the students' experiences of the study environment at DTU. In general, the students evaluated the study environment to be a positive one as they gave a 4 or 5 on a scale on 1-6 where 6 is the best. This is in itself a major achievement, as the goal was to score a minimum of 3 in all questions.

As feedback on investments in the study environment made in the last few years, the evaluation shows that the study environment has improved since the last survey in 2015, but also that there are possibilities for further improvement. A new action plan for further improving the study environment at DTU was developed and decided in March 2019, consisting of 11 result goals with associated process and efforts goals.

As research in added value this is a case study that reveals what matters the most for DTU students and therefor pointing to what could give the most effective value creation in the future.

ACKNOWLEDGMENTS

We thank the Technical University of Denmark, Oslo Metropolitan University and NIRAS A/S for co-sponsoring this presentation of the study environment survey and its impact on FM at DTU.

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Appendix 1: Questions in the DTU study environment Survey 2018

Theme 1: Respondent and spatial context

A. Student identification code inform about: study line, gender, Danish student or exchange student.
B. Which campus do you study at during this semester? (Lyngby, Ballerup, Sisimiut)

Theme 2: General well-being:

tot1: I have good social relations with my fellow students
tot2: I rarely experience stress symptoms in connection with my study in everyday life, which makes me uncomfortable. Stress symptoms may include stomach ache, headache, anxiety, depression, palpitations, insomnia, difficulty concentrating, etc.
tot3: I have knowledge of ways to prevent stress
tot4: I rarely feel lonely or isolated at DTU
tot5: I generally feel at ease and comfortable at DTU

Additional four Specific questions not included in the regression analysis:

C. I am not exposed to bullying or harassment from other students
D. I am not exposed to bullying or harassment from teachers or other DTU staff
E. I have not been subjected to unpleasant sexual advances from other students
F. I have not been subjected to unpleasant sexual advances from my teachers or other DTU staff

Theme 3: Study guidance and general information

Svg1: The Study Guidance can help me with any questions I ask them
Svg2: It is easy to find the information that I need regarding my study programme and courses
Svg 3: It is easy to find the information that I need regarding examinations
Svg 4: It is easy to find the information that I need regarding leisure activities at DTU
Svg 5: My teachers are available if I have questions or need guidance outside scheduled lessons
Svg 6: I consider myself to be generally well informed regarding my studies

Theme 4: Learning environments and campus life

lmc1: DTU's lecture halls are generally well-functioning
lmc2: DTU's classrooms are generally well-functioning
lmc3: DTU's databars (computer class rooms) are generally well-functioning
lmc4: DTU's laboratories and workshops are generally well-functioning
lmc5: DTU's informal learning environments are generally well-functioning
lmc6: There are enough workspaces for students at DTU where I can work myself an undisturbed
lmc7: There are enough workspaces for students at DTU where I can work with my group
lmc8: There is generally a good indoor climate in the classrooms
lmc9: The lighting conditions in the classrooms are generally satisfactory
lmc10: The classrooms have good acoustics
lmc11: I am not bothered by noise
lmc12: There is sufficient access to power outlets at campus
lmc13: The interior design of S-huset and other bars is satisfactory (Student community house)
lmc14: I am satisfied with the leisure activities offered at DTU
lmc15: I am satisfied with the academic events offered at DTU (excl. lessons)
lmc16: The facilities for sport and leisure activities at DTU are satisfactory
lmc17:There are good bicycle parking conditions at DTU
lmc18: Traffic safety is generally good at DTU
lmc19: The lavatories are hygienic and well-kept
lmc20: It is easy finding your way around DTU
lmc21: I am overall satisfied with the physical surroundings at DTU

Theme 5: Atmosphere and surroundings

amo1: The atmosphere at DTU is generally good
amo2: DTU's facilities generally appear neat and well-kept
amo3: DTU's outdoor areas generally appear neat and well-kept

amo4: DTU's outdoor areas invite both contemplation and active use

Theme 6: Safety

sik1: I know what to do in case of accidents
sik2: Do you use laboratories or workshops as part of your study programme? If yes

a. I have learned to think through my experiments to understand where in can go wrong or become dangerous
b. I have received instructions in how to take precautionary measures to avoid accidents when I work with….
c. I find that there is a focus on safety in laboratories and workshops

Theme 7: Virtual study environment

vsm1: DTU's wireless network is satisfactory- both in regard to speed and coverage
vsm2: It is easy to find the information I need on DTU Inside
vsm3: The homepage of my study programme at dtu.dk is easily accessible and offers relevant information
vsm4: The databars' computers – including their software – work satisfactory and meet my requirements
vsm5: The virtual tools used in teaching situations work satisfactorily e.g. CodeJudge, PeerReview, PeerGrade etc,
vsm6: Lectures that are streamed to the internet work satisfactorily

Theme 8: Awareness of cross-study initiatives at DTU (not in regression analysis)

G. I am familiar with the following major project activities for students

a. DTU Roadrunners
b. DTU Robocop
c. DTU Solar Decathlon
d. DTU Ecotrophella
e. DTU Biobuilders
f. DTU SensUs

H. I am aware of the This-for-that foundations that funds student driven initiatives to improve the study environment at DTU
I. I am aware that it is possible to use workshop facilities and get feedback on ideas in DTU Skylab
J. Is your job study relevant? (if you do not have a job, please skip this question)
K. Are you active in a student organization?

Become an Outperformer! – Measurement of added value

Bernhold, Torben
Professor, FH Münster
bernhold@fh-muenster.de
+49 251 83 65453

Lellek, Vanessa
H & M Hennes & Mauritz B.V.& Co.KG
vanessa.lellek@hm.com

Schlicht, Christian
ECE Projektmanagement G.m.b.H. & Co. KG
christian.schlicht@ece.com

ABSTRACT

Purpose: The purpose is to describe how the measurement of the added value of Facility Management can be transfered into operational practice. Measuring the impact of facility management on core business is one of the key tasks for the future. In the past, CREM/FM was often understood as a pure cost collector and the actual work was reduced to cost minimization, but now the connection between core business activities and CREM/FM is the core of considerations. Based on the concept of the Tableau de Bord a tool is developed which is applicable to visualize the horizontal and vertical goal relationships in a company.

Methodology: The approach followed in the context of research is above all of qualitative nature. The instrument itself is essentially developed on the basis of a case study at ECE. Within the framework of a literature-based comparison of different instruments from different industries in the area of measuring added value, important impulses for the case study could be identified. In addition, a quantitative study was carried out on the basis of the theory of planned behaviour in order to be able to describe the connection between attitude towards the measurement of added value and the actual implementation/measurement in reality. This also provided important impetus for the future implementation of the added value measurement. The empiric research was done by students in the winter semester 2017/2018 with coaching of the authors.

Findings: The developed instrument represents a first approach to combine the core business objectives directly with the CREM/FM objectives. It must be taken into account that the overriding corporate goals in the horizontal structure of the organizational structure are also influenced by other corporate functions. This degree of influence continues with further target cascading at following corporate levels. As a result a multidimensional measuring and controlling instrument based on the Tableau de Bord is presented to integrate vertical and functional target levels into the assessment of generated, additional value of Facility Management to strategic corporate goals.

Paper Type: Case Study/Conceptual Paper

Keywords: Added Value, Strategy Operationalizsation, Value Creation, Performance Measurement

1 INTRODUCTION

The dynamic world forces companies to face divergent market challenges and to change old strategies into new ways of thinking and solutions. Facility Management companies need to adjust to increasing digitization, increasing sustainability requirements and the increasing competition for talented employees. To keep up with competitors and dynamic requirements of stakeholders, innovations have become a crucial success factor in the Facility Management market.

To meet the customers' needs, it is therefore important to have a "comprehensive management approach" which involves leasing, marketing, operational center and Facility Management as well as the commercial management of the technical assets and the real estate itself (ECE Market Report 2015). It is therefore crucial to steer Facility Management processes towards precise targets and to measure achieved goals and highlight added values to the complex product of a shopping center. Due to the different changes in the market and the impact on the involved parties, Facility Management needs to become a more strategic focal point in the future – as a management discipline that touches all the stakeholders and constitutes the interconnection in the value chain of real estates.

2 MEASURING ADDED VALUE IN FACILITY MANAGEMENT

2.1 The idea of added value in FM

In the meantime, different models for the description of an added value are available in the literature (Jensen et al., 2013, Jensen, 2012, Lindholm and Leväinen, 2006) and the nature of the benefits of a Facility Management (FM) department is widely described in the literature and has become increasingly important in recent years (Jensen, 2010, Jensen et al., 2013). The reason for this is that FM has so far been regarded only as a "Cost Collector", although the management discipline contributes significantly to core business' value creation and to the entrepreneurial competitive position by controlling secondary processes (Jensen et al., 2013). However, this contribution is not clear to many managing directors and companies. It is, therefore, important to highlight those benefits in quality and quantitative measures. And so this paper does not discuss the different perspectives or the different ways in which Facility Management can create added value to the core business; its aim is to develop an instrument, which can be combined with other structures and elements, like the FM-Value Map (Jensen, 2012).

One of the main problems is that it is unclear how to measure the benefits that come with professional and effective FM. The measurement of the benefits of a FM department has not yet been operationalized and stays mostly in conceptual a manner. It is essential that the FM targets are derived structurally from the corporate strategy and that the added value is clearly related to core business.

Initially added value can be described as a "trade-off between benefits and sacrifices" in connection to organisational objectives (added value)" (van der Vordt et al., 2016). But for the measurement of the theoretical construct of added value it is crucial to identify all relevant factors which lead to a specific added value.

2.2 Research approach

In order to gain deeper insights of added value, the methodological approach was based on a combination of qualitative and quantitative methods, whereby this paper focuses primarily on the results from the first-mentioned design. A literature review as suggested by BECKER (Becker, 2012) addresses the research question, if concepts, models and/or methods are available in CREM/FM and other domains, which are suitable to measure the added value or the impact of an action.

Table 1: Characteristics and focus of the literature review; colored background = study focus

Attribute	**Characteristic**			
Focus	Results	Methods	Theories	Application
Target/Aim	Criticise	Integration (Generalization)		Challenges
Perspective	Taking an position		Neutral representation	
Coverage	Complete	Completely selective	Representative	Central
Organisation	Historic	Conceptual		methodical
Target group	Professionals	Researcher	Practitioner	Public

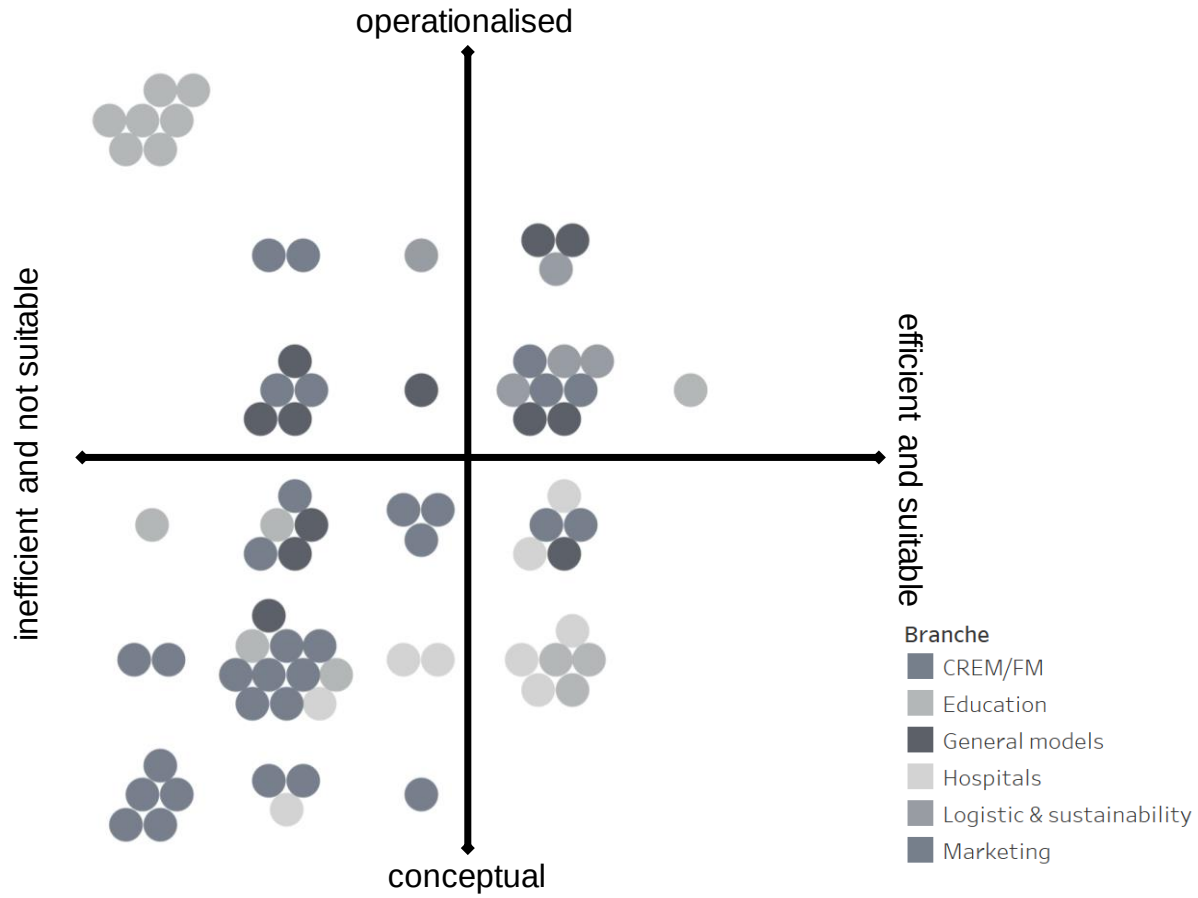
It showed that there is still no common definition for added value or rather different perspectives, neither within the different sectors considered in the literature analysis (sustainability, hospitals, logistics, etc.), nor in FM; this aspect was also stated by JENSEN (Jensen et al., 2012). Even more, most tools are measuring the performance of CREM/FM (output) in a functional perspective without the linkage to the original organizational performance (van der Vordt et al., 2016). Also, the literature review showed that many added value approaches in FM are limited to conceptual models which barely take key figures, key performance indicators (KPIs) or benchmarks into consideration. The practical use of those concepts and the assessment of achieved added value is therefore limited and hardly to handle in business context.

Within the literature analysis more than 65 sources brought up 72 different added value models/approaches from various industries. These models were classified and clustered using the following criteria, illustrated in Table 2.

Table 2 Model rating criteria in context of the literature review

Criteria	**Characteristic**	**Model Rating**
Operationali-zability	In what form does the model already integrate key figures?	from 1 = no key figures and specific context for measuring the added value in an organizational perspective to 6 = integrated key figures and linkage to the key figures on the organizational level
Efficiency	In what form does the model integrate measures at an organizational level?	from 1 = description only at the level of cause and effect to 6 = models with a focus on measuring the “added” value in an outcome orientated perspective

Figure 1 Result of the model clustering



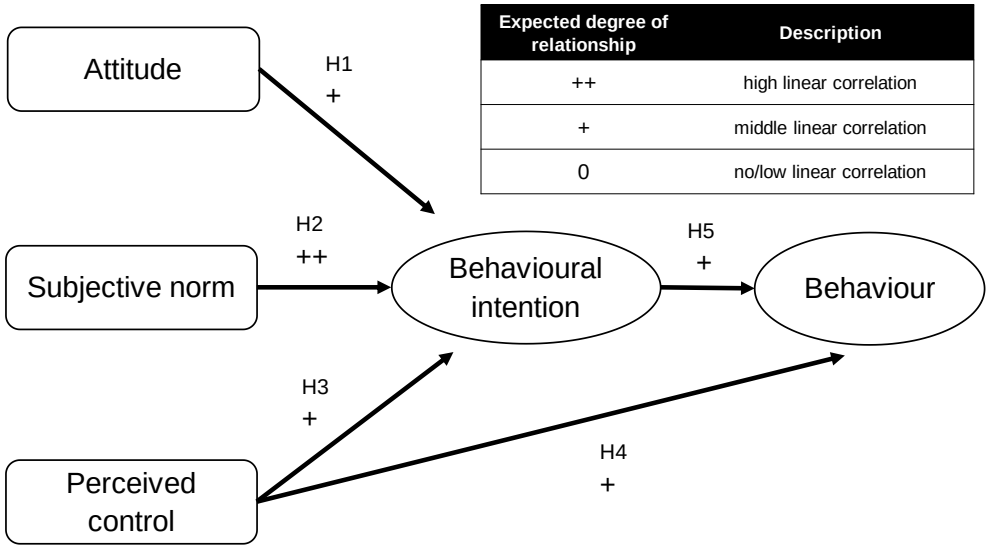
This paper considers added value in a broader view of goal fulfillment, that means it is not only about meeting targets, but over-fulfillment and outperformance of processes, business ideas or departments goals. The EU pointed out, that on "a general level, […] added value is the value resulting from an EU intervention which is additional to the value that would have been otherwise created by Member State action alone." (European Commission, 2011).

As a second part of research, a quantitative study - based on the theory of planned behavior (Ajzen and Madden, 1986) – had the mission to describe the relationship between attitudes and behavior with regard to the measurement of added value of Facility Management. The model from AJZEN and MADEN is particularly determined by a concrete behavioral intention, which itself is influenced by three variables: the attitude, the subjective norm and the perceived control (Ajzen, 1991, Kanning et al., 2008). In a first part, the aggregated hypotheses were derived from the general underlying theory (Table 3) to visualize the estimated impacts and relationships (Figure 2):

Table 3: Use hypotheses on a general level

Dimension (Factor)	No.	(aggregate) hypotheses
Attitude	H1	The more positive the employees' own attitude towards measuring added value in CREM/FM, the stronger their intention to measure it (act on it)
Subjective norm	H2	The greater the perceived social pressure to measure added value, the stronger the behavioral intention to measure it (to act)
Perceived control	H3	The higher the perceived control, the stronger the behavioral intention to measure it (to act)
Perceived control	H4	The higher the perceived control, the more likely the behavior to implement a measurement of added value
Behavioural intention	H5	The stronger the behavioral intention to measure added value, the more likely it is to be implemented

Figure 2: Results for measuring the added value (Bernhold et al., 2018)



The third used approach in the methodological research set was the case study approach. The core task of the case study (Yin, 2003, Mayring, 2002, Woodside and Wilson, 2003) was to develop a measuring approach including a prototype. On a general level, added value can be seen as any overfulfillment of the objective set by the company (i.e. the overfulfillment of objectives which should have been achieved even without special measures). The case study research involves a single case approach with embedded units at ECE; ECE is a shopping center specialist and one of the biggest asset managers in Germany with 20 Billion EUR assets under management. It was assumed that the added value of the CREM/FM would be generated by the involvement of different company functions. The added value is thus to be regarded as a key indicator of target achievement (or overachievement) and thus a cross-functional result. The embedded units are shaped through the Asset, Leasing and Center Management as well as through the Facility Management of a center/shopping mall.

The advantage of this case study approach lies in the acquisition of intensive and strategic insights into the development of objectives on the one hand and the comparison of objectives between functional areas on the other. The problem-centered interview was used as the data collection method and all interviews were recorded (Mayring, 2002; Hussy, 2013). The catalogue of key questions was divided into different categories:

1. General understanding of the term “added value”

2. Objectives/defines (e.g. real estate strategy, objectives)

3. Integrated stakeholders/shareholders

4. Added value (e.g. indicators, percentage equity share of result, possibility of influencing)

5. Sanctions (expected sanctions in case of target failure)

The recorded interviews were prepared in summary protocols; the individual statements were assigned to the individual aforementioned categories for evaluation purposes. According to the communicative validation (Mayring, 2002), the prepared protocols were made available to the interview partners again. One of the main case study results were the different KPI´s on the task level of a shopping center, which act as valuation surrogates in the measuring process.

3. MEASURING ADDED VALUE IN FACILITY MANAGEMENT

3.1 Conceptualization of an added value Measuring tool for CREM/FM

In general, the added value is a complex hypothetic construct (Homburg and Giering, 1996) which can not be observed directly. In this context, the conceptualization will include the development of constructional dimensions and the development of a measurement instruments as a model operationalization (Homburg and Giering, 1996). From this perspective, the added value at the strategic level can be multi-sighted and multi-dimensional; LINDHOLM and LEVÄINEN (Lindholm and Leväinen, 2006) for example, offer an initial starting point at the real estate strategy level.

Based on a descriptive analysis of the essential and relevant models from the literature analysis, the Balanced Scorecard (Kaplan and Norton, 1992, Kaplan and Norton, 2001), the Tableau de Bord (Bourguignona et al., 2004, Daum, 2005) and the FM Value Map (Jensen, 2012, Jensen and Katchchamart, 2012, van der Vordt et al., 2016) can be understood as adaptable models. The Tableau de Bord is particularly suitable as a model, since it combines the strategic perspective with the operative implementation and is also able to map a hierarchical structure. The Balanced Scorecard is very suitable for the mapping and visualization on an aggregated corporate level and the FM value map is especially suitable for the systematization of measures and the measurement of the results. One topic of the case study was to develop a tool, which is able to combine the strategic corporate level with the operational level and which is suitable for differentiating the degree of goal attainment in a cross-functional (horizontal between functions at the same corporate level) and hierarchical perspective (vertical within one function). The Tableau de Bord is a very practical and valuable instrument, because it gives the user a quick insight into actions and their status at different level (Bourguignona et al., 2004). Due to the lack of predefined categories - as given at the BSC - a consistent derivation of the CREM/FM strategy from the corporate strategy appears essential.

With consideration of the multidimensionality, the model was conceptualized through the following level:

Table 4 Hierarchy model level

Level	Main topics and description
Corporate Level	Description and derivation of the overarching corporate objectives (e.g. customer satisfaction) [possibility to use the target elements, e.g. of (Lindholm and Leväinen, 2006; (Jensen and van der Voordt, 2016)]
Functional Level	Description of the share of each corporate function (e.g. CREM/FM or Logistics) in this goal; in total the result over all corporate functions must be 100%
CREM-FM-Level	Description of the share of each CREM/FM department (e.g. Asset Management or Building and management) in this goal; in total the result over all CREM/FM-functions must be 100%
Task Level (Indicators)	Definition of the KPIs used to determine whether or not the objectives have been met

The framework assumes - in accordance to the Tableau de Bord - a cascaded development in a top-down manner and begins therefore with the corporate level. From this point, the KPIs at the task level are only an operationalized reflection from the company strategy on the top level and furthermore, the KPI is more like a surrogate, which combines the observable real world with the conceptual added value model.

2.2 Operationalization of an added value Measuring tool for CREM/FM

After conceptualization, one of the main tasks of the case study was the operationalization of the model and its practical application. The indicators at the Task Level (see table 5; result of the case study) act as Key Performance Indicators (KPI). Each KPI is weighted with regard to their meaning from 1 to 10 (1 = very low importance; 10 = very high importance) and the weighting is carried out in accordance to the Analytic Hierarchy Process (Saaty, 1986). Every KPI has a target and an actual level; table 5 give an overview over the calculation process as an example of the Asset Management Department of the case study.

Table 5 Measuring of goal achievement with Track Record

No.	Indicator	Unit	Target value	Actual value	Track Record (goal)	relative weigh-ting	Weigh-ting within the depart-ment	Track Record (weigh-ted)	Rating
1	Return	%	3	4	1,333	8	25,00%	0,333	Outperformer
2	Amount of rent	EUR/ sqm	6	6	1,000	4	12,50%	0,125	goal achieved
3	Ancillary costs	%	2	2,3	1,150	8	25,00%	0,288	Outperformer
4	Influenceability of ancillary costs	%	50	49	0,980	2	6,25%	0,061	Underperformer
5	Reliability of budget planning	%	95	100	1,053	5	15,63%	0,164	Outperformer
6	Real Estate value	EUR	100000	90000	0,900	5	15,63%	0,141	Underperformer
n									
In total	/		/	/	/		**100,00%**	**1,112**	/

The interdependencies of the numerous identified KPIs related to the management of shopping centers are highly complex. Therefore, we include the Track Record principle to assort the indicators by paying in on destined targets. The Track Record can be seen as a success indicator and will be calculated for every department and every function itself; its characteristic expressions can be described as follows.

Table 6 General characteristic of the Track Record

Value of Track Record	Degree of success
TR > 1	The set targets are exceeded (Outperformer)
TR = 1	The set targets are achieved
TR < 1	The set targets are not achieved (Underperformer)

From a mathematical perspective, the TR can be described as follows

$$TR_{jk} = B_k \times \frac{\alpha_j}{\sum_{i=1}^{n} \alpha_i} \times \frac{Output_j}{Input_j}$$

Equation 1 Measuring the added value[1]

[1] A big thanks in this description goes to Prof. Dr. habil. Michael May.

with:

$Output_j$ = actual value of a KPI_j

$Input_j$ = target value of a KPI_j

α_j = relative weighting of a KPI_j (in accordance to the other weightings)

B_k = endogenous influence factor of department k

n = Total number of KPIs considered

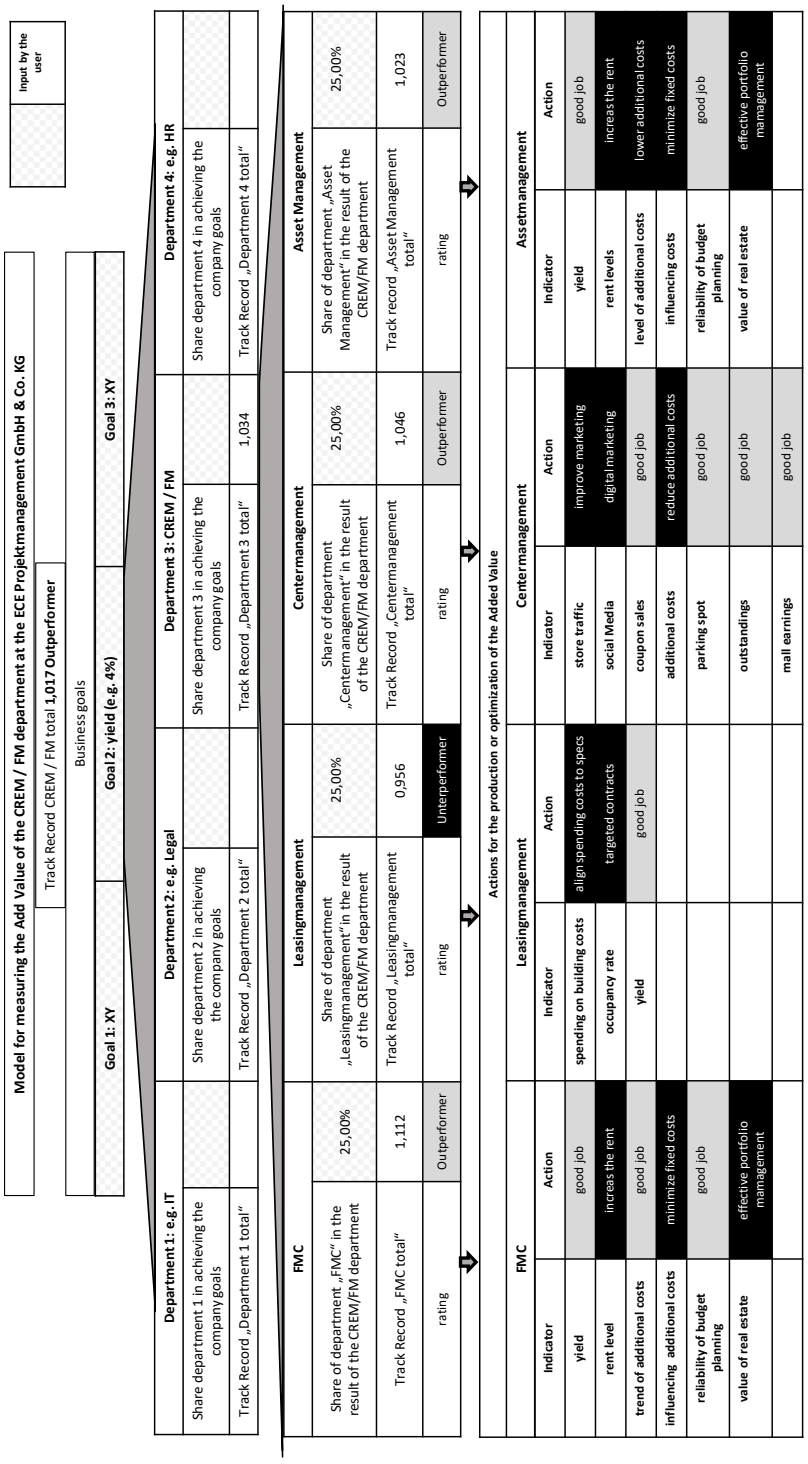
TR_{jk} = weighted Track Record for KPI j of department k

Using the model, it should be possible to measure how much one factor affects the other and what impact this has on the return - for example, how customer satisfaction contributes to the level of return through other factors. The weighted values within the model should make it possible to measure the actual given share that FM contributes to the return.

Bearing in mind, that the Tableau de Bord is a suitable decision support tool to assess and operationalize added value in an efficient way, we complement this model with the idea to

create a holistic overview ensure a cause-and-effect understanding, translate a company vision and strategic objectives to operational company levels in a top-down manner,create a generic overview of added values at an aggregation level that enhances fast steering and decision adjustments.

Figure 3 Example of the Track Record model for measuring the added value of FM at ECE



The model focuses on specific department goals that were derived directly from the corporate strategy as shown in figure 3. This means that every department has its own value creation target to contribute to the company's overall goal. Targets related to the KPIs may be adjusted dynamically by the company. Resulting from the combination of input, output and weighted assessment factors of the KPIs, the Track Record for each department and the associated targets is calculated. The sum of the Track Records of FM related departments (Center Management, Asset Management and Leasing Management as well as Facility Management) results as an entire Track Record of the overall FM efforts.

The results of the calculation are displayed in the model based on three categories. If the Track Record calculation for a target results in a value smaller than 1, the target for the corresponding indicator has not been reached and the department is classified as “underperformer”. If the Track Record result is exactly 1, the respective target was reached on point; the result is classified as “goal achieved”. Whilst, Track Record values higher than 1, are highlighted as “outperformer“.

Of course, categories for Track Record values may be modified for different business cases easily. As the Track Record model for added value is a comprehensive model for the use in different departments and various business units it supports a management display using the simplification of a KPI dashboard.

5 CONCLUSION

Summing up the results from the research case it is important to have a clear understanding of goals, outperformance and what added value in FM is about. With regard to this the preliminary literature analysis showed clearly, that there is no common understanding of added value in FM, although a widely accepted definition is the essential basis for any comparable and reliable measurement. This goes along with the necessity of visible company goals to departments and adding value stakeholders. The real estate strategy has to be clearly specified and operationalized to all departments in a top-down manner. This can be ensured easily be connecting CREM and FM figures with KPIs from core business activities. But simply the connection of KPIs is not sufficient enough: communication needs to be operated additionally, which means that the top management needs to be involved within the development of the real estate strategy and the identification of influencing performance factors between function departments. For a broader acceptance of using the Track Record model to identify the added value of all participants, it is also useful to make success visible to employees, managers and further stakeholders by using visual presentation forms like the dashboard and data driven calculations. The presented model is therefore both: an assessment tool for the measurement of added value, but also a communication instrument for all participants in adding value to core business.

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Towards an automated dynamic benchmark reporting

Alexander Bombeck
Karlsruhe Institute of Technology, Department of Civil Engineering, Geo and Environmental Sciences
alexander.bombeck@kit.edu

Kai Streiling
Karlsruhe Institute of Technology, Department of Civil Engineering, Geo and Environmental Sciences
kai.streiling@student.kit.edu

Kunibert Lennerts
Karlsruhe Institute of Technology, Department of Civil Engineering, Geo and Environmental Sciences
kunibert.lennerts@kit.edu

ABSTRACT

Purpose: This paper discusses and evaluates an automated benchmarking reporting system. We argue for a high degree of automation in the process and explain and illustrate the current solution. Furthermore, we deduct best-practice principles and discuss the advantages of their implementation.

Methodology: Starting in 2016 our methodology of conducting the benchmarks has been changed from scratch. Up until then each benchmarking-round had been conducted as a once only project; data acquisition, data manipulation and reporting were done in a static document structure using prevalent office software. This led to a high share of repetitive tasks, inconsistent data structures, graphics and bad over-time comparability.

Based on our overreaching strategic goals, such as reducing error-prone repetitive tasks, possibilities to automate parts of the benchmarking process and achieve higher reproducibility of results were evaluated. The migration of data manipulation and reporting processes to an R script (R Core Team 2017) using the package knitr (Xie 2014) were chosen. This reduced the repetitive overload, allowed for consistent, vector graphics, L^AT_EX typesetting and it rendered the number of participants irrelevant. Then, in 2017 data management was restructured. For historical reasons the questionnaires and data tables had been optimised for being processed as printouts. This approach hindered the data transfer and the adaptability to new questions. For that reason, the long table format was introduced. Although this step resembled a trade-off with human readability, it reduced the workload of data processing immensely and set the groundwork for data base normalisation. The latest improvements include the replacement of L^AT_EX with RMarkdown (Allaire et al. 2018) enabling multiple reporting formats, such as HTML presentations, without further changes to the script. Currently the focus lies on supporting our benchmarking participants with a more flexible way of data input and management via a web interface. This especially strengthens the communication of results and simplifies the flow of information.

Findings: Benchmarking consists of a high share of repetitive tasks that should be automated to reach positive scale effects. The design of questionnaires, data bases and data manipulating code must be congruent for dynamic automation. Utilising the scalability effects of automated reporting the number of benchmarking participants is no longer a limiting factor and once designed processes can easily be deployed to other fields of interest.

Intended impact of the study on either research, education or practice: Automated reporting can be designed to be flexible and adaptive. Presentations and reports can be created from the same source files without additional effort. Quality, robustness and efficiency of data flow and communication can be enhanced and reproduced following this paper's design. Multiple best practices for benchmarking in FM could be identified. These relate not only to data acquisition and processing, but also to communication structures and information design to enhance the benefit for our participants. We present and explain a modular code-structure using templates that can be re-used in each report-script reducing maintenance and enhancing scalability.

Paper type: Viewpoint paper

Keywords: Benchmarking, reporting, automation, scalability, data science

1 INTRODUCTION

Information is crucial to business decisions. But, in certain areas of business information is hard to come by. Construction and facility services are trades known for their lack of market transparency, with prices and qualities not only unknown but also widely varying according to time, location and service provider (Madritsch 2009). Required qualifications, the maturity of the market, differing service levels and many other factors reduce the amount and quality of information available.

Benchmarking is a powerful tool to overcome these opacities. By comparing information that is usually viewed as a company secret in a peer group an organisation can make out own inefficiencies and general best practices in order to achieve better performance (Voss et al. 1997). A common issue is the lack of knowledge of negotiated prices others pay. If there are only few service providers to choose from, prices might be overstated in tenders. A readily available price benchmark might reduce the cost to purchasers dramatically.

However, benchmarking is a task with a high organisational and repetitive overhead. Therefore, manpower and time are the prevailing limiting factors (Anand and Kodali 2008; Kevin Vaziri 1993). This is especially true for benchmarking rounds with ever changing questions and is further enhanced when using static document structures[2], e.g. a reporting system that relies on copy-pasting of results from one program to another.

This paper discusses the concept of automated benchmarking designed for the "OPIK – Offene Benchmarking-Runde", a semi-annual working group of technical directors in public hospitals in Germany, Switzerland, Austria and Luxembourg. Following this concept, a repeating benchmark can be conducted with less man power and time. Below benchmarking participants will be refer to only as "participants", while the service-provider in charge of conducting the benchmark will be referred to only as "provider".

[2] In contrast to dynamic documents static documents only contain text and not program code. They do not adapt to changes in the underlying data.

2 BENCHMARKING AS AN AUTOMATED SERVICE

According to Anand and Kodali (2008) the most widely used model for benchmarking is the 10 step Xerox model (Zairi and Leonard 1994) which was described by Camp (1989). While some stages may require individual decisions for each benchmarking round, such as the subject or data source selection, most are in some way repetitive and provide opportunities for simplification and automation as shown in *Table 1*.

Table 1: The 10 stages of Xerox benchmarking model (Anand and Kodali 2008)

Stage	**Involvement by provider**	**Repetitive**	**Typical Challenges**
1. Identify benchmarking subject	X	(X)	- evaluation of relevance
2. Identify partners	X	X	- contact and communication
3. Determine data collection method and collect data	X	X	- data management - security of data transmission - inconsistent data across partners
4. Determine current competitive gap	(X)	(X)	- metric selection and visualisation
5. Project future performance	(X)	(X)	
6. Communicate findings	X	X	- visualisation
7. Establish functional goals			
8. Develop action plans			
9. Implement plans and monitor progress	(X)	(X)	
10. Recalibrate the benchmark	X		- feedback channels back to provider

The two main factors that enable this automation are a closed set of potential partners with a standardised communication structure and a set of standard visualisation and metric templates.

The set of partners is predetermined by the sector this benchmark is operating in, i.e. public German hospitals, and the pool of participants. The provider can define a standard benchmarking process and a standard data collection method reducing repetitive overhead. It also operates as the central communication broker. Thus, stages two and three can be simplified and automated.

The set of communication and visualisation instruments enables automation of tasks six and in part four and five. The standard templates defined here can be applied to the specific subject. Templates can be graphs as well as metrics and they make up the core idea of the concept of automated benchmarking.

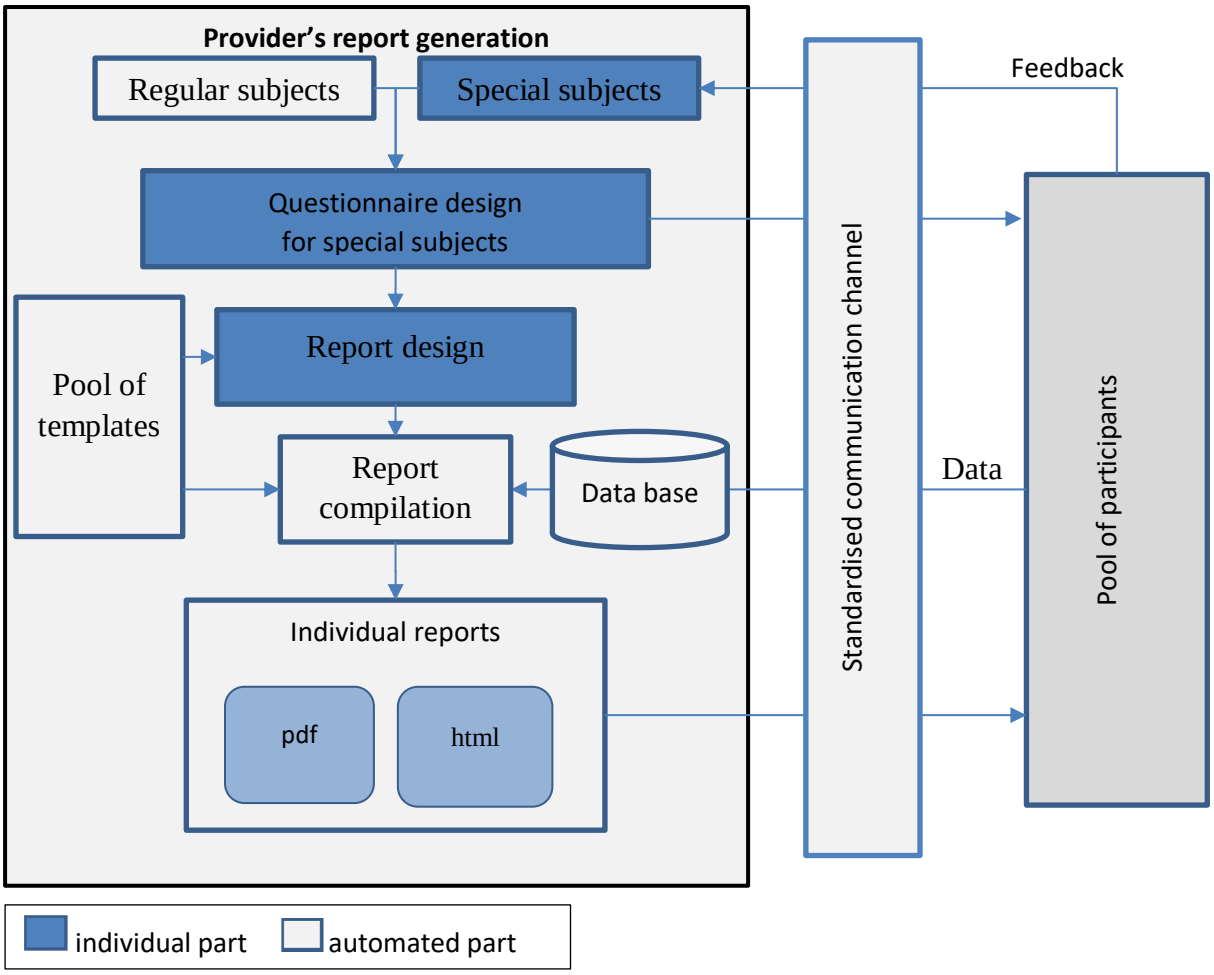
Stage one, although requiring attention in every new benchmark, can also be automated partly. In repetitive benchmarking rounds it makes sense to continuously survey basic characteristics or processes. First, this helps tracking the development over time, which can be of interest, e.g. in an energy benchmark. Second, it can help to characterise participants and put them into relation in each round, e.g. when benchmarking the surface area.

3 DESIGN PRINCIPLES

3.1 Dynamic and automated benchmarking reporting

The basic idea of the presented approach is to do things in a way they only need to be done once. As shown in *Figure 1*, our dynamic benchmarking reporting process consists of several steps: subject definition, questionnaire design, report design, report compilation and report distribution. Beginning with the objective – to generate reproducible, consistent, high quality statistical reports for numerous participants – this process can be automated using the following ideas.

Figure 1: dynamic benchmarking reporting process



Usually, statistical reports are generated in several steps: Calculations and graphics are first processed in statistical software and then selected pieces are copy-pasted into a typesetting program. This is an error-prone, tedious and non-reproducible process. Xie therefore argues for the usage of dynamic documents, reports which are generated from a "combination of code and the corresponding narratives" (Xie 2014). Xie also authored the R package knitr, that enables the employment of this approach with R (R Core Team 2017) or other programming languages and various document formats, such as LaTeX, HTML and Markdown.

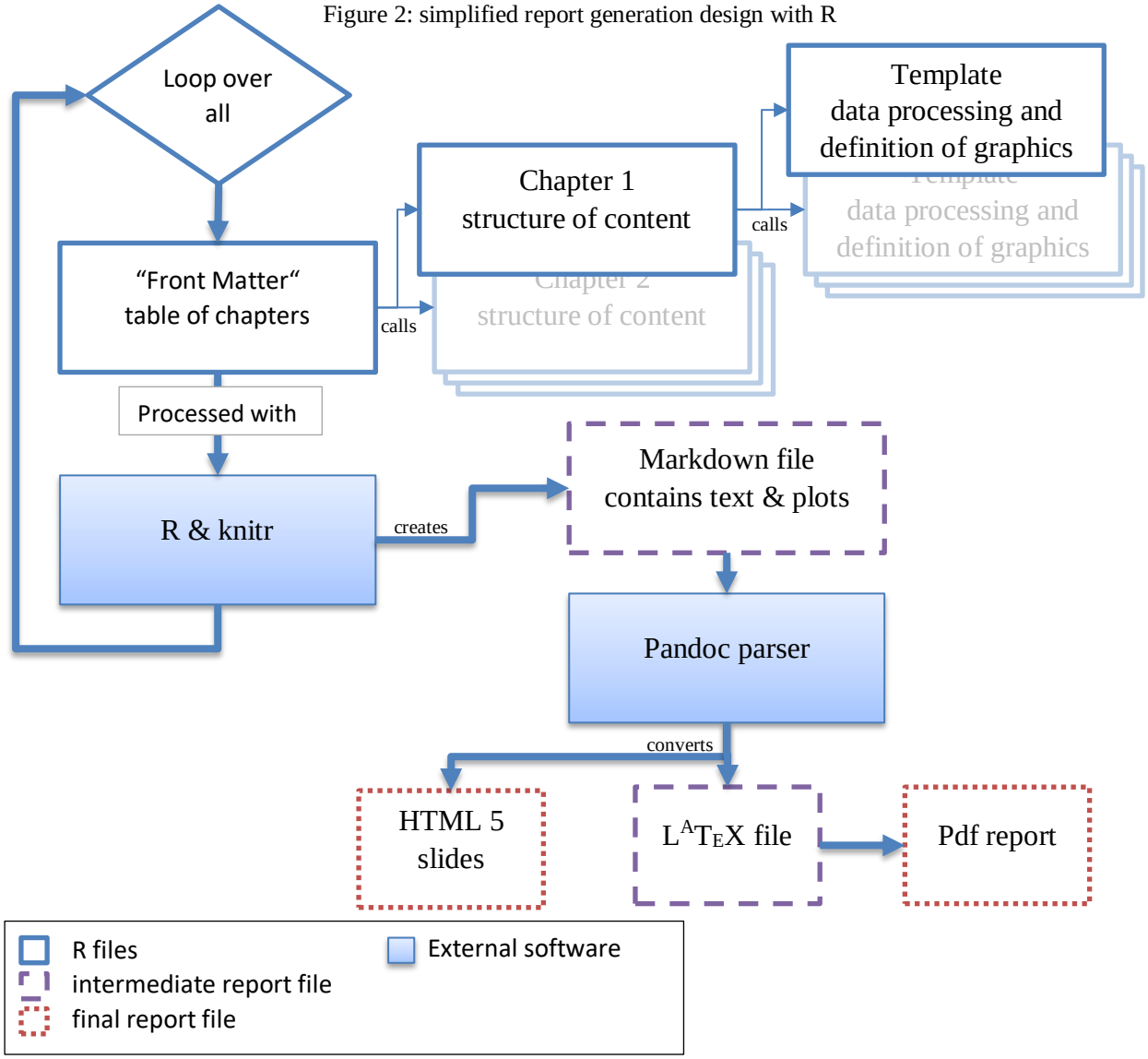
Applying the idea of dynamic documents, there is no difference between a benchmarking report and any other statistical report. All calculations, graphs and accompanying narratives can be defined in the same source files. Thus, a full report can be automatically generated only depending on the input data.

To generate individual reports, which highlight the addressee's position in graphs and tables, a loop that iterates through the whole process for each participant is implemented. The code then is structured according to the report's organisation following in part the idea of literate programming (Xie 2014). A simplified structure diagram of the approach used is presented in *Figure 2*.

A *"front matter" file* works as the table of content by calling a separate *chapter file* for each inquired subject in the benchmark. A chapter file then structures the content of a chapter and visualises the questions and data of the subject by using different *templates*. While the front matter file and the chapter files need to be adapted for each new benchmarking round, the templates, which carry most information about analysis and graphical representation of the data and make up most of the code, are report independent and can be reused when fitting. Which template to choose, is determined by the underlying data. E.g. numeric values may be more fitting for boxplots, while ordinal data or unstructured data must be visualised using bar charts or pie charts.

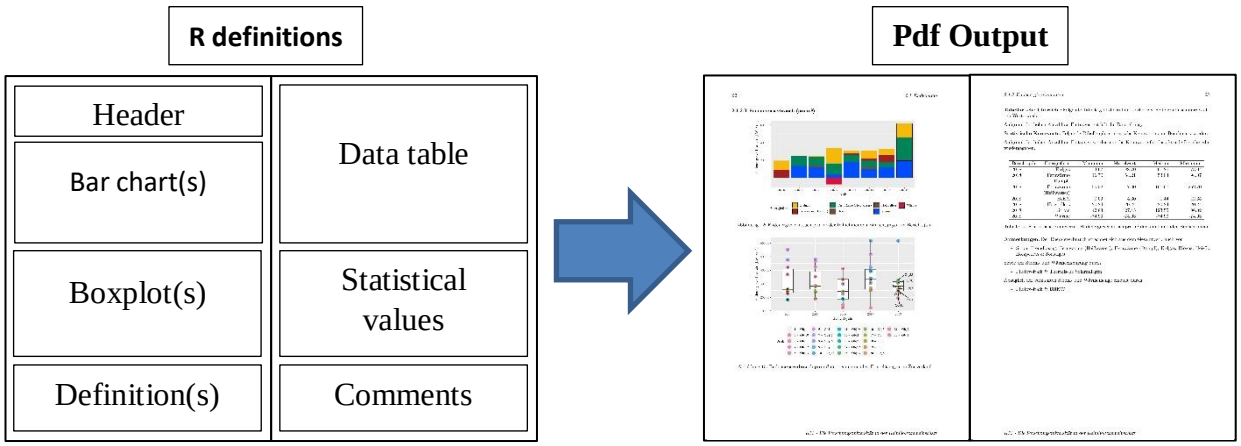
The code is compiled with R and knitr into a Markdown (.md) file which then can be converted into other formats such as HTML5 or PDF with the pandoc documents parser.

Figure 2: simplified report generation design with R



The template design is a crucial factor for the success of report automation. A template generally performs two tasks: processing and analysing the data it is given and visualising the results with plots and tables. For best compatibility and automatic pagination each template defines either a whole single or double page of the report as shown in *Figure 3*.

Figure 3: example of template design



Using a template design for benchmark reporting comes with advantages not only for the provider but also for the reader. Because templates create the same structure for different data, they also add familiarity and increase the recognition factor helping the reader to grasp quicker what is presented. Moreover, they enable standardised colouring, which additionally eases readability.

Visualisation should consider not only the presentation of data itself, but also of meta data such as questions, definitions or comments. The key to properly including meta information in a standardised manner is a suited database as described in the following subsection.

3.2 Database structure

As data is the most fundamental component of all benchmarking, its storage and structure deserve special attention. For a more flexible interaction and easier automated processing the long table format inspired by the idea of tidy data (Wickham and Grolemund 2017) was introduced in this benchmarking. The main idea is to identify each entry uniquely with a given variable name. In this case the identifier or key attributes for each entry is extended by the organisation's or participant's name, the year of the report and the section or subject the datum refers to as shown in *Table 2*.

Table 2 Database example

Organisation	Year	Section	Subsection	Variable	Definition	Value	Comment
Org. 1	2018	Energy	Electricity	External procurement	Total amount of electricity supplied by third parties [kWh]	55510632	Referring to CNS

The format corresponds to Codd's first normal form of data bases and not the third normal form as proposed by (Wickham and Grolemund 2017). It does not satisfy the requirements for the second normal form: not all non-key attributes are dependent on the whole compound key

{Organisation, Year, Section, Subsection, Variable}. E.g. the column “Definition” depends only on {Section, Subsection, Variable}. This is a consequence of the approach to apply the same format in both questionnaires and data base which comes with several advantages:

- Data transfer from questionnaire to data base is as easy as copy and paste making it perfect for automation.
- The chosen table format is perfectly compatible with standard data bases like MySQL, SQL or Oracle, which can be used without further adaption.
- Each entry contains all meta data about the value needed for its interpretation and presentation. This enables an automated explanation and annotation of evaluations. Especially the columns ‘definition’ and ‘comment’ improve readability and immersion for the participants.

However, designing questionnaires in a long table format slightly downgraded the readability for the participants in comparison to formerly used questionnaires which put more focus on easy human processability.

3.3 Limits to automation

When defining the subjects of a benchmark one can distinguish between regular subjects conducted repeatedly and special subjects motivated by economic or technical trends or feedback from the participants (*cf. Figure 1*). Examples for special subjects are service outsourcing or digitalisation and automation. These topics require individual attention in each round and, furthermore, need sector specific know-how in order to thoroughly attend to them from all relevant perspectives in the questionnaire.

The main task here is to define questions that balance the requirements of clarity, granularity and data availability. The key questions, “What is needed?” and, “What is available?” must be answered for, first, the type of data that is inquired and, second, the level of detail. While designing the questionnaire for an automated report one needs to bear in mind that data acquisition for the participants is still a manual task, and as such the main limiting factor for the extent of a benchmark. The manual overhead for the participants often results from heterogenous data sources grown over time, which make it difficult to guarantee a certain detail level or even the presence of data.

The second step that requires individual processing is the design of the report. However, this process is highly simplified by applying a pool of visualisation and computation templates. By reusing data processing functions, metrics, figures and graphs as building blocks a report covering the specific subjects can easily be assembled. Additionally, such template-based code can easily be maintained, because it makes overreaching changes feasible by adapting only one file.

Unarguably, the initial setup of these templates comes with a higher workload than computing one benchmark manually. However, facing repeating benchmarking rounds, individual reports and a great number of participants this initial time and work investment has a rather short period of amortisation.

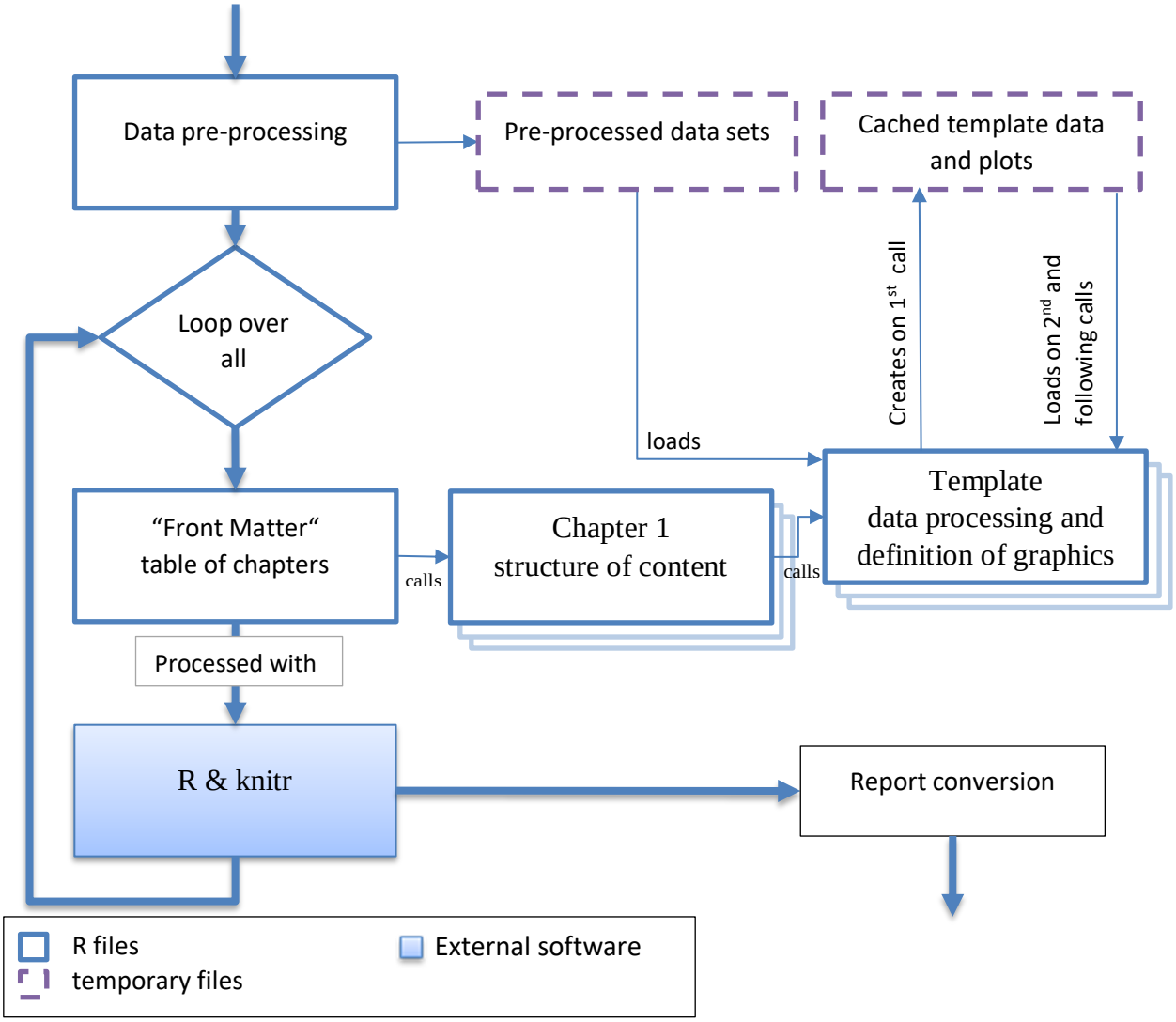
4 FINDINGS

4.1 Optimisation

As described in section 3.1, in the original reporting system the raw data is loaded and processed in each template when it is called. This procedure comes with a high computational overhead. Some data processing like initial correction of missing values or standard index calculations, e.g. per m², is done in each template and thus for nearly the whole data set. Furthermore, initial template calculations need to be repeated for each individual report. This suggests that general data *pre-processing* and *template-caching* can help to improve the performance of report compilation.

Data pre-processing is realised before the loop starts building the individual reports for all participants (cf. *Figure 4*). This is especially helpful for repetitive benchmarking subjects which yield the same type of data each year.

Figure 4: optimised report generation design with R



Template-caching can be applied on different levels. First, the template but not participant specific data analysis results can be cached after the first and loaded when compiling all following individual reports. Second, also the generated not yet individualised plots can be

cached. The R package ggplot2 (Wickham 2016) allows to construct plots as an overlap of layers where a layer can be added dynamically. A layer can be e.g. the plot type, a legend, or colour schemes which enables individualisation of each graphic.

These concepts for optimisation gain in importance the more complex a project becomes. Although ever more of the calculations needed have been relocated to the data pre-processing during the last two years, the increase in the complexity of the project has led to longer compilation times. *Table 3* gives an idea of optimisation potential. Since 2017 the line count as well as computation time in data pre-processing has increased nearly threefold. Because of growing complexity in the reporting, the compilation time for reports has increased nonetheless.

Table 3: Benchmarking the automated reporting

	2017	2018	2019
Data pre-processing	5.5 s	5.7 s	14.4 s
Line count pre-processing	737	900	2029
Compilation of one .pdf-report[1]	112.3 s	105.1 s	122.8 s
Total line count[2]	2375	6712	7692

[1]The compiled reports differ in scope and complexity. To establish a minimum amount of comparability only regular subjects have been compiled, but differences remain. Computation times may vary according to machine and workload; numbers are exemplary only.

[2]The line count includes all files *.R, *.Rnw and *.Rmd, even those that were omitted for measuring compilation time.

Since data pre-processing is conducted only once, while reports are compiled for each participant, the table demonstrates the importance of efficient code design. The benchmarked report for 2019 contains 119 different plots, each taking about 0.5 s (e.g. bar chart) to 1.5 s (e.g. boxplot) to compute. Plotting during data pre-processing and only individualising them afterwards in a loop might therefore save 2,000 s or about 30 min when compiling reports for 20 participants, assuming time savings of 100 s per report.

4.2 Best practices

Throughout the years of recurring benchmark reporting and continuous process improvement we could identify several best practices which simplify data analysis, circumvent repetitive tasks and make reports more meaningful.

Standardise, standardise, standardise

Defined standards encompassing everything from data acquisition all the way to global functions, that ensure that details such as table printing are consistent across all templates, help avoid manual labour and repetitive tasks in the long term.

Standardisation helps reduce the effort spent importing, cleaning and tidying data. Therefore, the amount of tools involved, such as software packages, is kept to a minimum (Wickham 2014). Using only packages that share the same underlying design philosophy helps keeping consistent data structures throughout processing and lower technical know-how hurdles (Ross et al. 2017).

Make questions as simple as possible but as detailed as necessary.

The data resources of our participants from big public German hospitals are often heterogenous and sometimes limited. Therefore, a question should target the datum of the lowest possible complexity level still leading to the sought result when combined e.g. with other questions or background information. However, in order to prevent ambiguous interpretation technical details and examples are needed where applicable.

The proximity of data and meta data

As described in section 3.2 meta data such as definitions is needed to automate meaningful interpretation and presentation. Proximity, here, refers to making it easy to address the meta data given the actual data. This was realised by using a structured relational database.

Differentiate between a lack of data, no answer and zero.

Especially when aggregating numeric data, such as data on energy usage, the difference between unavailable data and a stated zero becomes crucial. Also, there can be a semantic difference between an answer left out on purpose, e.g. for policy or privacy reasons, and an answer left out because of a lack of data.

5 OUTLOOK

Comparing today's implementation with the concept presented here, the sector with the biggest conceptual improvement potential is the communication channel between provider and participants as described in section 3.1. Here, an online platform as the main participant interaction portal for data collection and report distribution has great potential. It can help in basically three ways:

- unify and speed up communication
- simplify data collection and management
- enable instant benchmark reporting

The idea of instant benchmark reporting is born from the combination of automated data integration and report generation. Using the online platform also as report distribution channel, it would enable participants to instantly see and compare themselves in the chosen benchmarking subjects, freeing them from data acquisition deadlines and offering them more flexibility.

Looking even further ahead, such automated reporting in combination with building sensor systems and digitalisation could be used to realise a real time benchmark for basic subjects, such as energy, across multiple participants.

6 CONCLUSION

Dynamic documents offer numerous benefits over manual report compilation. Xie (2014) lists them as:

1. Reduction in errors due to manual work.
2. Reduction in human effort in report compilation.
3. Establishment of a standardised workflow.
4. Omission of repeated tasks because of changes to the data source.
5. Omission of effort to keep written narrative and analysis synchronised.

In the case of benchmarking this enumeration is not even nearly complete, when considering the business case. The automation of report compilation adds competitive advantage for the provider in several aspects.

Automated reporting comes with added benefits for customers. By defining multiple output formats, e.g. special summaries and presentations, participants can be provided with the material to disseminate findings in its own organisation. For external communications anonymisation of all contents is easily achieved with a few lines of code. Furthermore, if any of the participants would like to confine the pool of participants they want to be compared to or only take part in specific topics, the modular code structure allows for easy filtering and creating excerpts.

Another advantage lies in gaining reactivity. As mentioned, manpower and time are considered the prevailing limiting factors in benchmarking. With the automation of most tasks, this restriction is alleviated. Late responses can be reviewed and added on short notice. And despite pressure in time, reports and presentation will always be kept in sync.

Finally, the standardised workflow allows for continuous improvement. The proposed structure allows for traceable improvements in each reporting period according to the participants proposals and wishes. With the focus shifting from type setting to data manipulation deeper analysis becomes more achievable. Moreover, the code and the expertise gained can be re-used in new benchmarking projects or to go further in automation, e.g. creating a modular online platform.

ACKNOWLEDGEMENTS

We sincerely thank the participants of our benchmarks for their open-mindedness to test new approaches and steady constructive feedback.

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Opportunity Knocks: Green Leases and Green Leasing in Sustainable Office Buildings

Dave Collins
Centre for Real Estate and Facilities Management
Norwegian University of Science and Technology
Trondheim
david.collins@ntnu.no
+47 92501501

ABSTRACT

Purpose: This paper intends to illustrate the barriers and drivers for the development and implementation of Green Leases and Green Leasing in sustainable office buildings in Norway, with supporting data also from the United Kingdom (UK) and the United States of America (USA). This paper also establishes the difference between the terms 'Green Lease' and 'Green Leasing'.

Methodology: Through a combination of previously published empirical case studies (both qualitative and quantitative) and desk research, this paper outlines the barriers and drivers from the perspectives of owners and tenants of green office buildings. Using previously published studies conducted for the author's doctoral research, this paper brings all of the research for this project together in order to answer the core research questions of their thesis. Using desk research, this paper will also endeavour to tackle some of the terminological challenges associated with this doctoral project and will feature data from previous literature research conducted by the author.

Findings: This paper identifies that a variety of barriers and drivers exist, and are specific in terms of importance to each stakeholder type of 'Owner' and 'Tenant'. This offers challenges and opportunities to the further development of Green Leases and Green Leasing, from potential stakeholders in commercial real estate, as well as facilities management and related actors.

Intended impact of the study on either research, education or practice: This research is relevant for owners and tenants working in the fields of sustainable office buildings. The findings are also relevant to facilities management in the development of products and services that can support Green Leases, Green Leasing and other non-residential sustainable initiatives.

Paper type: Research Paper.

Keywords: green leasing, green leases, sustainable facilities management, sustainable development, sustainable office buildings

1 INTRODUCTION

Whilst attempts to address the sustainability deficit in the built environment is nothing new, *Green Leasing* (referring preliminarily to '*the leasing out of a building in a sustainable manner*') is a relatively new means by which this has been addressed. For many in research and practice, the justification for addressing environmental concerns through Green Leasing or a related means is clear. With 40% of energy consumption and 36% of emissions in Europe coming from buildings ("Buildings," 2017), sustainable development in the context of buildings and their use has great potential by which to reduce European and global emissions. Whilst sustainable development in the context of the built environment is not new, the potential of building users to contribute to this is only now being realised. The types of engagement that can be positive to a building's sustainability can vary widely in scope from turning off electronics, to having users involved in identifying problems, troubleshooting them, and even finding solutions for sustainability-related and other workplace issues (Bull et al., 2017, p. 312). More specifically, office buildings are an example of a building type that offers considerable potential for emissions reductions, mainly due to their operational practices.

With this level of potential to improve the sustainable credibility of offices, there also attracts research from a range of disciplines that can fit within the architectural, built environment, business and facilities management (FM) contexts. These range from the works of FM academics such Elmualim (2009) (Elmualim et al., 2009), to law experts such as Susan Bright (2014) (Bright et al., 2014), and even the social sciences such as the work of Thomas Berker (2017) (Berker, 2017). With a variety of fields that work with sustainability issues, there naturally comes a variety of potential solutions.

Whilst Green Leasing is not the only means by which these issues can be challenged, the importance of this approach specifically cannot be dismissed. This paper deals with Green Leasing issues primarily from the perspective of the Norwegian situation in the context of a concluding article of a recently completed Doctoral thesis in Sustainable facilities management.

This paper will summarise the results of this Doctoral thesis split in sections focusing on the research question thematics of the thesis. These themes are the state of the art of current Green Lease and Green Leasing research, the barriers and drivers for the development of Green Leasing, as well as the opportunities this presents for FM.

2 RESEARCH DESIGN QUESTIONS

The aim of this paper and it's associated thesis is to identify the barriers and drivers associated with the development and leasing of sustainable rental office buildings in Norway and its associated facilities management. The overall goal is of generating new knowledge in this field in new and existing buildings both the private and public sectors.

This paper will address many of these issues through the following 3 research questions:

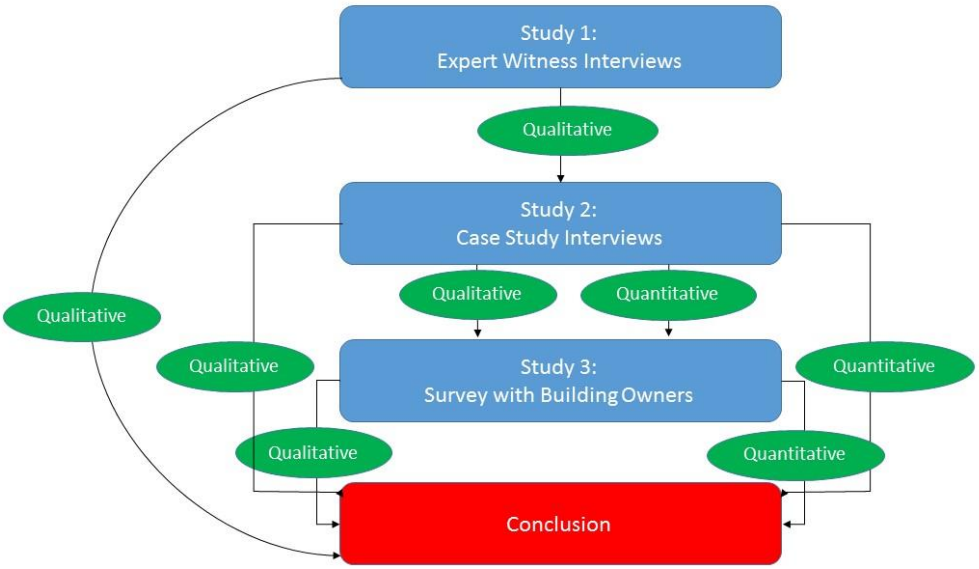
1) *To what extent is research and the implementation of Green Leases and Green Leasing being given attention by academia and practice in the context of Sustainable Corporate Real Estate and Facilities Management?*
2) *What are the drivers and barriers for the development and lease up of sustainable and Green Leased office buildings from the perspective of owners and tenants?*
3) *What are the challenges and opportunities for Facilities Management in the context of the development of sustainable office buildings?*

This paper will be organised under headings for each research question and will be dealt with in turn with each question corresponding to an individual study that was a part of the author's doctoral work. This will then be discussed and brought together in a concluding section.

3 METHODOLOGY

This paper gathers its data from three studies, each of which is pegged to a research question. Each of the studies informed the next stage of the overall project, before combining their empirical output in a conclusion. Whilst each study was conducted individually, they overall formed a method of systematic data collection combining both qualitative and quantitative data.

Figure 1 – Model for systematic data collection



In this project, each empirical study was not only mixed method for the most part, but also informed the approach, scope and perspective of each subsequent study. The data from each study is then brought together in its conclusion. The model also demonstrates how the data collection informed the conclusion. Each study did not just systemically inform the next step of research, but each study has important results in of itself. It was also important to state separately that ‘quantitative’ and ‘qualitative’ elements for each study. This is due to each form

of research offering different qualities. In studies where both were used, the quantitative provided the bulk of the comparative data whilst the qualitative provided context and depth of narrative, which each influencing a different aspect of the next study differently.

The first study of this project was in the form of quantitative interviews, which serve the purpose of answering the first research question - "*to what extent is research and the implementation of Green Leases and Green Leasing given attention by academia and practice in the context Sustainable Corporate Real Estate and Facilities Management*".

The primary purpose of this study was to try and articulate the need and attention that user based considerations are given in sustainable office buildings. The second purpose was to establish what issues there are within this topic and to analyse these issues to inform the next phases of empirical work.

After the completion of the first empirical study, the analysed and published data were used in part to form the approach (methodologically and thematically) for the second empirical study. The primary purpose of this second study is to answer Research Question 2 – "*What are the drivers and barriers for the development and lease up of sustainable and Green Leased office buildings from the perspective of owners and tenants?*". In order to answer Research Question 2, mixed method semi-structured interviews (featuring qualitative and quantitative elements) were conducted with owners and tenants of sustainable office buildings.

The third empirical study in this paper consists of a survey that is primarily quantitative in its focus, but also contained a few qualitative questions where relevant. The primary purpose of this study was to answer Research Question 3 – "*What are the challenges and opportunities for Facilities Management in the context of the development of sustainable office buildings*". The creation of this survey was considered the third step of the two previous studies, with this being evident due to two core reasons.

4 RESULTS

4.1. Study 1 – Interviews with Industry Experts

This is an empirical exploratory study with a focus on how users impact the sustainability of the buildings that they use - from the perspective of expert witnesses in the field of building energy efficiency and sustainability.

The interviewees in this study were asked in what ways the users of buildings impact its sustainability (both positively and negatively), and the degree to which this was important in the broader context of sustainability in the built environment. Users are an important stakeholder to consider due to their impact on the building, from being the core customer in a rented office to being an actor that impacts the kinds of changes and refurbishments to be made to the property, as we as sustainable considerations.

The '*sustainability mindedness*' of users was crucial in buildings where users enjoyed considerable control over their environment. A user who understands the sustainability needs of their building and cooperates with them can result in positive outcomes. The opposite is the case with users who do not consider the sustainability needs of their buildings. This also can

be considered in conjunction with the attitudes of users, who are more likely to leave electronics on in their office in ways they would not do at home, as they do not pay the bills for energy use in their workplace. In buildings that use automated processes such as Building Management Systems (BMS) that take the control (and thus risk) of sustainability management away from users, usability is important.

Some of the interviewees suggested increasing legislation and regulation to ensure buildings were operated better, but with an emphasis on '*carrots*' as opposed to '*sticks*' where at all possible. Voluntary regulation such as BREEAM certifications were considered as a possible solution, mainly due to a positive brand image, reduced operational costs, and other incentives such a certification can potentially provide. Green Leases are another possibility for regulation, although their implementation is challenging and the concept in of itself is still maturing.

Aside from a technological approach, FM's in some cases may be a key element in solving user related sustainability challenges. One of the interviewees noted that the FM in a building they had studied as a part of a doctoral project they had supervised had been the building 'champion', and they understood how best to reduce energy in that building, and had the personal competencies to engage users in these endeavours to a degree. According to the interviewee, the level of expertise in FM is an important reason why they should be core members of design teams, which in turn may result in better performing sustainable buildings.

Overall, the interviewees offered three key approaches to tackle user-oriented sustainability challenges – '*training*', '*technology*', '*regulation*' and '*FM*' – all of which are components that could be found in Green Leasing.

4.2 Study 2 – The Drivers and Barriers for the Owners of Sustainable Office Buildings

This was a piece of internationally focused research which involved data collection from Norway, the UK and the USA through semi-structured interviews with the owners and tenants of BREEAM or LEED-certified office buildings that were available for rental.

In this study, owners were mainly motivated by less tangible drivers. What this means more specifically is that although costs always matter in business, as an initial motivator they were considered less important. Owners developed these buildings primarily due to the company policy and culture within their organisation, which was a part of their company brand. This motivation sometimes came from the investment arm of the RE organisations studied, and was a message to potential customers that they wanted to be seen as leaders within their industry. Green certifications (such as BREEAM) were also important motivators, due to a combination of customer recognition and its status as a 'toolkit' for improving the sustainability of their building.

With regards to barriers, these were primarily bureaucratic, technical and structural in nature. Bureaucracy proved to be an issue for BREEAM certifications outside the UK. BREEAM documentation had to go via the UK headquarters and not regional NSO's, which meant that final certifications were both too a long time to finalise, and were complex to complete. LEED-certified building owners did not report such problems. In terms of technical challenges, these were often found in some of the Computer Aided Facilities Management (CAFM), more

specifically the BMS systems. Owners reported that they not only had usability difficulties with these systems but also found that the technologies it was meant to control were not always working correctly. Numerous strategies were attempted by owners, one of which hired their own commissioner to minimise the 'day one' challenges of integrating building technologies with the BMS systems designed to control them. Structural issues also place stresses on the process. Local building regulations sometimes reduced the sustainability potential of desired building refurbishments and were often not accounted for adequately in the BREEAM and LEED certification processes.

For tenants, their building certification was the highest priority for their choice of building. The reasons for this were numerous in nature, although taking up a tenancy with a well-recognised mark of sustainability such as BREEAM or LEED was an important factor. Unlike owners, costs were the second highest motivator for tenants. Managing their operational costs versus their rent was a key focus of them taking up a tenancy. The less tangible motivators of CSR and company policy followed on from this, with customer demand being seen as a much less vital consideration. For tenants, compliance with legislation at any level was a factor they least considered overall.

In terms of barriers, these were naturally very different than those of the owners. Whilst literature implied that the landlord-tenant relationship and associated frictions may be a barrier, none of the tenant interviewees mentioned any tensions of significance. They even implied that their productive relationship with their landlord was a key factor in them renting their office. Communication barriers, however, were a barrier noted by some, particularly concerning misunderstandings during design meetings which resulted in differences in the buildings that they had not accounted for previously, such as unwelcomed floor plan revisions.

4.3. Study 3 The Barriers and Drivers for Green Leased Rental Office in Norway

The survey in this paper consists of quantitative and qualitative elements, with the target respondents being building owners and tenants of sustainable office buildings in Norway. This piece of research was envisaged as a project influenced by the two prior stages of data collection. Whilst the line of questioning was heavily influenced by the data and 'unanswered questions' from the previous studies, it is not internationally focused (only focusing on Norway) in order to ensure that the data collected for this paper was not watered down due to a too broader country focus.

In this study, costs were considered to be the primary driving factor for all stakeholders, regardless of the sector. This is in contradiction to the findings of in the previous study, where intangible factors were of a higher value to owners (such as CSR), although tenants still considered the cost to be a significant factor. Whilst the study did not look directly at why these contradictions occurred, it can possibly be implied this is due to cultural and economic differences between both samples, as well as the survey study having a considerably larger sample than that of the interviews. The least significant drivers, however, were not the same across all stakeholders and sectors, but instead were more sector (but not stakeholder) specific. In the private sector, both owners and tenants considered CSR to be the least significant of the

drivers in the development and occupancy of their building. In the case of the public sector, both owners and tenants also had consensus on the driver that was of least significance in the context of the development or rental of their building. In this case, a green certification (such as BREEAM or LEED) was the least significant driver.

In terms of barriers (a question only addressed to building developers), these differed depending on whether they were from the private or public sectors. In the private sector, the most significant barrier to the development of their building was in both the construction and planning stages. This differed in the public sector, where the two most significant barriers were at the construction stage, but also those relating to bureaucratic processes. In terms of the least significant barriers, these were bureaucratic barriers in the case of the private sector. For public sector buildings, the least significant barriers were those related to market demand.

Overall, more than 80% of the respondents considered the FM they operated in their building portfolios to be sustainable. In terms of what elements this consisted of more specifically, this mostly took the form of energy management initiatives. Much of the data in this section indicated that much of their SFM approach was technical in nature, with the other significant initiatives being sustainable maintenance and sustainable technical installations. The lesser used initiatives were mostly strategic and tactical and consisted of contractually based initiatives such as energy performance contracting. This is indicative of a need for good technical competencies amongst FM's in higher performing sustainable office buildings.

5 DISCUSSION

5.1. The extent to research and the implementation of Green Leases and Green Leasing being given attention by academia and practice

Green Leasing and Green Leases are relatively new concepts in the study of Green Buildings and the built environment, however, they are experiencing varying degrees of growth. Whilst there is no universally accepted definition of either term, the sources accumulated as data for this indicate that a degree of common understanding does exist. A more universally accepted definition, however, would only benefit the field to avoid terminological misunderstandings and ensure that research is united under common terminology. Green Leasing is of particular note here, as it has yet to be given much in the way of significant attention in either academia or practice.

An understanding as to what constitute the barriers and drivers of both is also important to establish. There are however research gaps that need addressing that fall outside of the scope of this project and will require bespoke research projects in order to address them comprehensively.

5.2. The drivers and barriers for the development and lease up of sustainable and Green Leased office buildings from the perspective of owners and tenants

The findings of these studies are indicative of a broad spectrum of barriers and drivers for the interviewees and respondents. The diversity of the drivers and barriers for owners offers little

hope in the ways of generalisable factors that can be used by institutions to develop further means by which to promote the development of sustainable buildings. This indicated a need for green building councils, BREEAM and other appropriate stakeholders to develop the sector and country-specific strategies in order to foster growth in sustainable building stock. The results also indicate the weakness of legislation in this movement, a reversal of which may result in an increase in the development of sustainable office buildings. Further research would be needed however in order to establish the nature of such regulation and the degree to which this should be incentive or penalty based. This data also illuminates the need to overcome technological barriers, both in terms of usability and implementation. This can offer an opportunity not just for improvement in this area, but also possibilities to create jobs and income from the products and services that would be required to make this happen.

In terms of tenants, the commonality of the importance of costs does offer possibilities to further these drivers across sectors and countries. This can offer possibilities for governments and other sustainability-focused institutions to appeal to this driving factor with financial incentives. This also offers possibilities for building owners, who can lower vacancy rates by ensuring their marketing and operational strategies appeal to this driver, whilst also meeting some of the communication challenges yielded from the interview data. There is also scope for innovation off the back of these results. The barriers and drivers featured in this study not only reflect that we now know more about these issues, but also offer possibilities for further research in academia to understand these matters in more detail, and for the industry to create potentially lucrative solutions to meet the challenges.

5.3. The challenges and opportunities for Facilities Management in the context of the development of sustainable office buildings

Despite the prevalence of SFM reducing energy consumption as a primary FM initiative, there were other less energy and technologically focused initiatives that were also important to participants in this project. Many of the participants recognised the importance of considering sustainable maintenance initiatives (an aspect that was considered the most important factor after '*energy management*' in the Norwegian survey study). Sustainable cleaning initiatives were also a factor of value to respondents, as well as environmental management. Despite these other aspects of SFM, energy management is and still remains the aspect of FM given the most consideration by building owners and tenants in sustainable offices, despite the possibilities for the likes of waste management offered by FM aspects such as sustainable cleaning operations.

For practice, there are opportunities not just to optimise their existing processes and technologies, but also to create new products and services, and see new commercial opportunities in this area. In the case of FM and SFM, ensuring that the competencies of their FM staff are in tandem with their technologies is vital. This is particularly the case when considering the barriers and drivers noted in this project. Many of these can be met by better integration of FM and SFM related considerations at various stages of the building's lifecycle. In the case of early-stage technical challenges, FM along with the normal stakeholders associated with design teams could work towards more usable and less technically challenging projects. Similarly, better utilisation of FM's can result in a more functional operational stage

in a high performing building (combined with more CAFM and user interaction competent FM's). Whilst some of the technology and infrastructure exists to employ SFM and Green Leasing, there is also an opportunity to develop these possibilities further. There is considerable commercial potential to develop better energy and waste management systems, smarter buildings and even Green Lease and Green Leasing bespoke FM services.

6 CONCLUSION

Whilst this study offers significant possibilities to break new ground and offer new knowledge in the fields of FM and the built environment, it is only one step on a larger journey to push these issues even further.

In terms of further study from the perspective of academia, this study should stimulate a larger and more detailed study on the barriers and drivers. This study indicated that the barriers and drivers were hard to generalise, however, a wider multi-country study has the potential to discover the degree to which this is true more definitively. A further research project would need to focus not just on seeing if the barriers and drivers in this could be generalised on a larger scale, but also establish if there are other more valued ones to consider, such grants or support from governments and other funding bodies. It is also recommended that this study be more qualitative in nature in order to better look at the reasoning behind why these driver and barriers are important, particularly to provide more information regarding the impact of barriers. The same possibilities also exist for more detailed studies of the coverage of Green Leases on an international scale.

There are also possibilities for further research and development outside of the realms of academic institutions. This study presents the needs of governments, property developers and sustainable certifications to do extensive research into how to encourage developers to develop sustainable office buildings, encourage tenants to occupy them, and prevent some of the challenges that are holding these aspects back. A lack of generalisable drivers ensures that this will remain a challenging, but a vital piece of research to conduct going forward. Many of the challenges posed by sustainable buildings, Green Leases and Green Leasing can be met by FM. The FM service industry needs to diversify its personnel skill set to meet these challenges, as well as offer services to support them that may not currently exist. These challenges are also presented in the form of possibilities, and innovation and keen entrepreneurship that is vitally important in order to ensure that the FM service industry can develop in tandem with sustainable development, as well as the demand that this study shows are becoming increasingly more profound from their customer base.

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Towards a Standardised Definition of Room Categories for Healthcare Facilities (RakaS)

Nicole Gerber
Zurich University of Applied Sciences, Institute of Facility Management
nicole.gerber@zhaw.ch
+41 58 934 53 91

Oliver Kuchen
Zurich University of Applied Sciences, Institute of Facility Management
xkce@zhaw.ch

ABSTRACT

Purpose: Different industry-wide room categorisation standards and norms pertaining to space definitions have been set up in recent years. However none of them are being completely applied in Swiss healthcare organisations because they apparently fail to fully cover the needs of Facility Management in Healthcare. To overcome this situation, the standardised Room Categorisation for Hospitals (RakaS) version 1.0 was presented combining different aspects of existing norms, as well as the needs voiced from practice; the framework had, however, yet to be validated after application in practice.

Methodology: Another extended desk research into standardisations and norms for rooms and space was followed by a multi-stage evaluation process applying consortial research principles involving practice. A case study workshop with one specific hospital provided the basis for a semi-structured interview guideline for subsequent expert interviews with managers responsible for room-specific tasks in healthcare organisations. The sample includes eight different German-speaking Swiss hospitals of different categories. After a content analysis of the data, the framework could be validated, adjusted and extended.

Key Findings: The existing systematically illustrated overview with all room categories and the corresponding table with various details concerning the definitions of the categories and rooms were slightly extended and refined. One major change is the introduction of color-codes indicating the differentiation between room categories.

Based on the data analysis, a documentation describing the details of the discussions and decisions and a keyword index to support the finding of desired keywords concerning room category and room usage were developed and added to the framework.

Intended Impact: RakaS 2.0 is now a validated framework, providing a foundation for a standardised room classification. It is thus the basis for both benchmarking between healthcare organisations in terms of room KPIs and for transferring data to digital models in a standardised manner, allowing better planning and calculation of the necessary areas before construction.

Paper type: Research Paper

Keywords: Room Categories, Benchmarking, FM in Healthcare, Hospitals, Standardization

1 INTRODUCTION

Different industry-wide room categorisation standards and norms pertaining to space definitions have been set up in recent years. However, in previously conducted projects, it became clear that none of the norms mentioned above were being completely applied in Swiss healthcare organisations, indeed no standard was being used as a basis for room definitions at all. The evident reason for this was that none of the norms fully covered the needs of Facility Management in Healthcare (FM in HC).

To rectify this situation, the standardised Room Categorisation for Hospitals (RakaS) 1.0 was presented (Gerber, Hinnen, & Hofer, 2017). In the first version of RakaS, different systems of room categorisation and definitions were listed, showing the prevailing state of classification: Firstly, general inter-industrial classifications with a focus on space without a specific healthcare connection were listed:

- DIN 277-2:2005 and DIN 18960:2008-02
- SIA 416:2003 as well as SIA 0165:2000

Secondly, DIN 277-1:2016 was introduced with its classification of a specific healthcare section.

Thirdly, specific healthcare room classification norms were presented:

- DIN 13080-1999
- DIN 13080:2016
- GEFMA 812:2014-09

Based on these existing norms, a specific categorisation suitable for application in the complex context of healthcare facilities was developed in collaboration with hospital partners. The existing definitions and numberings were adopted as much as possible, however supplemented with specifications and sub-categories where necessary. The output was a systematically illustrated room categorisation and a corresponding table explaining the details behind all the different room categories. RakaS 1.0 was a deductively developed framework; its usability in practice had not yet been evaluated. After the application of the framework and a systematically conducted evaluation, it was possible to adapt it accordingly. In this article, the evaluation methodology conducted and the updated and extended framework are presented.

2 RESEARCH QUESTION, RESEARCH OBJECTIVES

The research question for the evaluation was defined as to find out which changes have to be made in the RakaS 1.0 framework in order for it to fulfil the quality criteria mentioned below.

Since RakaS is understood as a conceptual model developed on the basis of Design Science Research (DSR) principles, for the assessment of the quality of the model, the quality criteria framework of Gerber et al. (2018) was chosen. The main goal was to evaluate utility, practicability and viability by asking

- Is the goal, scope and contribution of the conceptual model clearly outlined?
- Is the context of the conceptual model relevant?
- Is the conceptual model economically efficient?
- Does practice accept and utilise the conceptual model?

- Does it satisfy the needs of the users?
- Does it solve the problem defined?
- Is it clear, readable and interpretable (using the appropriate language and adequate symbols)?
- Is it easy to understand and to identify the essentials?
- Does it have a systematic design and is it consistent (in meaning, structure, format and syntax)?
- Is it concise and compact?
- Is it comparable to other, parallel models?

The objective of doing this particular research was to contribute to a common understanding about room definitions within the HC industry as a basis for a systematic and transparent allocation of cost and future benchmarking initiatives. By doing so, the authors hope to contribute to a more sustainable provision of healthcare services in the future.

3 METHODOLOGY

Firstly, another extended desk research into standardisations and norms for rooms and space was conducted which also included available individual room categorisations used in Swiss hospitals. Secondly, a multi-stage validation was conducted applying consortial research according to Österle and Otto (2009) for the validation of the framework. A case study workshop with one specific hospital currently revising their room category system provided the basis for a semi-structured interview guideline (Flick, 2009a). Expert interviews with managers responsible for room-specific tasks in healthcare organisations were asked for individual feedback and opinions. The sample includes eight different German-speaking Swiss hospitals covering the following categories: General hospitals, Centrum care (Level 1, University Hospitals); General hospitals, Centrum care (Level 2); Psychiatric clinics (Level 1) and Special clinics (Surgery, Gynaecology/Neonatology, Paediatrics, Geriatrics, Diverse) according to BAG (2018). For the data analysis, the qualitative content analysis method was used (Flick, 2007; Mayring, 2010). The content generated was listed in tabular form using matrices. The order of the content was mostly determined by predefined codes and categories which followed the structure of the interview guideline (Flick, 2009b; Saldaña, 2009).

4 RESULTS

The result of the evaluation process is a validated framework providing a common understanding of room categories suitable for the application in different further practical and research developments. The output of the framework has four components:

(1) A documentation describing the details of the discussions and decisions
(2) A systematically illustrated overview with all room categories
(3) A corresponding table with various details concerning the definitions of the categories and rooms
(4) A keyword index to support the finding of desired keywords concerning room category and room usage

These four components are presented in the following paragraphs. The systematically illustrated overview (2) and the corresponding table (3) are revised versions of RakaS 1.0. The documentation (1) and the keyword index (4) are components newly added to the framework.

(1) Documentation

The documentation explains in detail the idea of standardised room categorisation. First of all, the starting position of the whole project as well as its objective and the benefits are discussed. Furthermore, the research project and its results are presented. The main goal of the documentation is to explain how to use RakaS 2.0. The documentation can be downloaded under www.zhaw.ch/ifm/fm-healthcare/rakas/en.

(2) Systematically illustrated overview

The room category overview is still based on the structure of RakaS 1.0 as the evaluation has shown that this setup is perceived as useful. Overall it can be said that the experts prefer a lean, clear structure instead of an extended version covering every detail, but being confusing. Instead, it was decided to set up a keyword index, allowing one to go more into detail. These include indications on how to handle concrete situations like detailed specifications of individually-designed room-usages such as “sanitary rooms”, “toilets”, “showers” or “bathrooms” where there might be many different combinations, depending on installations and gender division. A further aspect is the dual- or multi-use of rooms like the seating area in food zones, which can also be used for work. Therefore, only minor adjustments were performed in the overview illustrated, e. g. supplementing "hazardous materials storage" with“ storage / issuing rooms”. In addition, the case study showed that applying the colour scheme of the SIA416 norm (SIA 416:2003) was perceived as user-friendly by most experts and was therefore integrated into the illustration.

Figure 1 shows the principle of the systematically illustrated overview. The detailed illustration suitable to print-out can be downloaded under www.zhaw.ch/ifm/fm-healthcare/rakas/en.

(3) Corresponding table

The corresponding table explains the details of the room categories:

- Column 1: names the main room categories
- Column 2: lists the room types mainly corresponding with DIN 277-2:2005, partially adjusted with the descriptions from DIN 277-1:2016 but also including newly-added categories.
- Column 3: states the sources of the definitions in column two; in this way it is possible to find the original text if necessary, to distinguish between the previous definitions and the extended definitions of this project.
- Column 4: defines and specifies the room categories
- Column 5: justifies differentiations

As the illustrated overview only underwent minor adjustments, little change had to be made within the table - only the additional room and the corresponding details were added.

Table 1 shows the principle - the detailed version of the table can be downloaded under www.zhaw.ch/ifm/fm-healthcare/rakas/en.

Figure 1: Systematically illustrated overview of RakaS Version 2.0; Readable version can be downloaded under www.zhaw.ch/ifm/fm-healthcare/rakas/en

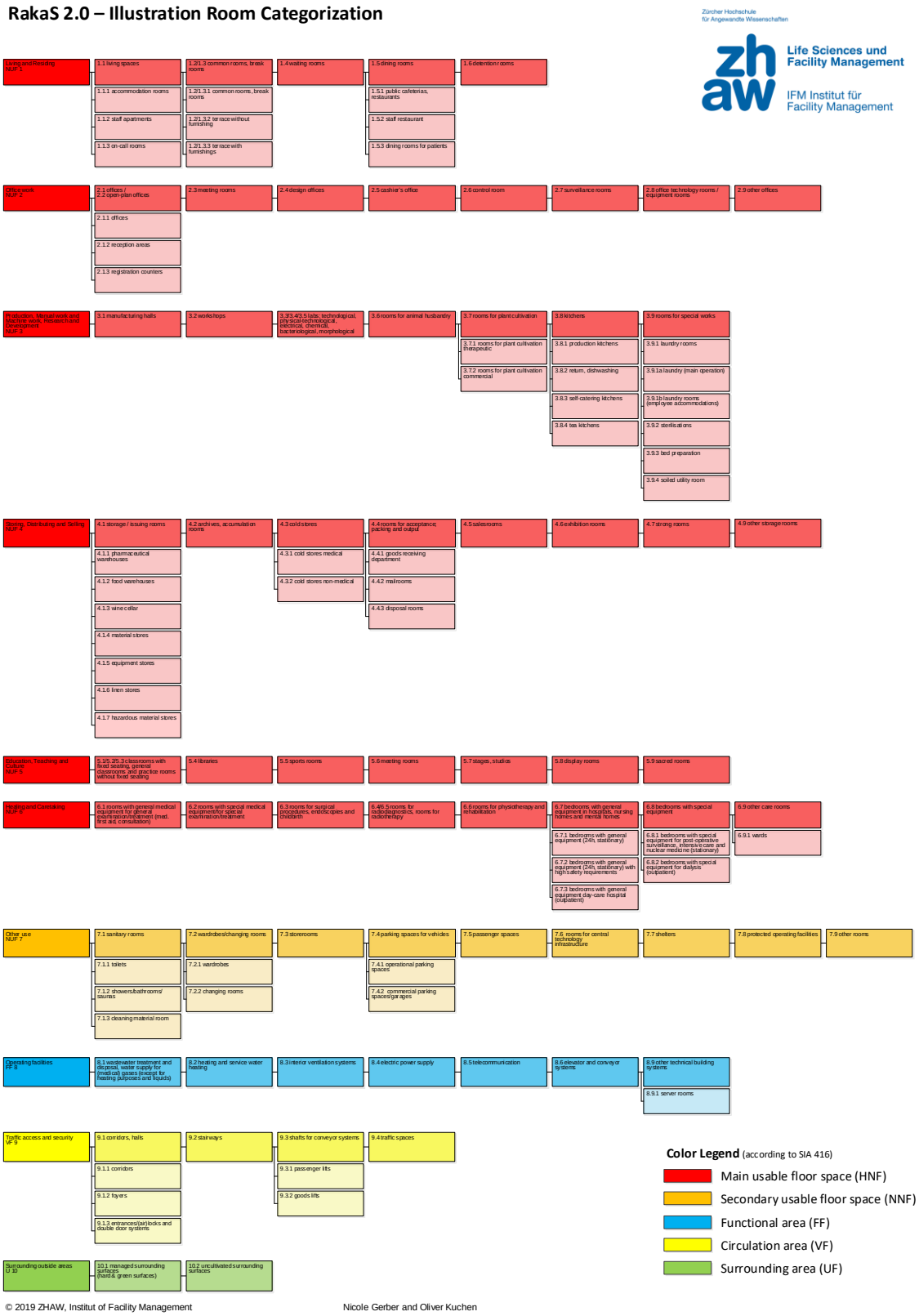

Table 1: Excerpt of table with details about RakaS 2.0; Readable version can be downloaded under www.zhaw.ch/ifm/fm-healthcare/rakas/en

Room Category	Room type/-naming	Source / Notes on	Definition/Specification IFM	Reasons for content-related differentiating
Living and Residing (NUF 1)	-	DIN 277-1:2016	living spaces, common rooms, waiting rooms and dining rooms	-
	1.1 living spaces	DIN 277-2:2005	living rooms and bedrooms in apartments, accommodations and employee apartments incl. eat-in kitchens, balconies, porches belonging to accommodation unit; on-call rooms	-
	1.1.1 accommodation rooms	DIN 277-1:2016	rooms of patient or guest hotels incl. eat-in kitchens, balconies, porches belonging to accommodation unit; on-call rooms	-
	1.1.2 staff apartments	Project	rooms of employee apartments incl. eat-in kitchens, balconies, porches belonging to accommodation unit; on-call rooms	-
	1.1.3 on-call rooms	Project	on-call rooms for employees with washrooms and beds	Only temporary use vs. permanent use in residential rooms
	1.2/1.3 common rooms, break rooms	Project, DIN277-1:2016, DIN 277-2:2005	common rooms, day rooms, break rooms, quiet rooms incl. adjacent balconies and terraces	-
	1.2/1.3.1 common rooms, break rooms	Project, DIN277-1:2016, DIN 277-2:2005	common rooms, day rooms, break rooms, quiet rooms incl. adjacent balconies	Inside rooms have a different standard of maintenance and cleaning to outside areas
	1.2/1.3.2 terrace without furnishings	Project	terraces with furnishings (fixed or mobile)	Outside areas have a different standard for maintenance and cleaning to inside rooms
	1.2/1.3.3 terrace with furnishings	Project	terraces with furnishings (fixed or mobile)	Outside areas have a different standard for maintenance and cleaning to inside rooms; furniture causes more cost for handling, cleaning and maintenance
	1.4 waiting rooms	DIN 277-2:2005	waiting rooms for patients for examination/therapy	-
	1.5 dining rooms	DIN 277-2:2005	dining rooms and cafeterias for patients, employees and guests	-
	1.5.1 public cafeterias, restaurants	Project, DIN 277-2:2005	cafeterias and restaurants publicly accessible, served or self-service	Have longer opening hours and more extensive infrastructure compared to staff restaurant
	1.5.2 staff restaurant	Project	Restaurants for staff only, served or self-service, open only during peak periods, less extensive infrastructure compard to public restaurant	Have shorter opening hours and less extensive infrastructure compared to public restaurants and cafeterias
	1.5.3 dining rooms for patients	Project	dining rooms for patients, in the wards	-
	1.6 detention rooms	DIN 277-2:2005	n/a	(see 6.7.2 bedrooms with general equipment (24h) with high safety requirements

(4) Corresponding keyword index

A keyword index was strongly suggested by most of the experts. A vast collection of key words concerning room categories and room usages provided by the experts and arranged in alphabetical order supports the user of the framework. In this way, it is possible to quickly locate the corresponding number of the category, to detect terms that might be used synonymously or which might be included in a category without being mentioned in detail on the overview. The keyword index can be downloaded under www.zhaw.ch/ifm/fm-healthcare/rakas/en.

5 CONCLUSION

Having systematically evaluated the framework of Room Categorisation for Healthcare Facilities by experts in practice, a validated RakaS 2.0 version can be presented which was assessed as utile, practicable and viable according to the quality criteria framework proposed by Gerber et al. (2018):

- The goal, scope and contribution of the conceptual model was declared to be outlined clearly.
- The context of the conceptual model proved to be very relevant.
- Because the framework is feely available for practice, the economic efficiency can be assessed as high for the healthcare institutions.
- The framework is being demonstrably applied in practice.
- The experts reported that the framework satisfies their need for a guideline on how to define room categories in practice.
- The interviews showed that the framework was clear, readable, consistent, compact and easy to understand, and has a systematic design.
- As the framework is based on existing norms and explains the connections, it is also comparable to them.

It can thus be concluded that RakaS 2.0

- provides a basis for a standardised room classification and is thus the basis for benchmarking between healthcare organisations in terms of room KPIs
- is the basis for transferring data to digital models in a standardised manner, allowing better planning and calculation of the necessary areas before construction.

6 CRITICAL REFLECTION, LIMITATIONS AND OUTLOOK

So far, the model has only partially been applied in practice by the interviewed partners – the feedback is therefore partially based on assumptions. The investigations were carried out only in the German-speaking areas in Switzerland – a translation into French and Italian would allow the evaluation to be extended across Switzerland. It must also be mentioned that only the German version of RakaS 2.0 was evaluated – the English version is a mere translation which has not been evaluated in practice. With respect to the sample, the wide variety of experts coming from space management, project management, IT application management, the department of technology, operations, infrastructure and operations as well as someone with a strong financial background have presented a valuable mix providing a variety of perspectives.

The framework should now be applied in practice and used by different hospitals before being reassessed. It would be exciting to see other countries taking such an approach to standardised room division in hospitals because it would then be possible to start comparisons on an international level and hospitals could benefit from each other. In addition, it would make sense to involve other partners from other disciplines, such as construction planning or architecture. A combination of interior design and medical technology could be used as a basis for better alignment of room type and usage and thus contribute to more sustainable resource planning. Great potential is expected when it comes to future projects defining and applying KPIs; these projects could use the categorisation and could, based on that, create systematic, comparable space KPIs. Combining the room categorisation with Service Level Agreement management (particularly in cleaning and energy management) in the future is also suggested.

ACKNOWLEDGMENTS

We thank all the participating experts for their contribution and John Bennett for proofreading.

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Minutes of FM Meetings in Swiss Hospitals – Worth a Look at

Franziska C. Honegger
Zurich University of Applied Sciences /
Liverpool John Moores University
franziska.honegger@zhaw.ch
+41 58 934 58 65

Susanne Hofer
Zurich University of Applied Sciences
susanne.hofer@zhaw.ch

Matthew Tucker
Liverpool John Moores University
M.P.Tucker@ljmu.ac.uk

ABSTRACT

Purpose: Effective communication is a prerequisite for a well-functioning Facility Management (FM) in any organisation. As part of formal communication structures, meetings are a powerful tool at the disposal of Facility Managers. Minute-taking is predominantly done in formal meetings and performs four essential functions: constitutional, historical, executive and progressive. This research looks at the structure and content of minutes taken in FM meetings in Swiss general hospitals. The aim is to provide a guideline for managers to analyse and, if applicable, improve meeting minutes and hence meetings they are responsible for.

Methodology: The research is based on a case study design. Data collection methods include document research. A total of 402 sets of minutes of FM department and division meetings amounting to 1420 pages have been analysed applying qualitative coding procedures.

Key findings*:* Even though the formal structure of the meetings is similar, the spectrum of their content varies. Predominantly the content provides passive information with little evidence that the meeting is used as a platform to piece together the knowledge and experience of several people advancing FM.

Intended impact of the study: Within FM and especially within the context of FM in hospitals meetings have not been looked at using the suggested methodology. It provides a unique insight on what minutes as historical evidence reveal of the meetings' purpose and provides food for thoughts for executives being responsible of meeting structure and content. The findings of this applied research and the method leading to them provide a guideline for FM executives, to analyse and, if applicable, to improve minute-taking practices and, critically, to improve their meetings. For instance, results indicating a predominant exchange of information among meeting participants whose areas of responsibilities due to the nature of FM have not so much common can lead to dissatisfaction of participants, as a large amount of meeting time is not directly addressed to their needs. Considering this, the findings enable to manage expectations, as knowing and if applicable proactively declaring that the purpose of the meeting is information exchange makes that procedure more tolerable for participants. Because in times of a tightening financial environment within the healthcare context, available resources such as meeting time must be used to their full extent.

Paper type: Research Paper

Keywords: Facility Management, organisational communication, meetings, healthcare

1 INTRODUCTION

The underlying research of this paper combines the specific setting of Facility Management (FM) in hospitals with elements of organisational communication. Hence, this introduction outlines the necessary background to orientate this research, starting with organisational communication.

The questions guiding this paper's research are:

How do minutes of FM meetings in general hospitals look?
What insights do they provide about the meetings content?

The methods used are based on a qualitative research approach using qualitative coding procedures to analyse meeting minutes, as explained in the upcoming methodology section of this paper. Firstly, a look at the corresponding literature is taken, followed by the methodology, a combined results and discussion chapter and the conclusion.

2. LITERATURE REVIEW

Conrad and Poole (2011) define organisational communication, also known as corporate communication, as "a process through which people, acting together, create, sustain and manage meanings through the use of verbal and nonverbal signs and symbols within a particular context". Communication within an organisation has several functions: control, motivation, emotional expression and information (Robbins, 2000). Rogers and Rogers (1976) argue that the behaviour of individuals in organisations is best understood from a communication point of view. These authors further characterise effective communication as a prerequisite for implementing organisational strategies as well as for managing daily activities through people. These sources are many years old but provide valid content until today. The commanding (Conrad and Poole, 2011) or also called directing (Miles, 2012) part of management tasks involves activities including leading, motivating and communicating with staff as individuals, groups or the organisation as a whole (Miles, 2012). Papa et al. (2008) state that communication is not just a tool for managerial control, but that all of the human processes defining an organisation arise from communication, pointing out that "the linkages and connections among subsystems depend on communication and information flow" (p. 109). This is supported by Mosley and Pietri (2015) stating that to be effective, organisations must utilize two critical linkages to sustain positive intra-organisational relationships: open and clear communications. This linkage argument is taken further by Modaff et al. (2016) who identify three distinct communication functions essential for organisational systems: 1. *constitutive function* by creating connections and acting as a binder allowing the coordination of activities and integrating of the elements into a whole; 2. *adaptive function* through referring to a constant information exchange between the organisational system and the environment to adapt appropriately to environmental change; 3. *maintenance function* as it provides information throughout organisational systems to ensure a dynamic state.

Another perspective on organisational communication is provided by Byers (1997), who points out that in today's society, effective leadership is seen as a key ingredient in determining organisational success. The author further states that regardless of which leadership theory one subscribes to, communication always plays a central role in the leadership process. Hence, it can be concluded that it is a leadership task to facilitate purposeful communication for the benefit of an organisation's success, as oftentimes, when communication is poor, people lack motivation and will react negatively. Hansen (2004) states that what frustrates managers the most is poor communication. Communication fundamentals include that communication flows vertically or laterally (Robbins and Judge, 2010); vertical communication pertains to

downward and upward communication, referring to the different hierarchical levels an organisation has. Lateral communication takes place among peer groups at the same hierarchical level (Robbins and Judge, 2010). Communication channels used can be formal or informal and can be classified in three ways: oral, written and non-verbal communication (Robbins and Judge, 2010). Formal communication is enabled by the setup of formal organisational and authority structure (Jian, 2013) and characterised as a type of verbal presentation or document intended to share information that meets planned and established professional rules, standards and processes and avoids using slang terminology (formal communication, 2018). Informal communication refers to emergent, unofficial, and unsanctioned communication among organisational members through informal social contacts (Jian, 2013). To process information, the managers have five communication channels at their disposal: mail (documented), telephone (purely verbal), unscheduled meeting (informal face-to-face), scheduled meeting (formal face-to-face), and tour (observational) (Mintzberg, 1971), for today, email (documented) and meetings via electronic channels need to be added.

This research focuses on scheduled meetings (formal, face-to-face), which consume a substantial part of managers' resources (Mintzberg, 2015, Mintzberg, 1971, Romano and Nunamaker, 2001, Allen et al., 2016). Rogelberg et al. (2006) state that a typical manager spends about six hours per week in scheduled meetings. Meinecke and Lehmann-Willenbrock (2015) state that this channel provides a window into social dynamics in the workplace. Drucker (1967) puts forward a striking definition of a meeting's purpose: "We meet because people holding different jobs have to cooperate to get a specific task done". Hence, scheduled meetings can be a platform for productive collaboration across disciplines (Romano and Nunamaker, 2001). But, despite this reasonable definition, numerous studies, as highlighted in an extensive literature review by Romano and Nunamaker (2001), reveal that this communication channel is often considered to be costly, unproductive and dissatisfying, and employees evaluate almost half of their meetings as ineffective (Schell, 2010, Lehmann-Willenbrock et al., 2016). Meeting minutes are often a result of formal meetings. They provide historical reference of an organisation's business, reducing the possibility of disagreement of what was discussed and decided, when and by whom (Waibel et al., 2001, Stanton, 2004). Buchanan (2000) summarises the value of minutes poignantly: "A good set of minutes can give the group a sense of progress; incoherent jottings […] leave everyone bewildered." (p.94-95).

The term Facility Management (FM) (also known as Facilities Management) is defined in an industry-neutral way as "integration of processes within an organisation to maintain and develop the agreed services which support and improve the effectiveness of its primary activities" (CEN, 2006). As primary activities differ depending on an organisation's purpose, the term FM is used in a broad range of contexts and contains many different supporting services. Regarding the organisation "hospital", Gerber et al. (2014) offers a clear and comprehensive definition and differentiation of the non-medical support services in hospitals. This information facilitates a common understanding of the type and scope of the services (Gerber and Klauser, 2015), as displayed in figure 1.

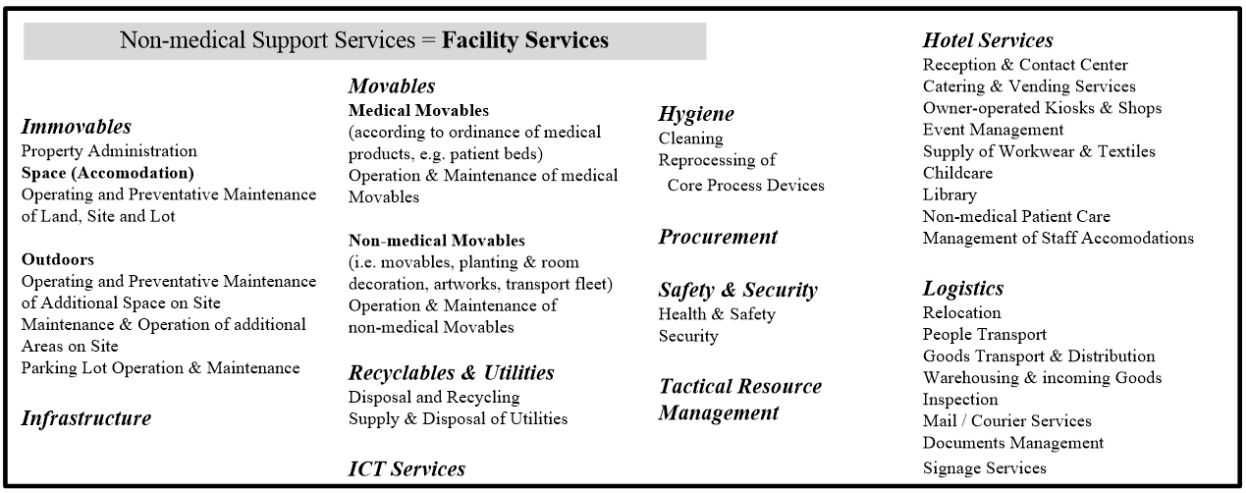


Figure 1: FM in hospitals – service allocation, source: based on Gerber and Klauser (2015)

The work from Gerber (2014) defines what can be put under the umbrella of FM in hospitals, but does not elucidate upon how FM is organisationally structured within individual hospital organisations. There are no mandatory standards of how to implement the FM part in the hospital's organisation. Furthermore, the term FM is not consistently used in most hospitals organisational structure (Honegger et al., 2016). Raab (2001) mentions the fact that structures and organisation forms are the way they are for historical reasons and that they do not always match the current requirements. However, FM accounts for up to 25-40% of a hospital's total costs (Abel and Lennerts, 2006, Jensen, 2008). Hence, out of the CHF 30 billion of healthcare cost caused by Swiss hospitals (BFS, 2018), about 60-75% is consumed by a hospital's core activities, medical and care leaving the substantial amount of up to approximately CHF 11 billion in the responsibility of hospitals FM. That alone justifies why a closer look at how FM processes are structured and thus FM services are delivered in hospitals, in addition to what part organisational communication plays in the setting of FM in hospitals.

3. METHODOLODGY

The inquiry strategy is based on a multiple case study. The unit of analysis / the case = communication activities within a hospital's FM department; the sampling rationale for the cases is rooted in the general care hospital population in German speaking Switzerland, where there are single and multiple site hospitals. The case sample consists of case 1= One (1) single-sited hospital and case 2 = One (1) with three (3) sites. Data collection includes non-publicly accessible minutes of diverse meetings, taking place within the two cases. The sampling of the minutes was purposive. Access to the minutes focusing on department, division and sub-division meetings was obtained via the heads of FM, acting as the gatekeeper for the two cases. The minutes were taken by persons other than the researcher, which classifies them as "secondary data" (Saunders et al., 2016). To acquire rich data on these, a whole year - at the point of data collection this was 2016 - was looked at. To overcome the heterogeneity of the FM department's organisational structures and to guarantee their confidentiality, the individual organisational structure of the two cases is subsumed into four major FM disciplines: catering, housekeeping, infrastructure / engineering, procurement & logistics. Figure 2 shows how many minute documents within these disciplines are analysed.

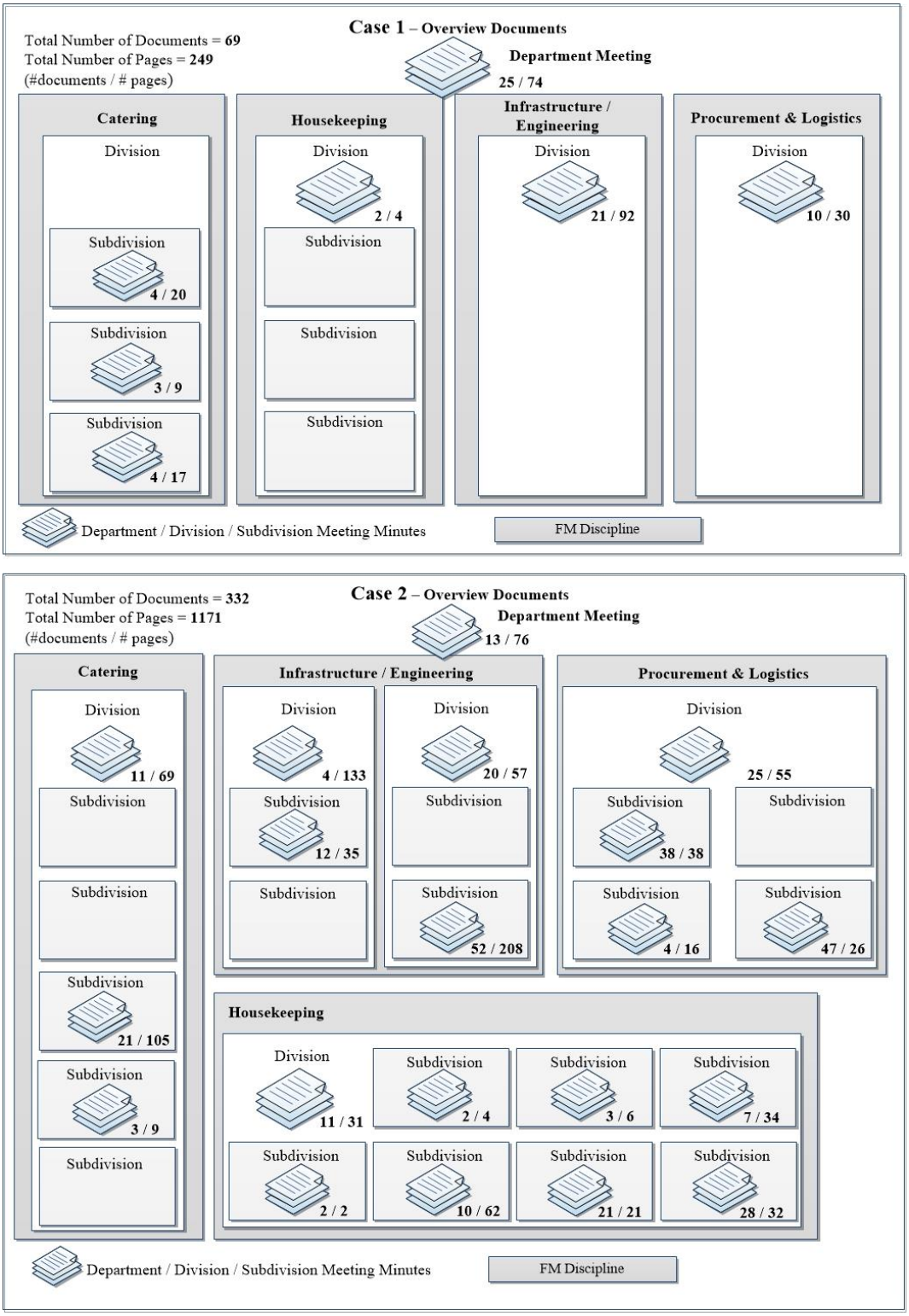


Figure 2: Overview analysed documents in case 1 and case 2

Over the two cases, a total of *402 documents* with a total of *1420 pages* are analysed. Some sub-divisions did not provide minutes. This is due to their communication procedures, where such documents are not produced. Data analysis is based on rigorous qualitative coding procedures, primarily guided by Saldana (2016) and Flick (2009). Coding was led by a predefined list of categories (= *a priori* codes). Their predefinition was led by the theoretical

background with respect to organisational communication, meetings and use of minutes, and by the structure of the cases' FM organisation. These categories were complemented by subcategories based on codes which emerged during the coding process. The coding list developed is visualised in table 1, categories with an * were used in all FM disciplines.

Table 1 Categories used to code documents

Category Name	**Description**
Adaptive (*a priori*)	Adaptive Function: referring to a constant information exchange between the organisational system and the environment to suitably adapt to environmental change (Modaff et al., 2016). For this analysis, this is specified as content from the hospital and its external environment impacting the FM that meeting participants can not necessarily retrieve themselves, content they need to know to carry out their tasks and maintain their processes.
Hospital Environment	Information from the hospital presented by the department / division / subdivision manager
Department / Division Environment	Information passed on from department level, which is found in division and sub-division minutes, presented by the division head and subdivision head.
Constitutive (*a priori*)	Constitutive Function: creating connections and acting as a binder allowing the coordination of activities and integrating the elements as a whole (Modaff et al., 2016). For this analysis, this is specified as the coordination of activities taking place within the meeting and is thereby an active part in contrast to the passive meeting action of merely passing on information.
Maintenance (a priori)	Maintenance Function: as it provides information throughout organisational systems to ensure a dynamic steady state (Modaff et al., 2016). For this analysis, this incorporates information exchange within FM - nice to know but not explicitly necessary for participants (information receiver) to maintain their processes.
lateral	Information presented by division / sub-division heads to the meeting participants present, which are mostly at same hierarchical level. Therefore, it is classified as lateral information.
Catering	FM discipline including: kitchen, restaurant, event management
Housekeeping	FM discipline including: cleaning, supply of work-wear and textiles, staff accommodation, reception services
Infrastructure / Engineering	FM discipline including: site maintenance, operation and maintenance of non/medical and medical devices, security
Division Information*	Contains information about current projects, responsibilities and tasks that are being carried out within the respective division and are dealt with in division meetings.
Staff issues*	Refers to information regarding staff decisions, allocations, personal issues
Subdivision * Information	Contains information about current projects, responsibilities and tasks that are being carried out within the respective subdivision and are dealt with in division meetings.

Purchasing & Logistics	FM discipline including: goods procurement, transport and distribution, warehousing, document management
Investments (emerged code)	Contains information directly related to investment decisions
Projects (emerged code)	Contains information directly related to purchasing projects
Miscellaneous	FM disciplines not considered (due to a similar adaption of the two cases) but which deliver content in the analysed documents.
Staff Issues	Refers to information on staff decisions, allocations, personal issues
Top down	Information from department / division / sub-division head (meeting chairs) classified as overarching information of interest to all participants.

Every item of information within the documents was coded accordingly. This led to categories of data, then to themes and concepts and thus to assertions and conclusions. In order to demonstrate the robustness of these categories, table 2 displays examples of data supporting their development based on minutes from catering. The distinction of different items of information was made due to their presentation in the minutes (e.g. as bullet points) and with the researcher's background knowledge. The language is German, *italics* represent the English translation.

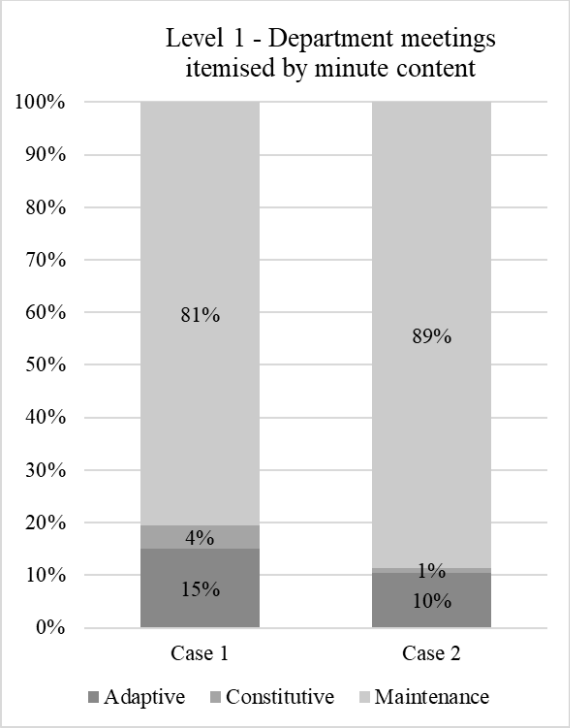
Table 2: Demonstration of data supporting the categories – *example catering division*

Category Name	**Data supporting category = minute excerpts**
Adaptive	
Hospital Environment	• Die vorliegenden Unternehmensziele 2016 wurden von der GL verabschiedet. *The hospital board approved the present corporate goals 2016*.
Department / Division Environment	• Grippeimpfung Es haben sich in dieser Saison doppelt so viele Mitarbeitende gegen Grippe impfen lassen, als im Vorjahr. *Flu jab: This year, twice as many employees have been vaccinated against the influenza virus than in the previous year.* • Wer neuer Verwaltungsratspräsident wird, steht noch nicht fest. *The new Chairman of the Board of Directors has not yet been decided on.*
Constitutive	• Am 9.5.2016 findet die ERFA Tagung KAPO/Spital statt. Gibt es Themen aus dem Bereich? *On 9.5.2016, meeting xyz takes place; are there any topics for it from the department?* • Die Auswertung der neuen Pikettzeiten muss erarbeitet werden, bis wann erhält xyz einen Vorschlag? *The evaluation of the on-call times must be worked out; by when will xyz receive a proposal?*
Maintenance ***lateral***	
Division Information	• Voraussichtliche Eröffnung neues Restaurant Juni 2018. *Expected opening of new restaurant June 2018*

Staff issues	• Das Probezeitgespräch mit xyz wurde geführt und war beidseitig sehr positiv. *The probationary interview with xyz was conducted with a positive result on both sides.*
Subdivision Information	• Im Restaurant wurden erstmals über 600 Essen, alleine vom warmen Buffet verkauft. *For the first time, the restaurant has sold over 600 meals from the warm buffet alone.* • Das Glace Sortiment 2016 wurde für alle 3 Standorte definiert. *The 2016 ice cream assortment has been defined for all 3 sites.*
Top down	• Ziele 2016 für den Bereich werden in einer separaten Sitzung vom 14.1.2016 besprochen. *The 2016 department goals will be discussed in a separate meeting on 14.1.2016*

4. RESULTS & DISCUSSION

With reference to the common schematic representation of the structure of meeting minutes, it can be said that the documents analysed do contain the required formal elements: heading, participants, approval of previous minutes and mentioning of the next meeting. However, regarding the nature of their content, many more maintenance elements, represented as items of information, than constitutive elements, represented as hints of discussion with conclusions reached within the meetings were detected. This can be seen in figure 3, displaying level 1 minutes (department meetings) itemised by minute content and also in figure 4, displaying the same itemisation in level 2 minutes (division meetings). The displayed case 1 and case 2 refer to the two samples as introduced in figure 2. These result contradict literature stating that scheduled meetings should be a platform for productive collaboration across disciplines (Romano and Nunamaker, 2001), especially as maintenance elements contain information exchange within FM that is “nice to know” but not explicitly necessary for all meeting participants to maintain their processes. Figure 3 also displays the minutes itemised by FM disciplines. Division meetings have not been itemised per FM discipline as they focus on just one discipline, meaning their respective division such as catering or cleaning. The results differ across the cases, but infrastructure / engineering content consumes many items, which reflects the complex nature of this discipline.



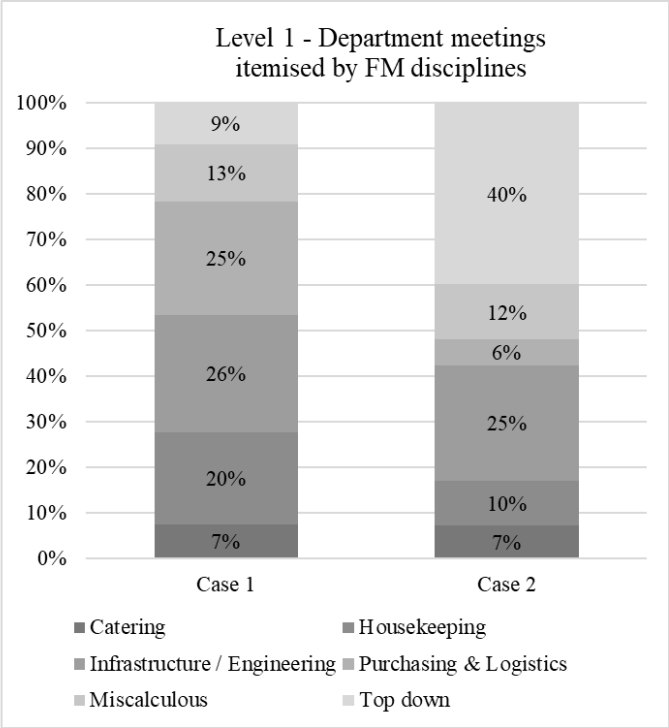


Figure 3: Minutes of department meetings itemised by content and FM disciplines

The literature section stated that employees evaluate almost half of their meetings as ineffective (Schell, 2010, Lehmann-Willenbrock et al., 2016). Employees siting in such FM meetings expecting a sense of cooperation will certainly evaluate the meeting negatively, whereas clarification on meeting purpose and managing expectations improves meeting perception and hence the use of meetings as such.

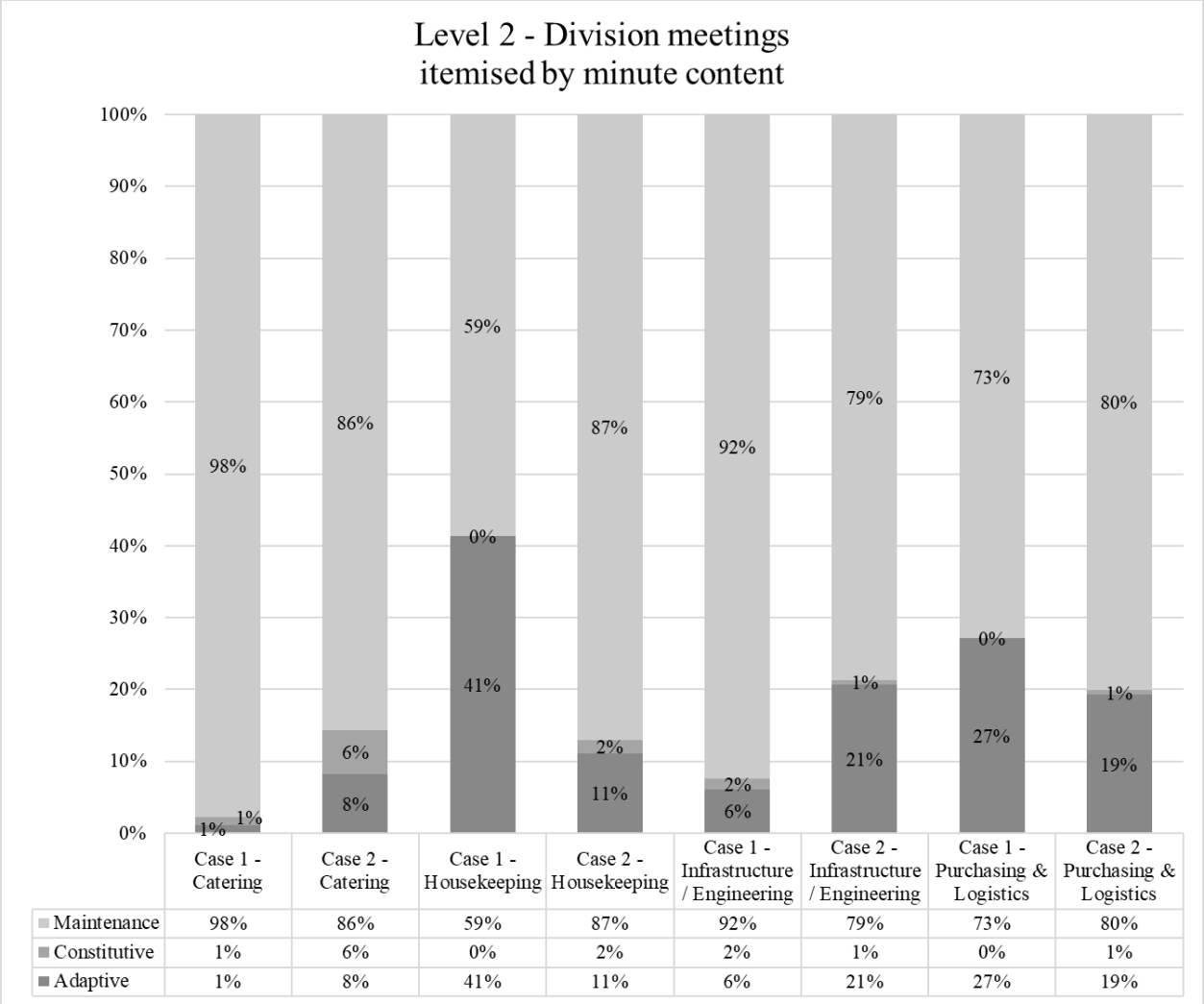


Figure 4: Minutes of division meetings itemised by content

These results are based on a total of 3474 codes extracted and hence itemised out of the minute documents.

5. CONCLUSION

This research set out to systematically analyse minutes produced in FM meetings taking place in Swiss general hospitals. Findings show that minutes predominantly display maintenance information and only few constitutive elements. Despite the constitutive function of meetings being the one element that uses the collaboration potential of meeting participants for the benefit of FM. The findings are based on a case study and are therefore assertions and not generalisations. Nevertheless, they and the method leading to them, provide a guideline for FM executives to analyse and if applicable improve minute taking practices and, critically, to improve their meetings. In times of a tightening financial environment within the healthcare context, available resources such as meeting time must be used to their full extent. Future research can include to determine structures of FM department meetings specifically addressing the participants diverse backgrounds across FM disciplines.

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Factors influencing the occurrence of food waste in the food service process in hospitals – a literature review

Gabriela V. Leiblein-Züger
Liverpool John Moores University, Built Environment and Zurich University of Applied Sciences, Institut of Facility Management
G.V.Zueger@2014.ljmu.ac.uk , gabriela.leiblein@zhaw.ch
+41 58 934 59 66

Matthew Tucker
Liverpool John Moores University, Business School
M.P.Tucker@ljmu.ac.uk

Susanne Hofer
Zurich University of Applied Sciences, Institut of Facility Management
susanne.hofer@zhaw.ch

ABSTRACT

Purpose: Food waste is a current and very important topic everywhere food is produced and consumed. From the facility management perspective, food wastage involves much more than just wasted food. Food waste is process waste as it manifests where process steps are probably not working very well. Of course, food waste has always, and will always, occur to some extent. However, the amount and the areas where food waste arises in the food service process is of high value to know.

Methodology: The project is based on a literature review about factors influencing the food waste along the food service process in hospitals. The literature was searched in German, English, French and Swedish and was among the main topics of the search food provision, food service in healthcare organisations, malnutrition and food waste research. At the same time, all publications were recorded in a database. In a next step, the literature was assigned to one or more process steps or topics based on the factors described. This was followed by the renaming and combination of the factors to obtain a general wording.

Key findings: The results derived from this is a list of factors related to food waste in the food service process in hospitals. It contains more than 100 factors divided into the fourteen process steps of the food service process as well as two holistic topics regarding hospitals in general. Overall, there is a larger number of factors related to the process steps at the beginning of the food service process than later on, means after consumption. Furthermore, results show that the food service process is a difficult and demanding process. The fact that patients go to hospital to get well and not to eat, makes the whole situation additionally challenging.

Intended impact of the study: For the first time food waste from a facility management perspective was looked at in such detail. The food waste factors from literature are the basis to develop an observation guideline to complete the list of factors. Furthermore, these factors provide valuable insights about the complexity of food waste reduction as well as providing ideas to reduce food waste in the food service process in hospitals.

Paper Type: Research Paper

Keywords: Food Service, Food Waste, Hospital, Process optimisation, Facility Management

1. INTRODUCTION & BACKGROUND

Due to the rising population as well as the economic growth, more food is needed worldwide (Alexandratos and Bruinsma (2012) as cited in Halloran et al., 2014 p. 294). Therefore, the necessity to reduce food waste is of urgent concern. (Alexandratos and Bruinsma (2012) as cited in Halloran et al., 2014 p. 294). The Food and Agriculture Organization of the United Nations (FAO) (2014) and the European Parliament have concluded that the reduction of food waste can only be achieved when reliable data is available (Kranert et al., 2012). Currently, there is a critical lack of data regarding food waste (Betz et al., 2015). This is also the case looking at food waste from a facility management (FM) perspective. So far food waste research in the food service process had the aim to learn about the nutritional situation of people (Williams and Walton, 2011). For FM food waste can be looked at as process waste, as a not well working process leads to process waste. The process of food service has the characteristic that process waste is measureable as food waste is a valuable and measureable type of waste. Other FM processes do not have such a type of process waste as e.g. idle runs and miscalculations are not generating this kind of waste as food waste is for the food service process. From an FM perspective, it is therefore important to know which factors influence food waste in the various process steps or the process as a whole. Therefore, the aim of this study is to discover the various factors related to food waste based on literature along the food service process. The related research question is:

Which factors in the literature influencing food waste along the food service process are described?

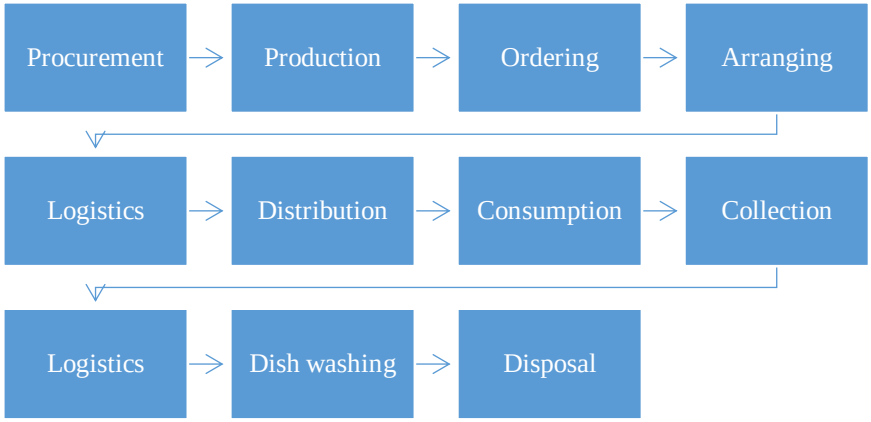
The field of research refers to hospitals because food is classified as food waste in these institutions much faster than in other institutions, for more explanation see section food waste in hospital.

This research paper is based on four chapters. In chapter 1, the introduction and background to the study are outlined. The introduction is already provided in the lines above. In the next paragraphs, the background information aligned to this research is in focus. This is followed by the methodology in chapter 2. In chapter 3, the findings of the study are explained and discussed. Finally, chapter 4 contains the conclusion, relevance of findings as well as some comments regarding further research.

Food service in hospitals

According to Lennerts (2009 p. 177), around 9% of the costs spent for facility management in hospitals are related to food service. This finding is in line with the number of 'BEG Analytics AG' (2017), which found out that 2 - 11% of the overall costs are spent on food service. In addition, the quality and experience of patients with the food is one of the most important factors for a hospital's image (Aden and Schneider, 2012, von Eiff, 2012). Therefore, the food service has an important role for FM as well as for the whole hospital. The food service process, is according to Wilson, Evans and Frost (2000) as cited in Walton (2012 p. 223) the most complex in the whole hospital context. The different steps are shown in Figure 1 and explained below the figure.

Figure 1 Visualisation of food service process in hospitalsbased on Bober (2001), Kelm et al. (2008), Kreutz (2012), Arens-Azevêdo and Lichtenberg (2011)



In the following, the food service process shown in Figure i is explained step by step. The description is based on Bober (2001), Kelm et al. (2008), Kreutz (2012), Arens-Azevêdo and Lichtenberg (2011). The food service process starts with Procurement. In this process step, goods are ordered and stored until they are used. In the next step, Production, the dishes are prepared and produced. Meanwhile, the customers select their meal in the process step Ordering. Based on this information, the Arranging of the meals is carried out. The trays ready for the patients are then transported to the wards in the process step Logistics. As a next step, the delivered trays are Distributed to the patients. During Consumption, patients eat their meals. After that, the trays are collected and brought back to the kitchen area for Dish washing. With the Disposal of the food waste as well as the other types of waste, the process chain ends.

The process steps described above are the basis for the data collection as well as the data analysis in the PhD project. In Swiss hospitals, the food production for the various customer groups, such as patients, staff, visitors and external customers, is done at the same time and mostly with the same facilities and staff.

Food waste in hospital

Research conducted in hospitals with respect to food primarily deals with the topic of patient malnutrition. The measurement of food waste has been a side issue in these studies over the last 50 years (Barton et al., 2000, Dupertuis et al., 2003, Edwards and Nash, 1999, Sonnino and McWilliam, 2011, Williams and Walton, 2011). Initial measurements of food waste from a facility management perspective, however, have revealed the dimension of the issue. 15% of all the trays delivered to the ward to be consumed by the patients return to the dish washing area for disposal untouched (Züger and Honegger, 2014). Furthermore, 30% of the cost of goods spend for patients meals are thrown away (Züger and Honegger, 2014). These costs include only the amount of waste from the meals prepared for the patients. As all food and beverages which have entered a patient's room needs to be disposed of, the food waste problem can only be minimised when the whole process of food service in hospitals is looked at and improved.

2 METHODOLOGY

This study is based on a literature review. According to Wilson (2010 p.55) "A literature review can be described as 'identifying, evaluating and critically assessing' what has been published on your chosen topic". Furthermore, a literature review needs to be seen as a process (Saunders et al., 2016, Wilson, 2010). The literature review conducted with respect to the topics of the theoretical part as well as the important factors regarding food waste in the different food

services process steps. As a first step, literature was collected. This was done in German, English, French and Swedish. Additional literature in Danish and Norwegian was considered, as the writing is similar to Swedish. The key topics for the research were food provision, food service in healthcare institutions, malnutrition and food intake, general food waste research as well as food waste reduction in the out-of home catering, interdisciplinary cooperation in the food service process in hospitals and food waste experiences from hotel management. In a second step, which was concurrent with the first, one the literature found was collected in a database for literature. In a third step the literature was assigned to the corresponding process steps, based on the factor descriped. Mostly the belonging was clear based on the literature and the content described. Where this was not the case the researcher decided to which process step this factor belong to. As the food service process is highly standardised regarding the different process steps, the allocation structure was clear. The additional topics of general hospital and overall arise while analysing the literature. The fourth step was to rename and combine factors that belong to the same process step and have the same meaning. This leads to the fact that most factors have more than one source, as displayed in the findings.

3 FINDINGS

The influencing factors collected based on the literature review are assigned to the different process steps of the food service process as well as to two holistic hospital-related topics - Overall and General Hospital. Overall refers to the food service process as a whole, while General Hospital focuses on topics regarding the hospital setting itself. In total, 107 influence factors related to food waste are collected. The number of food waste factors for each process step as well as the two additional topics are shown in Table 1. Most factors are related to Overall and General hospital. Looking at the food service process steps, Planning, Procurement, Storage, Producing and Arranging have ten or more factors. Of the remaining steps, Ordering and Service–distribution have between five and ten factors, while have the process steps Preparing, Logistics to ward, Disposal and Accounting have between one and five food waste factors. No such factors were found in the literature with respect to Service collection, Logistics from ward and Dish washing.

Table 1 Overview number of food waste factors

	Number of factors related to food waste
Planning	11
Procurement	10
Storage	10
Preparing	1
Producing	13
Ordering	7
Arranging	11
Logistics to ward	1
Service distribution	7

Service collection	0
Logistics from ward	0
Dish washing	0
Disposal	3
General hospital	14
Overall	17
Accounting	2

The detailed list of all 107 factors from literature related to food waste are shown in the Table 2. In the right column the factors are listed and in the left column the related reference(s) are shown. Each parts starts with a clear heading naming the process step or the topic the following factors belong to. After every list of factors, a short summary is given to provide a better understanding of the factors.

Table 2 list of food waste factors along the food service process

Factors	References
Planning	
Improved menu management	(Barton et al., 2000, Höss, 2014)
Calculation of quantities	(Fachhochschule Münster Institut für Nachhaltige Ernährung und Ernährungswirtschaft, 2014, Beretta, 2013, Göbel et al., 2014b, Goonan et al., 2014, Schendekehl, 2014, Canali et al., 2014, Göbel and Blumenthal, 2014)
Expectations target groups	(2014, Göbel et al., 2014b, Höss, 2014, Schendekehl, 2014, Canali et al., 2014, Göbel and Blumenthal, 2014)
Menu card	(Göbel et al., 2014a, Schweizer Eidgenossenschaft Projektgruppe Food Waste, 2013)
No choice/improve choice	(Dupertuis et al., 2003, Precey, 2008, NHSE Hospitality, 2005, McCaffree, 2009)
Optimised planning	(Beretta, 2013, Göbel et al., 2014a, Göbel et al., 2012, Goonan et al., 2014, Rohner, 2014, Schendekehl, 2014, Wagner, 2015, Canali et al., 2014)

Precise goods scheduling	(Schendekehl, 2014)
Quality reviews	(Precey, 2008, Iff et al., 2008)
Regional dishes	(Fachhochschule Münster Institut für Nachhaltige Ernährung und Ernährungswirtschaft, 2014, Friedrich et al., 2010, Göbel et al., 2014b)
Seasonal dishes	(Fachhochschule Münster Institut für Nachhaltige Ernährung und Ernährungswirtschaft, 2014, Göbel et al., 2014a, Göbel et al., 2014b)
Variation in demand	(Göbel et al., 2014a, Stenmarck et al., 2011, Huber, 2009)
The above mentioned factors are relevant to avoid food waste already in the planning stage due to the targeted orientation of the product range.	
Procurement	
Careful supply chain management	(Chardoul and Coddington, 2012, Goonan et al., 2014)
Defined responsible person for procurement	(Schendekehl, 2014)
Flexible suppliers	(Schweizer Eidgenossenschaft Projektgruppe Food Waste, 2013)
Knowledge of what is on stock	(Beretta, 2013, Schendekehl, 2014)
Lack of good practice	(Canali et al., 2014)
Lack of knowledge	(Beretta, 2013, Stenmarck et al., 2011)
Deliveries and amounts geared to internal processes	(Göbel et al., 2012, Höss, 2014, Schendekehl, 2014, Stenmarck et al., 2011)
Regional suppliers	(Beretta, 2013, Friedrich et al., 2010, Schweizer Eidgenossenschaft Projektgruppe Food Waste, 2013)
Procurement source reduction	(Chardoul and Coddington, 2012)
Warehouse management system	(Fachhochschule Münster Institut für Nachhaltige Ernährung und Ernährungswirtschaft, 2014, Schendekehl, 2014)
Factors in procurement show that food waste can be avoided with the help of tools, due to the overview they provide.	
Storage	

Careful storage	(Beretta, 2013, Göbel et al., 2014a, Göbel et al., 2012, Canali et al., 2014)
Chilled or frozen food is stored immediately	(Engström and Carlsson-Kanyama, 2004, Göbel et al., 2014a)
Equipment and containers	(Huber, 2009, Canali et al., 2014)
Vacuum treatment	(Wagner, 2015)
Principle of "first in first out"	(Schendekehl, 2014)
Expiration of best-before date	(Göbel et al., 2014a, Göbel et al., 2012, Stenmarck et al., 2011, Canali et al., 2014)
Appropriate temperature scheme for food which is kept warm and served portion-wise	(Engström and Carlsson-Kanyama, 2004)
Space to store leftovers	(Engström and Carlsson-Kanyama, 2004)
Storability	(Schendekehl, 2014)
Time needed to prepare leftovers for storage	(Engström and Carlsson-Kanyama, 2004)
Factors in the storage process step show that the handling of food in relation to storage is essential to avoid food waste.	
Preparing	
Portionable frozen food	(Schweizer Eidgenossenschaft Projektgruppe Food Waste, 2013)
Preparing has only one factor, therefore this is more an example who food waste can be prevented.	
Producing	
Colour	(Stroebele and De Castro, 2004)
Cooking	(Dupertuis et al., 2003)
Flexibility to tailor production ot changing demands	(Fachhochschule Münster Institut für Nachhaltige Ernährung und Ernährungswirtschaft, 2014, Göbel et al., 2014b)
Inappropriate food is served	(Dupertuis et al., 2003, Edwards and Nash, 1999, Thibault et al., 2011)
Nutritional quality	(Díaz and García, 2013, Höss, 2014)
Overproduction	(Schendekehl, 2014, Fachhochschule Münster Institut für Nachhaltige Ernährung und

	Ernährungswirtschaft, 2014, Göbel et al., 2014b, Göbel et al., 2012, Goonan et al., 2014)
Recipes	(Göbel et al., 2014a, Göbel et al., 2014b, Höss, 2014)
Reuse of leftovers	(Beretta, 2013, Göbel et al., 2014a)
Seasoning	(Betz et al., 2015, Huber, 2009)
Smell	(Stroebele and De Castro, 2004)
Taste	(Díaz and García, 2013, Dupertuis et al., 2003, Göbel et al., 2012)
Temperature	(Stroebele and De Castro, 2004, Huber, 2009)
To fatty food	(Betz et al., 2015)
Many factors are related to the characteristics of the food produced.	
Ordering	
Asking menu size	(Schendekehl, 2014, Ofei et al., 2014, NHSE Hospitality, 2005)
Food preferences	(Barton et al., 2000, Göbel et al., 2014a)
Menu system to order meals	(Goonan et al., 2014, Doward, 2013, Göbel et al., 2014a, Ofei et al., 2014, NHSE Hospitality, 2005)
Optimising feeding of patient	(Dupertuis et al., 2003, Höss, 2014)
Excess ordering	(Barton et al., 2000, Sonnino and McWilliam, 2011, Canali et al., 2014)
The absence of patient-self menu selection	(Thibault et al., 2011)
Lead time for ordering	(Ofei et al., 2014, NHSE Hospitality, 2005)
These factors show that a menu ordering system is central to systematically making orders together with patients/guests.	
Arranging	
Additional meals prepared as backup	(Precey, 2008)
Amount ordered was not amount delivered	(Edwards and Nash, 1999, Göbel et al., 2014b, Sonnino and McWilliam, 2011, Göbel and Blumenthal, 2014)
Buffet is loaded during the whole service time	(Fachhochschule Münster Institut für Nachhaltige Ernährung und Ernährungswirtschaft, 2014, Göbel et

	al., 2014a, Schendekehl, 2014, Göbel and Blumenthal, 2014)
Buffet is loaded fully every day	(Fachhochschule Münster Institut für Nachhaltige Ernährung und Ernährungswirtschaft, 2014, Göbel et al., 2014a, Göbel and Blumenthal, 2014)
Calculated portions are not ladle portions	(Fachhochschule Münster Institut für Nachhaltige Ernährung und Ernährungswirtschaft, 2014, Göbel et al., 2014a, Göbel et al., 2014b, Göbel and Blumenthal, 2014)
Creative arranging	(Wagner, 2015, Huber, 2009)
Flexible arranging of buffet	(Wagner, 2015)
Portioning	(Schweizer Eidgenossenschaft Projektgruppe Food Waste, 2013, Fachhochschule Münster Institut für Nachhaltige Ernährung und Ernährungswirtschaft, 2014, Precey, 2008, Göbel et al., 2014b, Göbel et al., 2012, Iff et al., 2008, Huber, 2009, Göbel and Blumenthal, 2014)
Too much food served for oneself by own choice	(Betz et al., 2015, Roth, 2014)
Customers expect shelves to be fully stocked	(Stenmarck et al., 2011)
Portioning size standards	(2014, Höss, 2014, Göbel et al., 2014a)
Factors of arranging show that the right dish should be served in the right quantity.	
Logistics to ward	
Meals are served too late (Process problem logistics and service)	(Edwards and Nash, 1999)
Logistics to ward has only one factors, it shows that cooperation is essential.	
Service distribution	
Few people responsible for food service distribution to patients	(Almdal et al., 2003)
Aid for patient with problem to eat independently	(Dupertuis et al., 2003, Barton et al., 2000)
Member of staff with well-defined responsibility	(Dupertuis et al., 2003, Almdal et al., 2003)
Member of staff with special training	(Dupertuis et al., 2003, Almdal et al., 2003, Precey, 2008, Göbel et al., 2014a, Iff et al., 2008, Sonnino and McWilliam, 2011, Fachhochschule Münster

	Institut für Nachhaltige Ernährung und Ernährungswirtschaft, 2014, NHSE Hospitality, 2005, McCaffree, 2009)
No nursing staff	(Dupertuis et al., 2003, Almdal et al., 2003, Precey, 2008, Doward, 2013)
Service of food	(Dupertuis et al., 2003, Barton et al., 2000, Doward, 2013, Sonnino and McWilliam, 2011, McCaffree, 2009)
Inadequacy of meal serving time	(Thibault et al., 2011, Sonnino and McWilliam, 2011)
Factors show that service of food is a difficult and demanding task that belongs in the capable hands of professionals.	
Service collection	
This process step was probably not considered, as consumption is already through and the food waste quantity can no longer be directly influenced.	
Logistics from ward	
As mentioned for service collection the reason is probably the same.	
Dish Washing	
As stated for service collection the reason is most likely the same.	
Disposal	
Absence of a feedback system for food waste	(2014, Göbel et al., 2014a, Goonan et al., 2014, Doward, 2013, Ofei et al., 2014, Roth, 2014)
Prohibition of feeding food waste to animals in Switzerland	(nd, Canali et al., 2014)
Number of waste collections per week	(Baier and Reinhard, 2007)
Factors in the process step of disposal have no direct influence on the actual food waste situation. Nevertheless, the information about the amount and type of food waste disposed can be of great help as feedback loop.	
General hospital	
Meal means highlight of the day for patients	(Edwards and Nash, 1999)
Increased morbidity	(Dupertuis et al., 2003)
Interruption while eating	(Betz et al., 2015, Edwards and Nash, 1999)

Absence of hunger	(Betz et al., 2015, Stanga et al., 2003, Huber, 2009, Kondrup, 2001)
Discomfort	(Betz et al., 2015)
Malnutrition	(Almdal et al., 2003, Dupertuis et al., 2003, Kondrup, 2001)
Mortality	(Dupertuis et al., 2003)
Patient is discharged from hospital	(Barton et al., 2000, Goonan et al., 2014)
Patient must keep an empty stomach	(Barton et al., 2000, Goonan et al., 2014)
Patient is transferred	(Barton et al., 2000, Goonan et al., 2014, Ofei et al., 2014)
Physical setting	(Stroebele and De Castro, 2004)
Presence of other people	(Stroebele and De Castro, 2004)
Stress	(Betz et al., 2015)
Time pressure	(Edwards and Nash, 1999)
These factors show that eating in hospital is important but not the reason to be there.	
Overall	
Benchmarking	(Fachhochschule Münster Institut für Nachhaltige Ernährung und Ernährungswirtschaft, 2014)
Communication between teams	(Fachhochschule Münster Institut für Nachhaltige Ernährung und Ernährungswirtschaft, 2014, Friedrich et al., 2010, Göbel et al., 2014a, Schendekehl, 2014, Wagner, 2015, Huber, 2009, Ofei et al., 2014, NHSE Hospitality, 2005, McCaffree, 2009, Göbel and Blumenthal, 2014)
Communication with customer	(Engström and Carlsson-Kanyama, 2004, Göbel et al., 2014a, Fachhochschule Münster Institut für Nachhaltige Ernährung und Ernährungswirtschaft, 2014)
Cross-linking and overlapping tasks with others	(Fachhochschule Münster Institut für Nachhaltige Ernährung und Ernährungswirtschaft, 2014, Göbel et al., 2014a, Goonan et al., 2014, Halloran et al., 2014, Schendekehl, 2014, Huber, 2009)

Doggy bag	(Schweizer Eidgenossenschaft Projektgruppe Food Waste, 2013, Wagner, 2015)
Flexibility	(Dupertuis et al., 2003, Fachhochschule Münster Institut für Nachhaltige Ernährung und Ernährungswirtschaft, 2014, Canali et al., 2014)
Information and knowledge flow	(Fachhochschule Münster Institut für Nachhaltige Ernährung und Ernährungswirtschaft, 2014, Barton et al., 2000, Goonan et al., 2014, Schendekehl, 2014, Sonnino and McWilliam, 2011)
Duration of stay	(Dupertuis et al., 2003)
Meal time	(Dupertuis et al., 2003, Huber, 2009, NHSE Hospitality, 2005)
Process feedback system	(Fachhochschule Münster Institut für Nachhaltige Ernährung und Ernährungswirtschaft, 2014, Goonan et al., 2014)
Protected meal times	(Connolly et al., 2011, Doward, 2013, Sonnino and McWilliam, 2011, NHSE Hospitality, 2005)
Quality	(Barton et al., 2000, Díaz and García, 2013, Doward, 2013, Dupertuis et al., 2003, Goonan et al., 2014, Höss, 2014)
Sensitisation of staff	(Fachhochschule Münster Institut für Nachhaltige Ernährung und Ernährungswirtschaft, 2014, Göbel et al., 2014a, Goonan et al., 2014, Schendekehl, 2014)
Staff awareness of economic value of food waste	(Engström and Carlsson-Kanyama, 2004, Göbel et al., 2014a, Göbel and Blumenthal, 2014)
Staff ideas for reducing losses	(Engström and Carlsson-Kanyama, 2004, Schendekehl, 2014)
Support executive board	(Fachhochschule Münster Institut für Nachhaltige Ernährung und Ernährungswirtschaft, 2014)
Further use of unserved meals on the ward	(Ofei et al., 2014)
Factors show that the catering process has a lot to do with people throughout the process, so cooperation is essential.	
Accounting	
Weight-related menu prices	(Engström and Carlsson-Kanyama, 2004)

Smart price arrangements	(Wagner, 2015)
Accounting has no direct impact on food waste as these two factors show but financial incentives can help to avoid potential food waste.	

Findings show that a high variety of factors is related to food waste. The presented list is certainly not complete but provides a detailed overview. The selection of search topics in the literature research has certainly had an influence on the fact that some process steps contain more detailed factors and others less. However, it has been noticed in many articles that consumption is the main focus. The majority of these factors were not taken into account in these results, most of them can still be found in the categories Overall and General Hospital. If factors specifically referred to production, they were added to Production. The fact that some process steps have no or hardly any factors related to food waste is therefore not directly related to the literature used but much more to the fact that these process steps have not been researched.

4 CONCLUSION

Process steps at the beginning have more influence based on a larger number of factors than process steps later in the process. This is not surprising due to the process logic that nothing can be changed regarding food waste after consumption. Overall, the factors show that the food service process is a difficult and demanding process. There are many different people involved in the process who have to co-operate with each other to ensure a target food service. To make it more difficult, guests did not come to the hospital to eat, but to get well.

In further research, the list of food waste factors can be used as basis for an observation guideline to complete the picture of food waste factors from an FM perspective. Which than can be used to invent a tool to help FM partitions analysing and in a further step optimise their food waste situation. In addition the list of factors related to food waste in hospitals can be developed further to be applied to other food service providers.

These findings are relevant for facility managers responsible for the food service process as they provide concrete indicators as to what avenues can be explored in the quest to reduce food waste. In addition, the results show how complex and interlinked food waste reduction is. Furthermore, this is an important initiative as it is the first time food waste has been looked at in such detail from a facility management perspective and will greatly facilitate meaningful progress in this area.

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Urban Facility Management for Healthy Cities

Mark Mobach
Hanze University of Applied Sciences Groningen, The Netherlands
Research Group Facility Management
m.p.mobach@pl.hanze.nl
+31 50 595 2833

ABSTRACT

Purpose: Worldwide, sedentary behaviours and overweight are major health concerns. Most adolescents are insufficiently physically active and have overweight. Moreover, most work is sedentary or requires only light activity. And most people live in cities, a context which discourages participation in physical activity. How can we change this situation? An analogy between urban design and facility design is introduced to elucidate spatial properties that may be beneficial in both contexts. It is the purpose of this paper to use this analogy for the advancements of health and well-being of both workers and city dwellers.

Methodology: The principles of abductive reasoning were followed. Abduction as a first phase of scientific investigation, in this case a process of introducing a new idea and attentive observation of phenomena in the communities of facility management, public health, and urban design. The method was desk research, which was done in the context of discovery.

Key findings: A built environment can support physical activity or deter sedentary behaviours in cities and workplaces. In cities the workforce can be seduced to move to attractive facilities at short distances. Safe and clean facilities for walking and cycling positively stimulate user activities. Moreover, the design of attractive environmental cues can raise user curiosity and stimulate user interaction. Facilities and cities that support active breaks at organizations and provide individual or group counselling as well as Internet-based tools and feedback loops for workers and inhabitants can promote healthier behaviours. Challenges, competitions and the monitoring of physical activity using log books have similar effects. In buildings, spaces can be much healthier by creating prompts for user behaviour, such as visually attractive stairwells, healthy food supply, and ergonomic furniture. Access to fresh air, daylight, plants, silence, and the right temperature can also make an important contribution to the health of people in organizations. These interventions allow cities and organizations to positively influence the health of both employees and residents.

Intended impact of the study on either research, education or practice: The reported spatial properties that support physical activity or deter sedentary behaviours can be directly applied to facility and urban design practices. Mutual relations between facilities and cities are new and can inspire both facility managers and urban planners to work together more closely for the benefit of end users in urban and workplace contexts. The findings can also be directly applied to facility management education by involving students via excursions, internships, and studies at city design practices.

Paper type: Conceptual Paper.

Keywords: Abduction, Facility Management, City, Health, Urban Planning, Workplace.

1 INTRODUCTION

Worldwide, sedentary behaviours and overweight are major health concerns. Globally, 39% of adults aged 18 years and over were overweight and 13% were obese (WHO, 2018a). More than 80% of the world's adolescent population is insufficiently physically active which is one of the leading risk factors for death worldwide (WHO, 2018b). Work and the city may be dominant factors in these developments.

Firstly, in developed countries most of the work is non-physical. For instance, of all U.S. jobs 80 percent is sedentary or requires only light activity (Church et al., 2011). Among this group, office workers are one of the most sedentary populations, spending 70-85% of time at work sitting (Edwardson et al., 2018). So, the workplace is a tough place for the ones that want to be active. Secondly, globally more people live in urban areas than in rural areas, with 55% of the world's population residing in urban areas in 2018 and expected to increase to 68% by 2050 (UN, 2018). Urban areas are often unhealthy places to live, characterized by heavy traffic, pollution, noise, violence, and potential social isolation (WHO, 2010a). WHO (2018c) reports that increased urbanization has several environmental factors which discourage participation in physical activity such as violence, high-density traffic, low air quality, pollution, lack of parks, sidewalks, and sports/recreation facilities. Hence, the city is non-inviting place for the active, and even worse, it creates barriers for the ones that want to become active.

As a response to these developments many initiatives, separate but related, have sought to change these situations. For instance, a healthy workplace is a place in which workers and managers collaborate to use a continual improvement process to protect and promote the health, safety and wellbeing of all workers (WHO, 2010b). In this context, an interesting example is the use of 'nudging' (Thaler & Sunstein, 2008) to stimulate active behaviours. Indirect hints can blend in design, such as a beautiful staircase at the entrance (and hiding the elevator) stimulating stair use (Engbers et al., 2007). As to now, the WHO has devoted almost a decade to the advancement of such workplaces. In a similar but also a much wider context, a healthy city is one that continually, for instance, creates and improves its physical and social environments (WHO, 2019a). The WHO healthy cities movement has been a pioneering driver of change for more than three decades, arguing to have created healthier urban settings that support the health and well-being of the people that use them (2019b). Urban planning being one of these drivers (WHO, 2017).

Most people work at desks and live in cities; two contexts which discourage participation in physical activity. How can we change this situation? An analogy between urban design and facility design is introduced to elucidate spatial properties that may be beneficial in both contexts. It is the purpose of this paper to use this analogy for the advancements of health and well-being of workers and city dwellers. Are health-directed design interventions in cities and facilities related, are there applicable cross-overs and emerging new research areas of interest for FM?

2 METHODS

In this paper the principles of abductive reasoning were followed. Folger and Stein (2017) argue that abductive reasoning should not be considered as stages of a process, but rather, it can blur together in ways other than what might be conveyed initially. Abduction can be a good first phase of scientific investigation. It merely suggests that something may be (Peirce, 1934). In this sense, abduction can be understood as a broad kind of reasoning that integrates scientific as well as non-scientific thinking in the context of problem solving (Rodrigues & Emmeche, 2019). They also argue that this method consists in attentive observation of phenomena within

the context of a scientific community. According to Cunningham (1998), abduction is the appropriate method for making sense of new (or unknown) situations. However, there must be a reason to suspect that the conclusion of an argument is worthy of pursuit (Folger & Stein, 2017). Moreover, abduction seems to be in need of scientific experience. Having an attentive eye to capture the new aspects of a surprising phenomenon is essential to the production of such new knowledge (Rodrigues & Emmeche, 2019). Abduction is the process of inferring facts and/or laws that render some sentence plausible, that explain some phenomenon or observation (Boutilier & Becher, 1995). Many intelligent tasks, including medical diagnosis, scientific discovery, and legal reasoning, have been characterized as abduction (Lin & You, 2002). According to Peirce (1934) abduction is the only logical operation which introduces any new idea. What is most significant about abductive conjectures is that they are conceptualizations that can frame future investigations (Shearer, 2015). Moreover, an abduction-based design framework provides a proactive tool for connecting basic research to applied research, exploring and exploiting, in a new and innovative way (Patokorpi & Ahvenainen, 2009).

In this present study, it is believed that the relationship between spatial design directed at user health in two different contexts provides a good reason for a quest. Motivation of the attentive observation can be found in the development at communities of facility management, public health, and urban design. Many studies focus on the interactions between the environment and health. Analogies between facility design and urban design were used to elucidate unknown characteristics of this matter (Crombie, 1994). It is the purpose of this paper to use this analogy for the advancements of health and well-being of workers and city dwellers. Related studies at workplaces and cities on the subject may allow for interesting cross-overs and learning opportunities. New research opportunities may also emerge when searching to practically promote user health in both contexts. Moreover, finding new starting points for conceptualisation of these cross-overs may be a desirable scientific outcome; and applicability of the findings in both design practices may have significant societal relevance. Societies may become healthier and more productive. But, be also reminded that this paper aims to explore and conceptualize in the context of discovery with abductive reasoning rather than aiming to be exhaustive as in a systematic literature review.

3 URBAN DESIGN

Worldwide, in cities countless people live and work. The wonderful property of a city is that work and entertainment are so close together. That provides organizations with many cues to stimulate healthy behavior (for example, with discount coupons for restaurants that focus on healthy food or for fitness subscriptions), but also to stimulate healthy exercise in other ways. Why not create the infrastructure to allow workers to bike to work? A nice city walk can be a welcome distraction from the work, which can also be combined with two- and three-person meetings, where reflection and knowledge exchange are central. The city is not very different from a business park: if you consider the city as an area where employees can be active, you have to admit that it can be fantastic for a walk. But also, where it is terrible or even dangerous to walk, due to traffic. Following the WHO (2018c) physical activity can especially be encouraged by taking care of environmental factors in a wider context. Reduction of violence, high-density traffic, better air quality, less pollution, and sufficient parks, sidewalks and sports/recreation facilities. Factors that ask for a high level of engagement of authorities. The Dutch situation is used to exemplify the possible commitment of authorities with urban design.

The Dutch Health Council (Gezondheidsraad, 2010) advises local authorities and urban designers to take measures in the city that stimulate the use of bicycles and reduce the use of cars. Consider, for example, designing a neighborhood infrastructure that can stimulate physical activity (socially safe and traffic-safe walking and cycling paths to destinations like work, school, shopping, sports) and mitigating car use (speed limits, car-free zones, low-traffic zones).

At city level, walking and cycling can also be stimulated, through a dense network of bicycle and pedestrian paths. Moreover, clever urban hubs could be designed in connecting public transport with hiking and biking. Think of an infrastructure for bicycle parking for work, education, healthcare, and leisure. In addition, the Health Council advises authorities to slow down the speed of car traffic with speed bumps for residential areas, road pricing, and paid parking.

Following the WHO-report (2018c) physical activity can also be stimulated with the design and construction of public gardens, parks, bathing water, and hiking opportunities that are easily accessible, socially safe, and clean. Preferably in combination with spot-on and sophisticated attractions, such as combinations of food, infotainment, and fun. In order to keep the growing population of (spoiled) users on board.

In this context, good urban planners create an exercise-friendly layout of the city. They always listen carefully to the needs and wishes of the users, and make it fun and pleasant to exercise. Stop talking about health: design. Create designs that expand the number of active people in the city. Designers are capable of packing, blurring physical activities with work, sports, dance, and party. Make active behaviors fun, easy and popular, according to Dutch authorities (Rijksoverheid, 2013).

These examples open up possibilities for urban designers and policy makers to design different cities. Cities that are designed for user activation. But how can this be done in and around buildings for organizations?

4 FACILITY DESIGN

Researchers did find it difficult to seduce office workers to use the stairs or to purchase healthy food. That is particularly unfortunate, because it would have supported global ambitions in creating a healthier workforce. For example, in the first FoodSteps project, Engbers et al. (2007) found that spatial interventions (such as footsteps from entrance to stairs, text encouragement for stair use on elevator doors, stimulating texts and facts at the stairs, and slimming mirrors at the stairs) tempted the workers to go climbing stairs. In the experimental group, workers took the stairs three times a week more often than in the control group. The study also provided information about the provision of healthy food in canteen and at vending machines. With these mixed interventions, according to the researchers, the cholesterol of office workers decreased (Engbers et al., 2007).

In the follow-up FoodSteps project (Engbers et al., 2014), however, the conclusions were less convincing. The researchers, just as in the first project, placed information posters at stairs and canteen and footsteps towards the stairs. This included organized lunch walks, a scale in the elevator, a game computer with active games, and a pedometer competition. This study showed show no effect of the interventions on stair use, elevator use, the sales of lettuce, and oven and/or fried snacks. Support from senior management and sufficient budget and time for the project leader, as well as the prevention of slacking of the project focus, were deemed vital. In this case apparently lacking.

Another study (Eves & Webb, 2006) advises us to position facilities in the vicinity or at the end of a staircase in a building. Preferably, of course, facilities that are often used (such as a canteen, a meeting room, or a toilet). The researchers also advise us to integrate stairs (or stairwells) with walking routes in the building, for instance, by explicitly including stairwells in the signposting of the building. In this context, Engbers (2008) advises us to focus on staircase use, reducing low-exercise workplaces or work tasks when introducing new workplace concepts. Moreover, expanding facilities for physical activity (such as bicycle parking, showers, fitness, or table tennis) and centralizing facilities (such as the printer, meeting rooms, and social relaxation rooms), so that physical activity is stimulated in the building.

At the moment there are also many experiments at organizations that seek to create a healthy workplace. It is an urgent matter. Duncan, Kazi, & Haslam (2012) have reported that in the UK people spend on average 5 hours and 41 minutes per day sitting at their desk and 7 hours sleeping at night in a typical working week. This is bad for the physical health of workers. Prolonged sedentary behaviour is associated with increased mortality, cardiovascular disease, type 2 diabetes, colorectal cancer, and poor mental health outcomes (Gray, 2018). In practice, advise is given with standing meetings, bicycle seats, and treadmills, to get employees exercising during work. Furthermore, research must also remain devoted to other spatial properties at work. Examples of the properties that remain to need are attention are air quality (airflow, particulate matter, CO_2), temperature (comfort, suitability for the task), noise (nuisance, privacy, intelligibility), and light (access to natural light, visibility in task performance, reflection on screens) (Becker & Steele, 1995). This may seem very obvious, but it is poorly designed in many places.

Loitz et al. (2015) advised to support active breaks at organizations and provide individual or group counselling as well as Internet-based tools and feedback loops for workers and inhabitants can promote healthier behaviours. Challenges, competitions and the monitoring of physical activity using log books have similar effects. A systematic meta-review (Jirathananuwat & Pongpirul, 2017) has confirmed that design interventions such as promoting stairway signs, indoor and outdoor walking routes, and walking groups were effective in promoting physical activity in the workplace. But even though the opposite is often claimed, we still know too little about the effectiveness of workplace interventions. We are only at the beginning and there is still much to learn. Gray (2018) confirms this observation by arguing that even though lifestyle interventions reduce time spent sitting, many studies are low quality and show only modest improvements in sedentary behaviour. So, we need to do better: to develop better studies, to seek better alignments with practice, develop a clear focus on application, and provide independent and reliable evidence on effective interventions. When cleverly interwoven and embedded in a work and city context, these interventions allow organizations and cities to positively influence the health of both employees and residents.

5 DISCUSSION

Given the alarming numbers of overweight and obese, it is surprising to see so little substantial change. Spaces and services can provide support. In adolescents to become sufficiently physically active, the mind may be willing, but the flesh is often weak. After all, all of us can have lunch while walking, go climbing stairs, and avoid unhealthy snacks, but do we do it? Organizations and governments can use the built environment for nudging. Seducing people in the right direction and sometimes adjusting them actively. Subsidizing and stimulating healthy food with higher pricing of unhealthy snacks? Having meetings during a walk outside (even though a different urban layout may be required)? How about something simple as an outdoor area? Walking pleasantly throughout the year, no matter the weather? A built environment that

protects you from weather, but also brings in fresh air and wonderful daylight. Unfortunately, many cities lack this kind of protection against cold, wind, rain and sun. Keeping people inside when the weather is harsh. Designers of spaces and services can bring change.

Healthy exercise in cities and buildings may sometimes be difficult, but it is feasible. Paths can be designed and constructed. Trees can be planted and water can be cleaned. Car traffic can be mitigated. Safe zones and spaces can be given to the active. The success of this will not depend on cooperation. Administrators of cities and organizations will have to work together, to stimulate physical activity in and around buildings, both in the public and in the private domain. A lot is already happening, but more drastic measures are needed. Starting with designs for children may be a relevant game changer.

Moreover, we need new research that unlocks experiences and capacities of the FM industry and applies this in a city context, vice versa. Let us try and link changes in the built environment with public health studies in and combine these with the health of the workforce. Focusing on the affordances of facilities and cities. Here the experiences of facility managers and urban planners can be expected to create synergy. The dreams of designers meeting the realism of the FM-experts of human behavior and needs. FM also needs new research into nudging, direct people with the built environment. To seduce them in becoming more active and live healthier. To normalize smoking free zones and strive for smoking free generations. To jointly work on a research and health agenda - facility managers and urban planners - their cooperation can be a game changer in creating healthy cities and workplaces for people.

6 CONCLUSION

The built environment of cities and workplaces can support physical activity or deter sedentary behaviours. In the public domain the workforce can be seduced to move to attractive facilities at short distances. Safe and clean cities providing space for walking and cycling further positive user experiences. Moreover, the design of attractive environmental cues can raise user curiosity and stimulate approach behaviours. Facilities and cities that support active breaks and provide individual or group counselling as well as Internet-based tools and feedback loops for workers and inhabitants can promote healthier behaviours. Challenges, competitions and the monitoring of physical activity using log books may have similar effects. In buildings, spaces can be much healthier by creating prompts for user behaviour, such as visually attractive stairwells, healthy food supply, and ergonomic furniture. Access to fresh air, daylight, plants, silence, and the right temperature can also make an important contribution to the health of people in organizations. These interventions allow cities and facilities to positively influence the health of both employees and residents.

ACKNOWLEDGMENTS

I thank Elsemiek Hes for her valuable contribution to the realization of this paper.

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The Lowest Common Denominator in the Maintenance Management of Critical Facilities in Europe

Robert Miles
University College Cork, Ireland
117223920@umail.ucc.ie

Mahmoud Kunbaz
Apleona HSG GmbH, Germany
mahmoud.kunbaz@apleona.com

Jürgen Bieser
Apleona HSG GmbH, Germany
juergen.bieser@apleona.com

Justin Amesz
University College Cork, Ireland
117223832@umail.ucc.ie

ABSTRACT

Purpose: This research paper aims to identify the lowest common dominator (LCD) in maintenance management, including maintenance standards, strategies, requirements, and programs applied in critical environments across Europe. Furthermore, the paper presents insights towards developing a transnational maintenance management approach that offers comparability and cost-effectiveness.

Method: This study is a part of industry-led R&D project executed by Apleona HSG master students in Europe under the supervision of industry experts. An extensive literature research combined with a state of the art analysis of maintenance regimes applied on critical technical systems of clients in four different European countries including Germany, United Kingdom, Ireland, and the Netherlands was carried out. The study also consists of in-depth interviews with maintenance experts.

Findings: The EN 13306 standard represents the lowest common denominator in maintenance management in Europe. Critical facilities practitioners adopt a time-based preventive maintenance as a default approach in an endeavour to remain legally and operationally compliant. Maintenance requirements have a unified structure across Europe starting with the obligation of local legislations. The lowest common denominator found here is the common objective of these legislations to mitigate HSE risks based annual checks. The adherence of Original Equipment Manufacturer (OEM) and insurance companies' regulations related to the maintenance of critical facilities and/or any client specific requirements follow. Client specific requirements and the application of chosen best practice regimes based on the organisation's strategic approach are then generally implemented in addition to legislative, OEM and insurance related obligations.

Originality/Value of the Study: The results of this paper will provide a strong basis for harmonising maintenance activities across Europe by allowing professionals to understand the state of the art in the maintenance of critical facilities as well as presenting the challenges towards implementing a transnational approach.

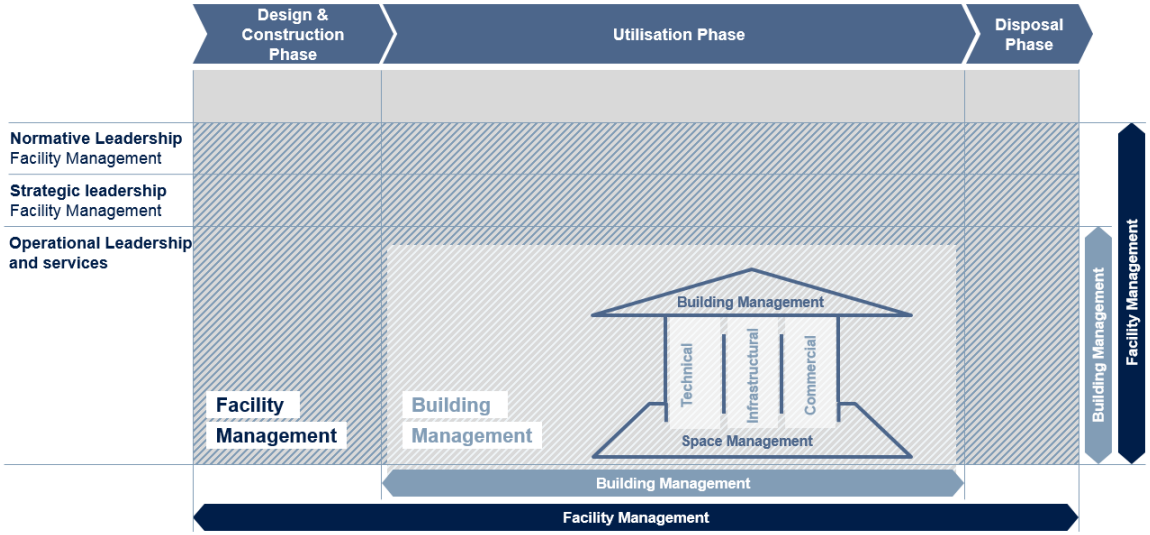
Paper Type: Research Paper

Keywords: Building Management, Technical Building Management, Facility Management, Maintenance Management.

1 INTRODUCTION

Facility Management (FM) can be defined according to ISO 41011 as a management discipline caused by result-oriented management of assets and services (ISO, 2017). In comparison to Building Management (BM) and based on the GEFMA 100-1 (GEFMA, 2004), Facility Management is not only limited to the narrow 'operational focus' but covers it the whole life cycle of facilities as shown in figure 01 below.

Figure 1 Facility Management vs. Building Management (GEFMA, 2004)



Building Management, as being an integral part of Facility Management, can be outlined into three individual pillars; Technical Building Management (e.g. servicing of building and equipment technology), (ii) Infrastructural Building Management (e.g. cleaning and security), and (iii) Commercial Building Management (Lünendonk, 2018).

As facilities have become more complex due to technical developments, Maintenance Management has gained increased interest as a result of being one of the main pillars of Technical Building Management and due to its direct impact on quality, availability, reliability and safety of operations (Bieser & Kunbaz, 2018).

Furthermore, as the global facilities management market grows at an exponential pace, questions have been raised about the adequacy of organisational processes for worldwide operations. Consequently, the need for a harmonised maintenance strategy has increased in order to remain globally competitive. It is estimated that the FM global market size will grow from USD 34.65 billion in 2018 to USD 59.33 billion by 2023, at a Compound Annual Growth Rate (CAGR) of 11.4 per cent during the forecast period (Service Futures, 2018). This presents new business opportunities but also imposes entirely new challenges, since today's global economy demands corporations to ensure uninterrupted business operations as well as health, safety and environmental compliance. Critical facilities can be defined as facilities containing

any operation that, if interrupted, will cause a negative impact on business activities, ranging from losing revenue to jeopardising legal conformity along with the cause of serious bodily harm (in extreme cases, loss of life) such as data centres or production plants (Organization of American States, 1991). Critical facilities can encompass a mixture of technical engineered systems, equipment, assets that are crucial for day-to-day operations, as well as continued economic and societal function in the event of disaster (Mangkusubroto & Tripathi, 2015).

As critical facilities increase in number and prominence within the FM industry, this paper presents the lowest common dominator in the maintenance management of critical facilities in Europe, providing a solid basis for developing a transnational maintenance management approach. The term lowest common dominator does not only refer to the main commonalities among various maintenance management approaches carried by international corporates but we have also used this phrase to identify that these commonalities represent the minimal requirements towards administering a transnational management approach.

2 LITERATURE REVIEW

Our extensive literature research reveals that terms related to the field of maintenance management are defined and understood very differently by authors. However, many maintenance standards have been developed at a European level, providing a common ground for a harmonised maintenance approach.

Maintenance represents a crucial part of various European legislations. The European maintenance standard EN 13306 (European Committee for Standardization, 2018) was created with the objective of defining generic terms used for all types of maintenance management irrespective of the system or element item considered. The European maintenance standard EN 13460 (European Committee for Standardization, 2009) defines general guidelines for the technical documentation of maintenance as well as documenting all information needed to support the maintenance requirements. Other European standards related to maintenance include, the EN 15341 (European Committee for Standardization, 2007) which specifies a system for managing maintenance key performance indicators, the EN 16646 (European Committee for Standardization, 2015) for maintenance within physical asset management and also the EN 17007 (European Committee for Standardization, 2017) which gives a generic description of the maintenance process.

Maintenance has been classified in a number of different ways in the literature according to Lind and Muyingo 2012 (Lind & Muyingo, 2012). Various maintenance approaches such as Preventive Maintenance, Condition Based Maintenance, Total Productive Maintenance and Reliability Centered Maintenance, were referred very differently in the literature as maintenance methods, strategies, concepts, programmes, philosophies, etc. (Fraser, 2014) (Braglia, et al., 2018) (Achamu, et al., 2018) (Hansson & Backlund, 2002) (Habidin, et al., 2018) (Bieser & Menzel, 2017).

Nevertheless, (Fraser, 2014), (Prabhakar P. & Raj V.P., 2014), (Mahlangu & Kruger, 2015), (Berger, 2010) and many others agree that Total Productive Maintenance (TPM), Reliability Centred Maintenance (RCM) and Lean Maintenance (LM) are the dominating maintenance strategies in terms of published literature as well as adoption rate by many world's leading organisations in different sectors.

Comparison between maintenance strategies; when comparing TPM, RCM, and LM, it is important to understand their key differences. TPM seeks to improve productivity through process, people, and waste elimination, it aims to change culture in the business (Nakajima &

Bodek , 1998). On the other hand, RCM has focus on maximizing plant reliability (Smith, 1993). LM is different as it could not be seen as an individual strategy but rather as a 'philosophy' for improvement of maintenance. In detail, LM is most comparable to TPM as both aim to increase productivity through process and people (Hollnagel & Woods, 2005).

Maintenance programmes; these strategies can employ one or more maintenance programmes which can be classified into two groups; corrective or preventative maintenance (European Committee for Standardization, 2018).

Corrective manner is represented by the corrective maintenance approach, which is considered as an unscheduled and event-driven task that is usually triggered by an event such as machine failure. According to (Mobley, 2004), it means, "fix it when it breaks".

Preventative manner is represented by; time based or planned preventive maintenance (PPM) and condition based maintenance (European Committee for Standardization, 2018).

PPM provides a systematic approach for the inspection, detection and correction of expected failures based on a predefined time schedule and/or predefined runtime of unit(s) (European Committee for Standardization, 2018).

Condition based maintenance can be further divided into non-predictive condition based maintenance (CBM) and predictive maintenance (PdM) (European Committee for Standardization, 2018). In the case of CBM, the leading factor for planning of maintenance works is the actual machine condition (e.g. deterioration of some operational or performance parameters), which is continually monitored and measured using methods like vibration analysis, thermal imaging or infrared scanning. In case of PdM a 'smart' factor is added as it includes real-time analysis of collected operational data and evolving performance trends that increases the possibility of detecting deviations in the machine condition at an early stage, and so reducing downtime and improving reliability (Schmidt, et al., 2014). The following section presents our methodology to determine the LCD in maintenance strategies, standards, requirements, and programs currently deployed in critical facilities across Europe.

3 METHODLOGY

Our qualitative study is based on an extensive literature research as well as in-depth analysis of two qualitative data sets. This approach allowed us to determine the settings of current maintenance concepts applied in critical environments as well as to capture different requirements, legislations, and standards related to maintenance in Europe. The word ''Europe'' always refer to the countries covered in our research (Germany, United Kingdom, Ireland, and the Netherlands), since those countries represent a major segment in the FM market in Europe (Global FM, 2018).

Data was acquired from 20 international corporate clients' contracts, representing different types of critical facilities, including twelve Data Centres on different size scales, four manufacturing industries, and four Banks across the four countries considered in this research. Additionally, semi-structured interviews were held with four maintenance experts in each considered country with a selection criterion of a minimum five years of experience with maintenance in critical facilities. Each contract was analysed to quantify what maintenance programs, strategies, and requirements currently present, and at which percentage each maintenance program is applied.

The interviews were analysed by content analysis, whereby each interviewee determined maintenance requirements, standards, strategies and then stated the percentage of applied maintenance programmes in critical environments based on their experience. Corrective

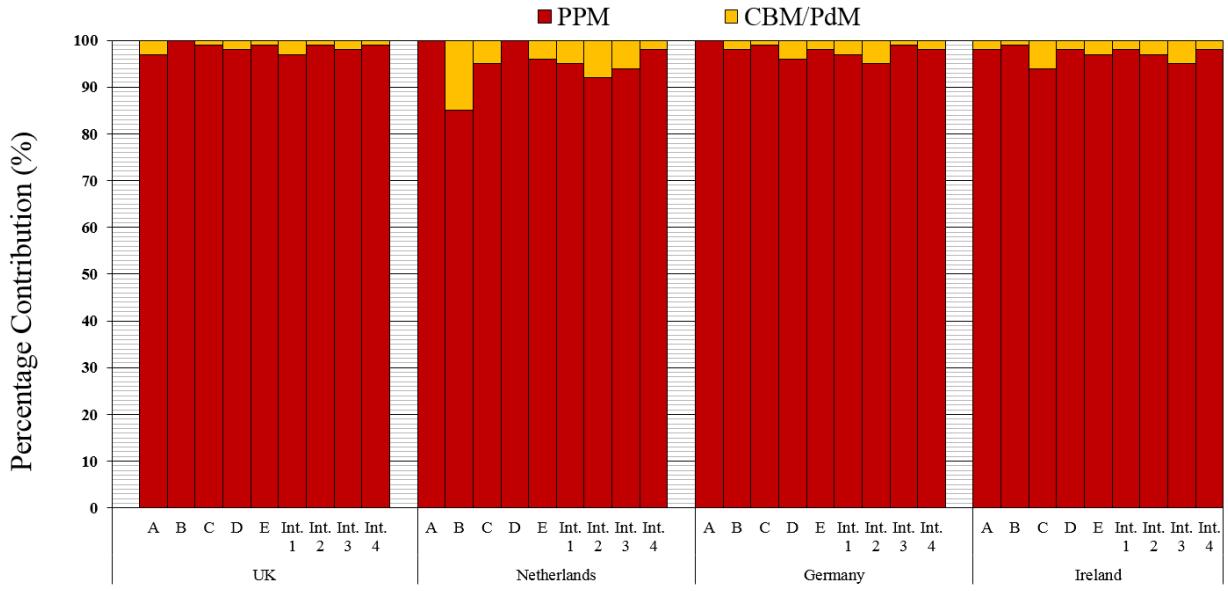
maintenance although acknowledged is excluded from our study since it only presents in breakdown situations. The next section presents the results of the study.

4 RESULTS

Our pan European study comprising of representation from Germany, Ireland, the Netherlands and the United Kingdom shows that the EN 13306 European standard stands out as the lowest common denominator in the maintenance management of critical facilities in Europe from other generic European standards which are not widely practiced. Results show also that there is no holistic maintenance strategy (e.g. TPM or RCM) being applied in critical environments according to our contract and interview analysis. Some maintenance experts and clients' representatives were not able to recognise TPM or RCM strategies nor understand the distinction between them. For a transnational maintenance approach, it is vital to have a comprehensive maintenance strategy as it will assist with the standardisation of processes and will facilitate the creation of internal and external partnerships between maintenance and other elements in the supply chain (Alsyouf, 2007).

Since only maintenance programmes are considered for the allocation of maintenance activities, we decided to perform further analysis. In addition to contracts' analysis, interviewed maintenance experts were also asked to quantify the percentage of time based Preventive maintenance (PPM) in comparison with CBM/ PdM initiatives applied in critical environments based on their experience in each specified country (see figure 2). For instance, interviewee 1 in Ireland states that 98 % of maintenance in critical facilities in Ireland is based on PPM approach. In figure two, clients A, B and C represent Data Centres on different size scales, client D represents the manufacturing industry and Client E represents the banking sector. For the reason of confidentiality, no names are presented.

Figure 2 Percentage of Maintenance Activities PPM vs. CBM/ PdM



As shown in the figure above, PPM is widely adopted across Europe in different critical environments with an average utilisation percentage of 97%. However, CBM/ PdM initiatives represent only a small portion with about 3% of implemented maintenance programs. Our analysis reveals that this 3% refers only to CBM, where Infrared thermography and vibrational

analysis are the most common methods employed. Therefore, PPM stands as the lowest common denominator in terms of applied maintenance programmes across Europe due to the fact that this program is widely supported with standards and viewed as an economical proactive approach that reduces downtime. Nevertheless, following such a lowest common denominator approach by planning and implementing set frequencies irrespective of need or condition is a result of lack of understanding to explore alternative strategies/methodologies. Such an LCD approach would represent challenges against the endeavours towards implementing a transnational maintenance management approach in terms of flexibility and effectiveness as other strategies may well return greater yields in performance and economisation.

Finally, our analysis identified relevant maintenance, legislative and regulatory standards applicable to the compliant continuance of thirteen distinct system types, all of which can readily be identified as intrinsic to critical environments. Table 1 below identifies our chosen reference criterion and qualified findings.

Table 1.Asset type against relevant maintenance legislations and standards

Country \ Asset Type	UK	Netherlands	Germany	Ireland
	Relevant Maintenance Legislations and Standards			
High and Medium Voltage Systems	BS7671:2008, (EAWR) 1989, (HSW) 1974, SFG20, OEM	NEN3140, SCIOS Scope8, SFG20, OEM	VDMA 24186-5, PrüfVO,AFB(VdS), DGUV V3, BetrSichV, OEM	ET101, SFG20, OEM
Low Voltage	BS7671:2008, (EAWR) 1989, (HSW) 1974, SFG20, OEM	NEN3140: SCIOS Scope8: SFG20, OEM	VDMA 24186-5, PrüfVO,AFB(VdS), DGUV V3, BetrSichV, OEM	ET101, SFG20, OEM
Generator	BS7671:2008 (EAWR) 198, (HSW) 1974, (PUWER) 1998, SFG20, OEM	Activiteitenbesluit SCIOS Scope4, SFG20, OEM	VDMA 24186-5, PrüfVO,AFB(VdS), DGUV V3, BetrSichV, OEM	IS 820:2010, SFG20, OEM
UPS System	BS7671:2008 (EAWR) 1989 (HSW) 1974, (PUWER) 1998 OEM, SFG20	Milieuwetgeving' SFG20, OEM	VDMA 24186-5, PrüfVO,AFB(VdS), DGUV V3, BetrSichV, OEM	ET101, SFG20, OEM
Cooling Units (CRAH and CRAC)	F-Gas Regulation No. 842/2006, (HSW) 1974, (PUWER) 1998 SFG20 OEM	EU-1005/2009 & EU-517/2014 (F-gas verordering), warenwetbesluit drukapparatuur (Stb. 311, 1999), Wijzigingsbesluit (Stb. 339, 2001), Wijzigingsbesluit (Stb. 387, 2004), European Guidelines 2010/31/EU SFG20, OEM	VDMA 24186-3, PrüfVO, ASR, BetrSichV,OEM	EN14511, SFG20 OEM

Air Handler Units	CIBSE TM44 OEM SFG20	OEM SFG20	VDMA 24186-1, PrüfVO, ASR, BetrSichV, OEM	EC517:2014, SFG20, OEM
Boilers	2000 (PSSR),(PUWER) 1988, (EAWR) 1989 HSC ACOP L122 1998 HSC ACOP Iso 14001:2004 PPG2 OFTEC technical book 1 and 3 SFG20, OEM	Activiteitenbesluit; NEN3028: SFG20 OEM	VDMA 24186-2 PrüfVO, ASR, BetrSichV, OEM	IS 820:2010, SFG20, OEM
Sprinkler system	BS 12845 2004 LPCB CoP FIA, LPC or similar OEM SFG20	NEN12845:2015 / NEN1073:2018, Technisch Bulletin 80, Technisch Bulletin 67b, wijzigingsblad A1, SFG20, OEM	VDMA 24186-7 PrüfVO, ASR, FM Global, OEM	NFPA-25, SFG20, OEM/Insurance
Fire Detection System	BS 5839-1: Loss prevention standard 1014 FIA, LPC, CIBSE OEM, SFG20	NEN2654-1:2015 , SFG20, OEM	VDMA 24186-7 DIN 14675, PrüfVO, ASR, FM Global, OEM	IS 3218:2009, SFG20, OEM/Insurance
Fire protection systems	BS 5306-0:1986 OEM SFG20	NeRF (MSC.1/Circ.1432) OEM	VDMA 24186-7 DIN 14675, PrüfVO, ASR, FM Global, OEM	IS 291: 2002, SFG20, OEM/Insurance
Lighting Emergency	BSEN 50172:2004 (BS5266-8:2004), CIBSE, SFG20, OEM	Bouwbesluit 2012: SFG20, OEM	VDMA 24186-5, PrüfVO, ASR, FM Global, OEM	IS3217:2008, SFG20 OEM/Insurance
Access control	BS EN60839 SFG20 OEM	SFG20 OEM	VDMA 24186-5, VDS, OEM	I.S. EN 50131/1:2006 SFG20, OEM

Table 1 presents numerous maintenance standards and regulations, which are related to individual clients' contracts considered in this study. Furthermore, table 1 reveals a structure of maintenance requirements that must be adhered to when planning and developing a transnational approach.

The statutory requirements takes precedence and have the highest priority. Compliance with such requirements is usually administered by governing bodies comprised of similarly experienced system experts and generally endorsed by governmental approbation. Statutory regulations define just the general requirements for executing maintenance, focusing and responding mainly to health, safety, and environmental (HSE) requirements.

Our analysis reveals that the lowest common denominator between these legislations is the common objective of mitigating HSE risks by regularly checking and proving the critical

functionality of assets, which occurs annually on average. It is important to note that there are still many regulations that follow under this category, however, table 1 presents only the legislations covered within our research. The myriad maintenance regulations at a local level makes the aim of developing a standardised maintenance approach very tough.

Next, the recommendations stipulated by OEM from the time of installation take precedence above all other mandates until such times warranty obligations have been fulfilled and that RSL (Remaining Service Life) can be managed by an alternative but suitably compliant maintenance approach. Following OEM, insurance and/or client specific maintenance requirements must be considered, since some clients/insurance bodies might demand a particular maintenance approach and/or inspection intervals. Lastly, the maintenance best practice is utilised such as the SFG20 (BESA, 2018) which is a UK standard for implementing time based planned preventative maintenance activities produced by BESA (Building Engineering Services Association) or the VDMA 24816 developed by the Mechanical Engineering Industry Association (VDMA, 2017).

Selecting which best practice to implement is based on the organisation's strategy (e.g. harmonisation at local or transnational with European/international scopes and whether FM services are in-house delivered or outsourced). These results presented in this section demonstrates potential benefits and/or challenges faced in developing a transnational maintenance approach.

5 CONCLUSIONS

Assuming the maintenance standard EN 13306 as the lowest common denominator in maintenance management in Europe provides a common ground, in which all terms related to maintenance can be similarly understood and used in the formulation of maintenance contracts as well as facilitating communication between maintenance professionals, thus establishing a mutual base for harmonising practices in a structured and coherent manner. However, our research reveals that better cooperation is required to develop a more comprehensive and intuitive standardised framework that will enable the application and proliferation of a transnational maintenance approach.

The results of the paper present a structure of maintenance requirements that must be adhered to on a European level. The lowest common denominator identified is the singular objective of local legislations to mitigate HSE risks based on annual checks by average. The huge number of local regulations in comparison to the European regulations stands as a major challenge towards developing the approach of deploying "one" standard across borders.

Time-based maintenance programmes stand as the lowest common denominator among other maintenance concepts. However, when considering cross-border application and the best practice for implementing PPM concepts, it must be noted according to Labib (Labib, 2004), that preventive maintenance should be based on the current state of the machine. This is mainly due to the fact that each machine may operate in a different environment and that the failure of the machine (due to component failure) may not have manifested as OEM' predicted (only based on component age analysis – wear and tear process). Furthermore, in the light of Big Data and the Internet of Things (IoT) technologies, a predictive maintenance approach (PdM) as one of the core components of Industry 4.0 offers great insights when considering a cross borders maintenance management approach. PdM offers advantages to the FM industry that include but is not limited to optimising asset life cycle, reducing downtimes, forecasting asset replacements and offering a developed approach for risk identification. Many pilot projects and initiatives have been recently launched in this direction (Apleona, 2018). Building Operation

Control Centre (BOCC) as an example was recently introduced by Apleona, offering PdM as one of many services based on the IBM Watson IoT cognitive system.

Future research could explore and identify the role that different areas of risk such as health and safety, equipment, human and intellectual property risk for example, as well as how their potential impact on maintenance management in relation to ISO 31000 for risk management can be managed. Furthermore, setting up a holistic life cycle asset management approach in tandem with current maintenance management advances in light of ISO 55000 stands as an interesting area of research.

ACKNOWLEDGMENTS

This paper has been developed with the financial support of APLEONA HSG Facility Management GmbH.

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‘Facityly' management: The influence of facility design on urban quality of life from the perspective of students research

Ir. J. (Hans) Netten
The Hague University of Applied Sciences, The Hague, the Netherlands
School of Facility Management
J. Netten@hhs.nl
+31 (0) 704458123

R. (Rachel) Kuijlenburg MA
The Hague University of Applied Sciences, The Hague, the Netherlands
Research Group, Spatial Environment and user, the Netherlands
R.Kuijlenburg@hhs.nl
+31 (0) 657870895

Drs. C. (Cateleine) de Jong
The Hague University of Applied Sciences, The Hague, the Netherlands
Research Group, Inclusive Education, the Netherlands
C. deJong@hhs.nl
+31 (0) 657870888

ABSTRACT

Purpose – This paper aims to explain the influence of facility design on urban quality of life from the perspective of students' research. The outcome of this paper is to determine the influence of facility management (FM) on the quality of life of citizens in the city of The Hague by actively using facility design to positively influence the liveability.

Methodology – This current explorative study has been qualitative in nature, including desk research, literature study in relation to urban environment, walk through, observations and interviews with local residents and officials from the local government. This paper indicates how urban FM is defined based on the student perspective.

Findings - More than 2000 FM students of The Hague University of Applied Sciences have been conducting research on urban facility management over the last 15 years. This educational module has provided data on changes at neighbourhood level resulting in numerous small-scale improvements initiated by the department of Urban Development, Housing, Sustainability and Culture of The Hague.

Intended impact –A better understanding of urban facility management and integration of people, places and processes within the urban environment, improving liveability in neighbourhoods and an entrance into global citizenship for young professionals. This study will support The Hague University of Applied Sciences in the evolving field of urban FM. It provides the school of Facility Management with the opportunity to perform additional research in order to deliver evidence to society on the influence and impact of urban FM.

Paper type: Research paper

Keywords: Urban Management, Facility Management, City management, World citizenship

1 INTRODUCTION

According to the United Nations (2018) 68% of the world's population will be living in urban areas by 2050. Urbanization is an irreversible global trend involving a multitude of social, economic, environmental and spatial aspects (Langeweg, Hilderink & Maas, 2000). Whilst urbanization is widely accepted as an indicator of economic development, its pace and impact on social and spatial conditions pose unprecedented challenges. It requires highly structured systems of human organization for large-scale communities where the spatial environment should furnish housing, education, healthcare, employment, a safe environment and an identity for its members. It is not only that our daily life takes place in a certain physical environment as a sort of necessary décor: '*People try to create an environment in so far as it is within their abilities whereby the physical environment is converted into a so called 'man-made environment*'. According to Wilterdink & Van Heerikhuizen (2012) man-made environment is the result of continuous, social and conflict-like processes.

The starting point for allocation of space is mostly the desire for a certain form of exclusivity of the available space. People pursue privacy and have a need to identify themselves with the environment. They strive to shape the environment into a manifestation of lifestyle and self-expression, which can lead to collective dilemmas. In particular, increasing urbanization leads to sharing less space in the urban environment. This results in urban crowding, congestion, reduced liveability and an unsteady resilience of the city, particularly if the process is not well governed (McGranahan & Satterthwaite, 2014).

In addition to urban governance, there is a need for urban management. The aim is to organize and realize a sustainable allocation of resources and overseeing the day-to-day operation of the urban space. Urban management is a broad concept with complex economic, social and psychological ramifications. That is why urban environment is a shared responsibility, also in terms of facility management, which is an enabler of integrating people, places and processes within the urban environment. Its purpose is to improve quality of life, to increase productivity of the core businesses, to enhance sustainability and reduce negative impact for the living environment (ISO, 2018). After all, as stated by many scientists, urban prosperity is provided by good governance and a flourishing community. Hence, a prosperous society needs urban facility management.

In our view, urban facility management starts with the premises of 'global citizenship'. This reflects the principle of awareness and understanding of the wider world. Global citizens actively participate in their community, and work with others to make the planet equal, fair and sustainable. The Hague University of Applied Sciences (THUAS) strongly believes that students must have tools to become involved, aware, critical and inquisitive human beings. THUAS equips students for future challenges and works towards the development of curiosity, problem-solving skills, and the ability to make sound and well-informed choices (The Hague University of Applied Sciences, 2018).

Based on this vision the school of Facility Management (FM) from THUAS developed an education module in order to incorporate the principles of global citizenship within the FM-context. Composed as the module 'Facityly' management, it is commissioned by the department of Urban Development, Housing, Sustainability and Culture of The Hague city with the aim to investigate the benefits of FM in city districts and neighbourhoods of The Hague.

2 APPROACH TO THE MODULE 'FACITYLY MANAGEMENT'

Around 2003 a number of papers were published about 'neighbourhood management' (Power, 2004) and new urban alignments (Roberts, 2004), which were a guideline for the EUROFM community and triggered the debate whether Facility Management should play a role. This discourse led to the publication of Keith Alexander in 2006 regarding the concept of 'community-based facilities management' (CbFM). Alexander (2006) concluded that facility management, in addition to acting on behalf of its client and focusing on its own operations (Ure & Hampton, 2004; Nicholson & Hampton, 2005) also has a shared responsibility for the social and community context. This resulted into the following definition whereby CbFM is described as '[…] *the processes by which all the stakeholders in a community work together, deliver and maintain an enabling environment, where the local economy can prosper, quality services can be delivered and natural resources protected, in order that citizens can enjoy a quality of life'* (Alexander, 2006, p.264).

In contribution to this discussion, the school of Facility Management of The Hague University of Applied Sciences (THUAS) developed an independent module for community-based facility management in 2004. The overarching goal is to grow awareness among the FM students about global citizenship and liveability in the multi-cultural city of The Hague. Moreover, the school of Facility Management of THUAS has set itself the task to investigate if facility management could contribute to improve liveability and sustainable urban development.

For all these reasons, more than 2000 bachelor FM students over the past 15 years have been dispatched into the city to conduct explorative and qualitative studies based on desk research, literature study, demographic surveys, and observational research by means of photography, film and interviews with both local residents and council representatives. The students then have to analyse the gathered empirical data and present this within the theoretical framework of their literature study and desk research. Finally yet importantly, students are obliged to make a *vlog* (video blog). The results are presented during the final film festival in front of not only lecturers and fellow students but also representatives of the city council and a social housing corporation. Overall, students are taught to conduct validatable and verifiable research where they devote special attention on the presentation. The visualisation contributes to a better understanding of the influence of facility design on urban quality of life.

3 THEORETICAL PERSPECTIVE FROM STUDENTS' VIEW

More than any other animal species man has been able to change his environment and is capable of turning nomadic existence into a sedentary way of living. The history of humanity is framed by archaeological traces of human habitation from prehistoric settlements to modern cities. The genesis of the city helps to understand the ever-changing nature of growth and spatial friction. Particularly, the cutting-edge research in 1950 of Gordon Childe set out in *the Urban revolution* gave insight and knowledge on the role of revolutionary technological and economic developments in human society concerning societal development. In short, Childe stated that from ancient times up to the present day cities are 'just the resultant and symbol of a *revolution* that initiated a new economic stage in the evolution of society'.

The emergence of cities is connected with economic growth. From ancient times, the production of agricultural surplus was one of the reasons for full-time specialization and advanced division of labour as a continuation of the nomadic and autarkic existence. History has shown that this surplus established a public body bound. It evolved to taxation that allowed public assets and facilitated long-distance trade. It entailed also an exchange of revolutionary ideas between indigenous people. This exchange of inter alia exact and predictive science and

art led to innovations and developments across continents (Childe, 1950; Frankopan, 2015) which resulted into urban development over the centuries.

Based on long-term archaeological research Childe (1950) made a set of 10 criteria. This so-called 'urban revolution' distinguishes the city from the village. Childe did not limit himself to the development of cities. Cities were just one component of the overall process by which complex, state-level societies came into being. This was the beginning of an extensive discussion about the characteristics of the city. As a whole, however, Childe's criteria still give a good idea of the most important distinctive aspects of the city.

Figure 1 the Urban Revolution (Gordon Childe)

10-point model for the changes that characterized the Urban Revolution
1. In point of size the first cities must have been more extensive and more densely populated than any previous settlements.' (p. 9)
2. 'In composition and function the urban population already differed from that of any village … full-time specialist craftsmen, transport workers, merchants, officials and priests.' (p. 11)
3. 'Each primary producer paid over the tiny surplus he could wring from the soil with his still very limited technical equipment as tithe or tax to an imaginary deity or a divine king who thus concentrated the surplus.' (p. 11)
4. 'Truly monumental public buildings not only distinguish each known city from any village but also symbolise the concentration of the social surplus.' (p. 12)
5. 'But naturally priests, civil and military leaders and officials absorbed a major share of the concentrated surplus and thus formed a "ruling class".' (pp. 12–13)
6. 'Writing.' (p. 14)
7. 'The elaboration of exact and predictive sciences – arithmetic, geometry and astronomy.' (p. 14)
8. 'Conceptualised and sophisticated styles [of art].' (p. 15)
9. Regular "foreign" trade over quite long distances.' (p. 15)
10. 'A State organisation based now on residence rather than kinship.' (p. 16)

It is an interesting point that archaeologists not only investigate the rise but also the decay of cities. Based on archaeological research it appears that apart from natural disasters, archaeological research has shown that cities do not disappear suddenly.

Often a combination of population and economic growth in relation to more intensive use of resources leads to demise (Childe, 1950). The realm of the Mayan civilisation is a striking beacon. Although no conclusive answer has yet been found, the widely supported theory of their decline is the exhaustion of natural resources, which were needed for construction of rapidly expanding cities and the daily life needs for a growing population. The Mayan had insufficient insight into the effects of intensive use in relation to the effects on liveability. There are scientific indications that economic growth of the Mayan resulted in exhaustion of natural resources and led to severe droughts causing water shortages. It resulted gradually into a disruption of social cohesion. This downward spiral led to the disappearance of the Mayan civilization over a period of 100 years whereby the inhabitants gradually left in search of better places with a greater chance of survival (Mann, 2005). Archaeological excavations show that not only the Mayans but also ancient civilizations on other continents were able to build large cities with complex economic orders and spatial infrastructures, which have collapsed.

In short, not only in antiquity but also nowadays the city is considered crucial for prosperity. Cities contribute to the progress of humanity whereby the size of a city, in particular, is regarded as an important driver of economic development (Rosenthal & Strange, 2004; Melo et al. 2009). However, the ecosystem of the city is vulnerable to exhaustion of the living environment. As declared by the United Nations in 2014 growing cities and economic success

are under greater scrutiny because the relationship between spatial friction and aggregate economic growth requires a spatial theory of cities. The widely accepted assumption about the relationship between the size of the city and a country's economic growth does not hold true. The economics literature (Camagni et al. 2013; Glaeser 2014; Castells-Quintana 2017), refers to other factors, such as urban infrastructure, governance, and industrial composition which play a non-neglible role in the economic fortune of cities, but has – with few exceptions – rarely been tested empirically to date (Frick & Rodríguez-Pose, 2017). Moreover, as seen by the decline of ancient vanished cities, it becomes evident that the benefits of increasing city size are not without limits. Scale often seems to play a role, both positive and negative.

Frick and Rodríguez-Pose (2017) developed an econometric model to investigate the link between city size and economic growth that has led to the conclusion that there is a non-linear relationship between these two entities. It is a nuance to the scarce empirical literature that links city size to aggregate economic performance, which tends to emphasise the benefits of increased city size (Brülhart & Sbergami, 2009; Rosenthal & Strange, 2004). It endorses the importance to use detailed indicators for urban growth in relation to country size because bold assumptions on the presumed correlation between urban and economic growth lead to simplified and non-adequate recommendations on city planning and spatial conditions.

It remains a given that the exponential increase in urbanization across the planet brings new challenges. Technological progress has led to cities becoming bigger, denser and more populous which puts the liveability under tension. According to Zef Hemel (2019), professor urban and regional planning at the University of Amsterdam, urban planning should focus on its core: economy, ecology, democracy, art and imagination. With the result that a new kind of open planning is developed – a planning that can easily adjust to permanently changing circumstances and benefits from unexpected opportunities.

The pressing question is how to find this balance? Mega cities or large-scale regions like Detroit and the Ruhr in Germany whose economic foundation collapsed, do have difficulties to manage equilibrium. Another example are complete city districts as in the former GDR, which are being demolished and / or have to be demolished. Striking is the recent example of imbalance in New Orleans. Almost half the population left within a year due to a large-scale ecological disaster. Even in the economic district La Defense in Paris, once built from a solid ideology where art and architectonic innovation was an important starting point, serious signs of decay are visible. In all these cases, no satisfactory recovery has taken place to date. The urban equilibrium goes a long way. The increase in scale and size offers great opportunities but creates proportionately large risks. New potential disaster areas are located where recent urban and industrial upscaling has taken place. What if a financial crisis strikes Dubai? Or Chinese ghost towns, built for millions of inhabitants, but already largely empty. Finally yet importantly how likely is the chance that the London market for (commercial) real estate collapses due to Brexit? About a hundred office towers and residential towers with over 20 floors have recently been built (in the past five years) or are still under construction in London. Another 50 of these towers are planned. The tantalizing question is if they are actually needed. Moreover, are megalomaniacal structures to some extent missing the mark of actual market demand and balance in human scale? How are we going to manage these urban areas?

Mario Polèse (2013), professor at the Centre Urbanisation Culture Société at Montreal's Institut National de la Recherche Scientifique, set up a draft of urban economics principles that affect city's outcomes positively. Size and location play a major role, outside events drive change, well-connected cities grow faster, because they can move goods more efficiently and human capital to where it has needed most and a diverse set of industries is crucial. According Polèse (2000; 2006) good governance and management do make the difference of a thriving city.

The fact remains that much research into urban development is done at the macro level. However, seeming urban trivia on a micro-level provides interesting information and makes patterns visible. The British sociologist Ruth Glass (1965) noted small patterns in research into the relationship between housing and class struggle in English cities. She introduced 'gentrification' of cities. The process of renovating deteriorated urban neighbourhoods were established by means of the influx of more affluent residents. Gentrification also leads to population migration and displacement with the result of social change and economic shifts somewhere else (Morisson & Bevilacqua, 2018). To be able to observe the small changes, it is not only a matter of investigating the census indicators and big data, but also the apparently minor changes of inter alia maintenance and vacancy rates as indicators for urban change. For this reason, observation research is a very suitable research method for observing the changes at the micro level and an adequate technique to implement in the education curriculum of a university.

4 RESULTS

The overarching question is what has 15 years of research with bachelor FM students yielded? For a more accurate understanding of the city of The Hague, we first explore the genetics of the city. Over half a million inhabitants live in The Hague, as part of an extensive urban area that runs from Rotterdam to Amsterdam, called the 'Randstad' with 7 million inhabitants (Randstad Monitor 2017). Moreover, The Hague is the most the densely populated city of the Netherlands with ± 6,500 inhabitants per square kilometre (City of The Hague, 2018). It is also the administrative capital where many ministries and extraterritorial institutions are housed like embassies, the International Court of Justice, Europol, OPCW, Eurojust etcetera. Approximately 270.000 people find employment in The Hague of which a part commutes from neighbouring areas (DSO, 2018).

About the population structure more than half (54%) of the inhabitants of The Hague are of non-Dutch origin[3]: 18% of the inhabitants do have another Western (non-Dutch) origin and 36% a non-Western background. Compared to the rest of the Netherlands these rates are twice as high as the average rates in the Netherlands. (CBS, 2018; DSO, 218). The Hague is thus one of the most ethnically diverse cities in the Netherlands where approximately 120 different nationalities live spread throughout the city. It should be noted that less than 10% of the research FM students are originally born, raised or are living in The Hague. Most FM students at THUAS are originally from neighbouring suburbs. This makes it an even more interesting exercise to get these students acquainted with urban issues where preconceptions must be ignored.

The Hague is divided into eight districts, consisting of 44 neighbourhoods split into 121 blocks. As far as the housing stock is concerned, the city is characterized by a dichotomy. Besides attractive 19th-century neighbourhoods with mostly expensive housing options and new housing development neighbourhoods at the edge of The Hague, large parts of the city were historically working-class neighbourhoods. In the last 25 years, large-scale urban renewal has taken place in these poorer neighbourhoods resulting in a sustainable housing stock.

At the same time, these neighbourhoods are vulnerable. The Hague is a colourful metropolis but the impact of the denseness puts a strain on social systems and creates imbalances for social cohesion in the various neighbourhoods in terms of simmering tension amongst local residents regarding acceptable conduct (Broekhuizen, van Wonderen, & Marrissing, 2013). These

[3] Persons with a migrant background are persons who live in the Netherlands and of whom at least one parent was born abroad (CBS, 2018).

tensions are visible in the public and semi-public domain as manifested by noise nuisance, remaining waste, pollution, traffic violating and past-due building maintenance which can lead to urban blight (Morenoff, Sampson, & Raudenbush, 2001).

The student research and the corresponding rapports resulted in all kinds of findings concerning polluted streets, broken street furniture and deferred maintenance with clear differences between the various neighbourhoods. Students also captured on footage neighbourhoods changes due to urban developments on property and infrastructure, but that does not alter the fact that certain districts are visibly impoverished. This is partly caused by higher rents due to real estate and infrastructural and sustainable adjustments, but income pattern for minority groups did not change (CBS, 2019). These findings make students realize that the difference between rich and poor is bigger than expected. In addition, the level of facilities per neighbourhood is different. The era in which the neighbourhood is built partly determines the provisioning level. City parks, playgrounds, parking facilities and electric charging stations for cars, bicycles facilities and dog exhausts are different per neighbourhood. It marks the difference between the healthy and troublesome neighbourhood.

An interesting but worrying development is the vacancy of retail space in less-favoured neighbourhoods (Van Ham, 2012). Undoubtedly, e-commerce results in changing shopping behaviour of local residents and increased vacancy rates, but students also note the difference between the shopping streets of affluent and poorer neighbourhoods. Where shopping streets in better neighbourhoods are resilient and filled with an extensive range of small retailers, the provision of shops in poorer neighbourhoods is more uniform. Additionally, there is a rapid circulation of retail spaces, with more than average bankruptcies. These findings are confirmed by student desk research whereby retail and small business are more often set up in priority neighbourhoods but with a more likely chance of failure (PBL, 2010; EIM, 2008). However, neighbourhoods are important breading grounds for entrepreneurial activity and of great importance to sustainable economic growth and creating jobs. Poor quality of liveability in a district opposes economic activities and increases the chance of a decrease in liveability.

Another interesting question is how to keep young people in the city? A large number of THUAS students live in the suburbs and have no ambition to settle in The Hague after graduation. To the question why students do not want to live in The Hague, they reply that besides the scarcity of affordable housing the density, the lack of social cohesion and the anonymity of existence chases them out of the city. The shortage of appropriate facilities but above all the unstable social cohesion in those neighbourhoods with affordable housing stock makes youngsters rather stay in their hometown with all that that entails for a thriving place.

This brings us back to the initial question of how the facility manager can facilitate the city. After all, the facility manager is not responsible for economic activities in a neighbourhood and issues on housing, but in our perspective on good urban management whereby social cohesion is facilitated, the urban facility manager can play an important role. Connecting people by managing place and process in an urban context can improve liveability and sustainable urban developments. With the pressing question from which capacity or organization the urban facility manager operates.

5 CONCLUSION

More than 2000 FM students have been conducting research on urban management over the last 15 years with the result that they realize the great variety in habitats with a large diversity of inhabitants. Moreover, they have learned that neighbourhoods where social problems arise often have the least capacity for self-organization. The absence of self-organization of

neighbourhood residents can lead to tensions between groups, but also between citizens and government or citizens and other institutions. A lack of mutual or collective sharing of space leads to deterioration of the physical environment. Therefore, global citizenship calls for an active role from people, thus also students, in their community, and the cooperation with others to make our planet more equal, fair and sustainable. Recent research (2018) among FM alumni has shown that this educational module contributed to their awareness of social issues at neighbourhood level from both a theoretical and empirical point of view.

In addition, the module has provided data on changes at neighbourhood level resulting in numerous small-scale improvements initiated by the department of Urban Development, Housing, Sustainability and Culture of The Hague. And last but not least, it yielded a network and projects for the minor real estate of THUAS. Empty churches, languishing office buildings and shopping centres were investigated with the help of students to find new destinations.

This all contributed to a better understanding of urban management and endorsed the definition of Keith Alexander (2006) that facility management, as well as performing on behalf of its client and focusing on its own operations, also has a shared responsibility for the social and community context.

6 LIMITATION AND SOCIAL DEBATE

This paper gave the school for Facility Management at THUAS pause for thought. It made us realize that we have been doing meaningful research over the last 15 years. For years, student reports with data and photo essays were submitted, checked and assessed. They have been of value to our commissioners. The lesson-learned is that we have failed to collect and analyse the multi-year data, which could have helped us into a better foundation of the term urban facility management.

In addition, we have been debating the past years how FM should be made explicit in the neighbourhood. In particular, the role of the urban FM manager is an issue. What is the benefit and on behalf of whom does it function? We do not have an answer to this question and hope that a European debate can facilitate a better understanding and an opus operandi for higher education of applied sciences. Last but not least, which responsibilities do universities of applied sciences have in the ‘bildung’ of students? Moreover, how should education programs be organized to make a successful contribution to global citizenship? This also requires a debate for a better world for all of us.

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When you must prioritize – Activity based working for students

Rebecca Sjølingstad Olsen
UiT The Arctic University of Norway
sjolingstad96@gmail.com

Hanne Marit Vågen
Oslo Metropolitan University
s306508@oslomet.no

Knut Boge
Oslo Metropolitan University
kboge@oslomet.no

ABSTRACT

Purpose: Many universities' reading areas for students have numerous similarities with office landscapes and workplaces designed for activity-based working. Students are tomorrow's knowledge workers. Thus, students are good proxies for knowledge workers and provide an excellent opportunity to investigate which physical work environment factors that really matters for knowledge worker's well-being and productivity.

Methodology: The present research is based on two surveys and observations from February until late May 2018. The first survey was undertaken in March 2018 (N = 97). The second survey was undertaken in May 2018 (N = 115) during the exams season. The surveys' questionnaire was based on best-worst scaling, a method commonly used in marketing and hospitality research. Best-worst scaling elucidates the respondents' most and least preferred alternatives, and usually provides highly valid data. The survey data have been subject to descriptive statistics and statistical tests to identify what matters.

Key findings: Students value god air quality. Adequate air quality is of particular importance during examination periods, when the students really must perform. Students would like the opportunity to change places for private studies and self-tuition depending on tasks.

Intended impact of the study: Good workplaces for knowledge workers require adequate ventilation and other relevant indoor environmental qualities. Secondly, knowledge workers should be able to change workstation depending on their tasks; i.e. activity-based working. Finally, many knowledge workers may live well with free seating and clean desk schemes in office landscapes, given the opportunity to change to other places when needed.

Paper type: Research Paper

Keywords: Activity based working, Best-worst scaling, Knowledge workers, Physical work environment, Students.

1 INTRODUCTION

Today, knowledge workers can carry out their tasks both in physical and virtual spaces. This paper does not address virtual spaces, but physical spaces. The work environment is often divided into the physical, social and cultural domains (Woolner et al., 2007). This paper addresses the physical domain. One of our times' big questions is how to organize workplaces that nurture the knowledge workers' productivity. Knowledge work is usually less tangible

than manual work. Another complicating factor according to Heerwagen et al. (2004) is the fact that knowledge work is "both highly cognitive and highly social". According to Nenonen et al. (2009), knowledge work is more dependent of collaborative work than traditional manual labour. Workplaces for knowledge workers may thus benefit significantly from inclusion of areas that facilitate interactions between knowledge workers.

Jensen (2001, p. 129) distinguishes between four main categories of offices at workplaces. The first is open landscapes; i.e. large rooms with several desks or workstations. The second is cubicles or cell offices, usually for individual workers or small numbers of workers. The third is group offices where employees are seated according to their organizational belonging. The final category is so-called activity-based offices with different zones and workstations that facilitate different kinds of work, ranging from individual concentration work to communication and interaction among groups of knowledge workers.

A big issue in many organizations is whether the employees have a designated personal desk or workstation, or if the organization has implemented flexible offices, combi-offices or hot-desking, where a department or team shares several workstations (Jensen 2001, p.121; Booty 2011, p. 359; de Been and Beijer 2014). The most extreme space sharing concept is so-called free seating combined with a clean desk policy, where no employees have designated workstations and where workstations are available across organizational boundaries.

This paper investigates how students at a Norwegian university perceive the physical work environment in areas designated for the students' private studies or self-tuition; i.e. the areas where many students spend time before, between and after lectures. The university where this study took place is one of Norway's most space efficient universities; i.e. very few square metres per students and employees. Some of the upsides with space efficiency is low property costs and small environmental footprint per students and employees. The downside is among others few traditional reading rooms for students, and hardly any reading rooms at all with designated desks, which is the norm for graduate students at Norway's traditional universities. Most areas for the students' private studies or self-tuition at the university where this study took place are corridors between auditoriums and classrooms equipped with tables and chairs that among others facilitate collaboration and informal learning, and some areas in the libraries and canteens. Thus, most of the areas for the students' private studies or self-tuition at the university where this study took place have many similarities with open office landscapes and partly also activity-based offices. Students are tomorrow's knowledge workers. Thus, studies of students' preferences concerning their physical work environment in areas designated for the students' private studies or self-tuition may have transfer value to workplaces for knowledge workers.

2 LITERATURE

The WELL Building Standard (International WELL Building Institute, 2018) have defined comfort boundaries for indoor environmental qualities (IEQ). The air quality is very important for workers' productivity. Perceived air quality is among others influenced by number of persons in the rooms in question, type of work activities, cleaning scheme, temperature and ventilation (Booty, 2011). Air quality, temperature and heating may influence students' behaviour and performance, and Earthman (1998) found a positive relation between building quality and test scores. Woolner et al. (2007) found that fewer particles in the air improve the air quality, and improved air quality may reduce absenteeism. CO_2 levels above 800 ppm may have the consequence that users of the building experience so-called sick building syndrome (SBS); i.e. concentration problems, headaches, etc. (Seppänen et al., 1999).

At many workplaces, noise is a potential problem source, among others because noise may disturb the workers and reduce their productivity (Oseland and Hodsman, 2015). Constant exposure to noise may also reduce persons' cognitive capacity (Woolner et al., 2007). Noise may also influence persons' mood (Stansfeld and Matheson, 2003). The problem is that what is perceived as an acceptable noise level varies between individuals (Miljødirektoratet, 2017). Oseland (2015) found that 65 per cent of the workers reported that high noise level had a negative effect on their work performance, while only 10 per cent of the workers reported that noise level had a positive effect on their work performance. Oseland (2015) also found that other persons' conversations may be very disturbing. Thus, noise at workplaces may represent a problem, but some noise that masks other persons' conversations may actually be desirable.

Lighting is of importance for humans' health and well-being. Lighting influences the mood, emotions and our state of mind. Lighting may also influence humans' circadian rhythm. Lighting serves three basic human needs. Firstly, lighting provides visual comfort and well-being. Secondly, lighting may also improve the workers' productivity and the quality of workmanship. Finally, lighting provides a feeling of security (NS-EN 12464-1, 2011). In northern countries like Norway, artificial lighting is a very important supplement or substitute for daylight. Barret et al. (2015) found that lighting is very important for pupils' performance.

Cleaning influences the indoor environment and may thus influence both the work environment and the indoor climate. Adequate cleaning also reduces dissemination of diseases. The rule of thumb, according to Nilsen (2012) is that small and light particles usually represent a greater health risk than large and heavy particles.

Hunter and Cox (2013) studied students' use of a library's informal learning spaces and found both "espressos" who used the areas for a short period of time, and "campers" who spent many hours in the library's informal learning areas. Hunter and Cox (2013) also found that some students worked best in calm and tranquil surroundings while other students worked best when exposed to background noises.

3 METHODS

The present research is about a university building's informal study areas, where many students carry out their private studies or self-tuition. The study is based on two surveys and observations from February until late May 2018. The first survey was undertaken in March 2018 (N = 97). The second survey was undertaken in May 2018 (N = 115) during the examination period.

The survey was based on best-worst scaling (Louviere et al., 2015), a method commonly used in marketing and hospitality research. Best-worst scaling is a furthering of paired comparison and elucidates the respondents' preferences through asking about their most and least preferred alternatives. Best-worst scaling usually provides highly valid data and shows where the respondents are indifferent.

The questionnaire included background questions about the students' age, gender, which floor they were in when they answered the questionnaire, their study program and how many days per week they used the university's premises for self-tuition. The remaining questions about the building's premises for self-tuition, were best-worst scale questions about how they perceived various indoor environment quality factors, what in the building they would like to change, and which of the building's areas the they preferred for private studies or self-tuition.

Anonymous paper questionnaires were randomly distributed to students who were present those days the survey took place. The respondents' answers written on the questionnaires were

thereafter manually registered as a data matrix in an Excel spreadsheet. The data matrix was thereafter subject to extensive proofreading and comparison with questionnaires, to minimize errors and to improve the reliability. As soon the data in the spreadsheet were correct, the data were exported to IBM SPSS version 25 for further analysis.

The data has been subject to descriptive statistics, such as recommended by Louviere et al. (2015, p. 22 ff.). The respondents' answers to the best-worst scale questions were transformed into new variables recoded with 1 = Most valued, 0 = Not answered (indifferent) and -1 = Least valued. These calculations established each individual respondent's preferences concerning each question with best-worst scaling. Each question's relative importance was thereafter established through calculation of number of most minus least scores (Louviere et al., 2015, p. 21 ff.).

The respondents' answers to the best-worst scale questions are not normal distributed. Hence the use of non-parametric distribution free statistics to test whether different categories of students have different preferences. Independent samples Mann-Whitney U tests were used when the data could be divided two independent groups. Independent samples Kruskal-Wallis one-way ANOVA were used when the data were divided in more than two independent groups (Israel, 2008, pp. 29-37, 92-101). The Mann-Whitney test's effect size r was calculated manually as z/Sqrt N (Field, 2013, p. 227). The effect size in the Kruskal-Wallis' case the is not a particularly useful measure because it represents a general effect (Field, 2013, p. 248).

4 RESULTS

The survey was carried out in the building that accommodates the university's School of Engineering (Faculty of Technology) and Business School (Faculty of Social Science). This building was initially an office building but was later converted to accommodate the university and many students. Thus, the building now accommodates far more persons than initially planned, and the ventilation and climate control system is sometimes struggling.

In total, 186 respondents answered the questionnaire (73 women (39%) and 113 men (61%)). The survey was answered by 112 engineering students (60%), 69 business students (37%) and 5 other students (3%). Most respondents (92%) were bachelor level students.

24 (21%) of the engineering students were women, and 88 (79%) were men. 47 (68%) of the business students were women, and 22 (32%) were men. The respondents' mean, and median ages were 23 years. The youngest students were 19 and the oldest 35 years. The engineering and business students' age distribution were very similar, but the oldest business student was 31 years while the oldest engineering student was 35.

The university's School of Engineering and Business School have somewhat different teaching schemes. The engineering students usually have one lecture in the morning, where they receive tasks and work with these individually or in groups during the day, and thereafter wrap up the day with a lecture late in the afternoon. The business students usually have three or four lectures per week. 30.4% of the engineering students spend 3-4 days per week at the university and 49.1 % of spend 5-6 days per week at the university. 30.3% of the business students spend 1-2 days per week at the university, and 47.8% spend 3-4 days per week at the university. Thus, in average, the engineering students spend more time at the university than the business students do.

4.1 The most and least valued indoor environmental qualities when students do concentration work

The first best-worst scaling questions in the questionnaire were about the most and least valued indoor environmental qualities when doing concentration work.

Table 1 The most and least valued indoor environmental qualities when students do concentration work

Quality	Most valued (%)	Least valued (%)	Indifferent (%)	Rank (Most minus least valued)
Ventilation	103 (55.4)	13 (7.0)	70 (37.6)	90
Noise	51 (27.4)	47 (25.3)	88 (47.3)	4
Lighting	16 (8.6)	58 (31.2)	112 (60.2)	-42
Cleaning	16 (8.6)	67 (36.0)	103 (55.4)	-51

Table 1 shows all the respondents' most and least valued indoor environmental qualities when doing concentration work in the building's areas for private studies or self-tuition. The column most minus least valued shows that ventilation is most valued. Noise level is second most valued. Lighting and cleaning are least valued.

Independent samples Mann-Whitney tests of female and male students, engineering and business students, and the two samples from the middle of the semester and during the exams period concerning ventilation, noise, lighting and cleaning when doing concentration work gave insignificant results. Thus, female and male students, engineering and business students, and students in the middle of the semester and during the exams period have similar preferences concerning ventilation, noise, lighting and cleaning when doing concentration work.

Independent samples Kruskal-Wallis one-way ANOVA of the answers from students sitting in the four different floors also gave insignificant results. Thus, students using the five different floors for concentration work and private studies or self-tuition have fairly similar preferences concerning ventilation, noise, lighting and cleaning. Independent samples Kruskal-Wallis one-way ANOVA of the answers from students depending on how many days per week they spent at the university doing private studies or self-tuition gave significant results ($H(4), 10.93, p = .027$). Students who seldom use the university's facilities for private studies or self-tuition have significantly lower preferences for cleaning than students who spend more time at the university.

4.2 The most and least valued improvements of the building

The students were also asked about the most and least valued improvements of the building.

Table 2 The most and least valued improvements of the building

Improvements	Most valued (%)	Least valued (%)	Indifferent (%)	Rank (Most minus least valued)
Ventilation	79 (42.5)	7 (3.8)	100 (53.8)	72
Group rooms	57 (30.6)	23 (12.4)	106 (57.0)	34
Quiet rooms	34 (18.3)	31 (16.7)	121 (65.1)	3
Noise	10 (5.4)	30 (16.1)	146 (78.5)	-20
Cleaning	4 (2.2)	39 (21.0)	143 (76.9)	-35
Lighting	3 (1.6)	55 (29.6)	128 (68.8)	-52

Table 2 shows that ventilation is the number one priority for improvements. Groups rooms and quiet rooms are the second and third priorities for improvements, because the building has few group rooms and quiet rooms. Noise, cleaning and lighting are the least valued candidates for improvements.

Independent samples Mann-Whitney tests of female and male students concerning improvements of the building were not significant. However, independent samples Mann-Whitney tests of engineering and business students' most and least prioritized improvements gave a significant result concerning quiet rooms. Engineering students (N = 112, Mean Rank = 85.30) valued quiet rooms significantly less than business students (N = 69, Mean Rank = 100.25) (U = 4502.0, z = 2.218, p = .027, r = .16). This seems reasonable since engineering students have more group tasks than the business students have.

Independent samples Mann-Whitney tests of the mid semester and exams season samples' most and least prioritized improvements gave a significant result concerning ventilation. The exams season sample (N = 99, Mean Rank = 101.08) valued ventilation significantly more than the mid semester sample (N = 87, Mean Rank = 84.87) (U = 5057.0, z = 2.338, p = .019, r = .017). Even this seems reasonable, because the building is more crowded during the exams season.

Independent samples Kruskal-Wallis one-way ANOVA of the answers from students seated in the four different floors, and from students with different presence in the building were insignificant. Thus, the respondents' preferences concerning improvements were not dependent of the floor the respondents were seated or how many days per week they spent in the building doing private studies or self-tuition.

4.3 The most and least used study areas

The respondents were also asked their most and least used study areas.

Table 3 The most and least used study areas

Study area	Most used (%)	Least used (%)	Indifferent (%)	Rank (Most minus least valued)
Tables in corridors	149 (80.1)	3 (1.6)	34 (18.3)	146
Group rooms	18 (9.7)	12 (6.5)	156 (83.9)	6
Library	17 (9.1)	54 (29.0)	115 (61.8)	-37
Canteen	2 (1.1)	115 (61.8)	69 (37.1)	-113

Table 3 shows that a clear majority of the respondents prefer the tables in the corridors. The canteen is the least preferred alternative.

Independent samples Mann-Whitney tests of female and male students concerning the most and least used study areas gave a weakly significant difference concerning use of library. Male students (N = 113, Mean Rank 88.09) were more negative to use of the library than female students (N = 73, Mean Rank = 101.87) (U = 4735.50, z = 1.983, p = .047, r = .15).

Independent samples Mann-Whitney tests of engineering and business students concerning most and least used study areas gave a significant difference concerning use of library. Engineering students (N = 112, Mean Rank 82.16) were more negative to use of the library than business students (N = 69, Mean Rank = 105.5) (U = 4854.00, z = 3.354, p < .001, r = .25). Independent samples Mann-Whitney tests of engineering and business also gave a significant difference concerning use of tables in the corridors. Engineering students (N = 112, Mean Rank 98.98) were significantly more positive to use of the tables in the corridors than business students (N = 69, Mean Rank = 79.03) (U = 3038.00, z = -3.447, p < .001, r = -.26).

Independent samples Mann-Whitney tests of the samples made during mid semester and exams season gave a significant difference concerning use of tables in the corridors. The mid semester sample (N = 87, Mean Rank 87.99) were less positive to use of the tables in the corridors than the exams season sample (N = 99, Mean Rank = 98.87) (U = 4835.50, z = 2.096, p = .036, r =.15). Thus, when the building is crowded, students use what is available.

Independent samples Kruskal-Wallis one-way ANOVA concerning use of study areas were insignificant concerning students seated in the different floors and concerning students with different presence in the building. Thus, the respondents' preferences concerning study areas were not dependent of the floor the respondents were seated or how many days per week they spent in the building doing private studies or self-tuition.

5 CONCLUSIONS

This study has shown that engineering and business students have somewhat different behaviour. The engineering students are rather like what Hunter and Cox (2013) described as "campers", because they spend most of the week in the university's areas for private studies and self-tuition. The business students are more like "espressos" (c.f. Hunter and Cox, 2013), because they spend considerably less time in the university's areas for private studies and self-tuition than the engineering students do.

This study has shown that adequate ventilation is the respondents' priority number one, both concerning existing qualities and concerning needs for improvements. This study has also shown that students who are frequent users of the university's areas for private studies and self-tuition value cleaning more than students who seldom use the premises. The respondents who answered the survey during the exams season were more concerned about improvements of the ventilation than mid semester respondents were. The students' priority of ventilation support findings from other research about the importance of good ventilation (International WELL Building Institute, 2018; Booty, 2011; Earthman, 1998; Woolner et al., 2007; Seppänen et al., 1999).

Noise level was the students second most valued quality in the current building, but only the fourth priority for improvements. Noise in areas for concentration work is important (Oseland and Hodsman, 2015; Woolner et al., 2007; Stansfeld and Matheson, 2003; Miljødirektoratet, 2017; Oseland, 2015), but the respondents' priorities concerning improvements of the building

may indicate the noise level in the building's areas for private studies and self-tuition is manageable. Some noise in such areas may be desirable because noise masks other persons' conversations, which can be very disturbing.

The respondents' second and third most preferred areas for improvements of the building were group rooms and quiet rooms. Thus, the students can live with the corridors' de facto office landscapes but would like the opportunity to use group rooms and quiet rooms when needed. The students here actually ask for possibilities for activity-based working. This is clearly in line with research-based recommendations about workplaces for knowledge workers (cf. Heerwagen et al., 2004; Nenonen et al., 2009; Jensen, 2001; Booty, 2011; de Been and Beijer, 2014).

Finally, the study has shown that most respondents prefer a kind of office landscape; i.e. tables and chairs in the corridors to group rooms, library and particularly the canteen. This finding is a bit puzzling but given that knowledge work is "both highly cognitive and highly social" (Heerwagen et al., 2004), and that knowledge work depends more on collaboration than traditional manual labour (Nenonen et al., 2009), these findings make sense. A library with restrictions on verbal communication may not be the best workplace for knowledge workers. A canteen may similarly be too crowded and noisy for concentration work. The corridors' tables and chairs; i.e. office landscapes provide something in between the quiet library and the very noisy canteen. Thus, students and maybe even knowledge workers may accept rather simplistic but functional workplaces, given decent ventilation, manageable noise level, opportunities for communication and cooperation, and acceptable lighting and cleaning.

The managerial implications from this study, and transfer value to traditional workplaces for knowledge workers are first and foremost that good workplaces for knowledge workers require adequate ventilation and other relevant indoor environmental qualities. Secondly, knowledge workers should be able to change workstation depending on their tasks; i.e. activity-based working. Finally, knowledge workers may live well with free seating and clean desk schemes in office landscapes, given the opportunity to move to other places when needed.

Further research should investigate relations between students and knowledge workers' physical work environment and their performance.

ACKNOWLEDGMENTS

Thanks to those students who participated in the study and answered the questionnaire. Also, thanks to the reviewers. Their comments clearly led to improvements of this paper.

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CarMa – Carbon Management for Facility Services
Developing of a Method and Tool to Determine CO_2 Emissions through Facility Services on an Approximate Basis

Andrea Pelzeter
Hochschule für Wirtschaft und Recht Berlin – Berlin School of Economics and Law
andrea.pelzeter@hwr-berlin.de
+49 30 30877-2230

Michael May
Hochschule für Technik und Wirtschaft Berlin – University of Applied Sciences Berlin
michael.may@ htw-berlin.de
+49 30 5019-2601, -2691

Stefan Schmid
Hochschule für Wirtschaft und Recht Berlin – Berlin School of Economics and Law
stefan.schmid@hwr-berlin.de
+49 30 30877-2450

Philipp Salzmann
Hochschule für Technik und Wirtschaft Berlin – University of Applied Sciences Berlin
philipp.salzmann@htw-berlin.de
+49 30 5019-2601, -2691

Tim Herrmann
Hochschule für Technik und Wirtschaft Berlin – University of Applied Sciences Berlin
tim.herrmann@htw-berlin.de
+49 30 5019-2601, -2691

ABSTRACT

Purpose: With climate change on the rise, decarbonisation is becoming the new guideline for all industries. Therefore, methods and benchmarks are needed. While these already exist for the construction sector (e.g. EN 15804 "Sustainability of construction works – Environmental product declarations" and databases like 'Ökobaudat' and 'IBU.data') there are almost none to be found for the service sector, especially for facility services. Furthermore, IT tools that support carbon management in that field efficiently do not exist. This challenge was picked up by a consortium of two universities in collaboration with practitioners from facility services, consulting and IT resulting in the research project "CarMa – Carbon Management for Facility Services". The main objectives of CarMa can be summarised as follows:

The first one is to develop a transparent method to estimate CO_2 emissions through facility services. Therefore, key figures and/or benchmarks regarding CO_2-eq emissions of equipment and operating consumables used in FM must be derived. The second main objective is to develop and to provide an open IT tool (web service) for a standardized capture and evaluation of key figures for carbon management. Both the CarMa method and tool will be implemented and evaluated based on case studies. The third main objective is to provide guidance on how to reduce the carbon footprint of FM service providers (GEFMA[4] guideline).

[4] German Facility Management Association.

Methodology: In Addition to the literature review on Life Cycle Analysis (LCA) and Carbon Footprint (CFP), the research team works closely with six external partners in the facility management sector[5]. Regular workshops, surveys (questionnaires filled out by employees of the external partners regarding their everyday operations during the service delivery), databases (for benchmark analysis) and on-site investigations with measurements are used to collect the necessary data.

Findings: As the project is ongoing, final results can only be presented within the next year. The paper will discuss the motivation, detailed objectives, scientific approach as well as first insights about the IT tool (e.g. user requirements, functionality, architecture, user interface, data capture, results).

Intended impact of the study on either research, education or practice: As there is no easy method to estimate the carbon footprint of facility services yet, the implications are to be expected to have a great impact on research and practice in the services sector.

Paper Type: Research Paper

Keywords: Facility Management, Facility Services, Carbon Footprint, CO_2 Emissions, Sustainability

1 INTRODUCTION

At the United Nations Framework Convention on Climate Change, 21st Conference of the Parties (COP 21), in 2015, the so-called "Paris Agreement" has been approved and has been ratified by 185 of 197 parties to the convention so far United Nations Framework Convention on Climate Change [UNFCC], 2019a). Its "central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius (UNFCC, 2019b)."

To achieve this all emissions that are climate relevant have to be reduced substantially over the next few decades to near zero until the end of the century (Intergovernmental Panel on Climate Change [IPCC], 2015: 20). Climate relevant are the emissions of the so-called greenhouse gases (GHG) like Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Ozone (O_3) and others. With an equivalent factor, their global warming potential (GWP) is expressed in (giga)tons of CO_2-eq (eq for equivalent) (IPCC, 2015: 5). Therefore, each participating country works out an implementation plan. The German government adopted its "Climate Action Plan 2050" in 2016. It foresees a reduction of the greenhouse gas emissions of at least 55 % by 2030 compared to 1990 (Federal Ministry for the Environment, Nature Conservation, Construction and Nuclear Safety [BMUB], 2016: 7). In this plan, the service sector is not taken into account. By using systematically low-carbon products, every service would increase the demand for CO_2-eq-optimized products and therefore accelerate the transformation towards low-carbon technologies. In addition the CO_2-eq emissions contained in service delivery would be counted as indirect emissions in the service customers' overall balance ("scope 3" regarding Greenhouse Gas Protocol (World Resources Institute and World Business Council for

[5] Apleona GmbH, Berliner Immobilienmanagement GmbH (BIM), GEFMA, Gegenbauer Holding SE & Co. KG, Institut für Facility Management GmbH (iffm), Integrale Planung GmbH (Intep).

Sustainable Development [WRI and WBCSD] 2011: 4)) which would further improve their competition in the field of sustainable economy.

Outside the energy sector and the car industry, the declaration of CO_2-eq emissions is not common practice yet. This also applies to the Facility Management (FM) sector that offers a broad variety of different services in the area of building management and in the support for key processes of the FM customers. FM combines and manages many different facility services such as cleaning services, grounds keeping, security services, operation and maintenance of buildings and equipment. Only in lighthouse projects, e.g., sport events, CO_2-eq emissions are calculated in FM. Therefore, usually external consultants are involved. A transmission on all operations and all customers' orders taking this effort is not realistic.

Without knowing the drivers of service-related CO_2-eq emissions, an optimization cannot be achieved. A preceding case study concludes that through optimized facility services the overall savings of facilities could sum up to 10 % (Pelzeter and Sigg, 2019: 5). In addition, a transparent communication regarding actually reduced CO_2-eq emissions in facility services requires a comprehensible and not too complex approach. This is where the project starts.

The main objectives of the CarMa project are:

Developing a transparent method to estimate CO_2-eq emissions generated by facility services,

Identifying key figures and/or benchmarks regarding CO_2-eq emissions of equipment and operating consumables used in FM,

Developing and providing an open IT tool (web service) for a standardized capture and evaluation of key figures for carbon management,

Implementing and evaluating the CarMa method and tool based on case studies,

Providing guidance on how to reduce the carbon footprint[6] of FM service providers (by drafting a GEFMA[7] guideline).

The collaborating industry partners are involved in any decision on the project, are informed regularly about the project's progress and their requirements and suggestions are considered.

2 STATE OF THE CURRENT KNOWLEDGE

With "Sustainability in Facility Management; Fundamentals and Concept" GEFMA published a guideline on sustainability in FM (GEFMA, 2014). Although it asks in the criterion "energy management" for CO_2-eq key figures, it does not give a method at hand on how these should be estimated. Basic principles on how to assess CO_2 emissions can be found in standards that define the procedure of life cycle assessment, the phases of the life cycle and the impact category of CO_2 (Pelzeter and Sigg, 2019: 2).

2.1 Standards on Life Cycle Assessment and Greenhouse Gas Balance

International standards on life cycle assessment (LCA) are ISO 14040 "Environmental management – Life cycle assessment – Principles and framework" and ISO 14044 "Environmental management – Life cycle assessment – Requirements and guidelines" as part of the ISO 14000 family "Environmental management" (Klöpffer and Grahl, 2014). As further part of the family, ISO 14067 "Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification" was published in accordance with ISO 14040

[6] Merriam-Webster (2019): "the amount of greenhouse gases and specifically carbon dioxide emitted by something (such as a person's activities or a product's manufacture and transport) during a given period".
[7] German Facility Management Association.

and 14044 in 2018. According to ISO 14040, an LCA consists of four successive steps (International Standards Organization [ISO], 2006a):

Definition of the goal and scope of the LCA (including the functional unit and the system boundary),

The life cycle inventory analysis (LCI) phase,

The life cycle impact assessment (LCIA) phase,

The life cycle interpretation phase.

In "Product Carbon Footprinting – a study on methodologies and initiatives" commissioned by the European Commission 44 methods and 62 initiatives (most of them derived from ISO 14040/44) are listed on how to estimate product carbon footprints (CFPs) (Ernst & Young and Quantis, 2010). Among these are the methodologies "PAS 2050 (British Standards Institution [BSI], 2011)" (UK), "GHG Protocol – Product Life Cycle Accounting and Reporting Standard (WRI and WBCSD, 2011)" (worldwide) and ISO 14067. With VERUM 2.0, the German Environment Agency (Umweltbundesamt (UBA)) published the so-called simplified environmental assessment. Its aim is to achieve a first plausible environmental assessment, without a complete and quantitative examination as done in an LCA or an environmental impact assessment (EIA) (German Environment Agency [UBA], 2017: 11). Starting from the above standards the following methodology was developed for CarMa.

2.2 Reflections on current LCA methodologies

2.2.1 Four Steps of an LCA

As one of the main aims of the project is to develop a transparent method to determine CO_2-eq emissions on an approximate basis, the methodology corresponds mainly to the approach of VERUM 2.0 and not of an LCA. Yet, the four successive steps of an LCA according to ISO 14040 will be used as framework. As the project is ongoing only the first step "definition of the goal and scope" can be explained so far. As already described in the introduction, the goal is to develop a transparent method to determine CO_2-eq emissions by facility services on an approximate basis. The scope will be defined in the next section.

2.2.2 Data Sources and Data Quality

Types of Data

It is the goal of VERUM 2.0 to get a first plausible environmental assessment even without the need of a complete quantitative study. To ensure its applicability even in cases of difficult data situations simplifications and estimations are allowed and in some cases even necessary.

For quantification reasons four types of data and sources are defined (see table 1).

Table 1 Data Sources For The Quantitative Determination Regarding VERUM 2.0 (UBA, 2017: 25)

Type of Data	**Examples**
Primary Data	Own measurements
Secondary Data	LCA inventory databases like GaBi, Ecoinvent or ProBas; literature; available studies; emission databases; environmental statistics
Calculations	Physical calculations like power demand to heat up material; chemical calculations like the determination of emissions of stoichiometric ratios
Quantitative Estimations	Estimation of power consumption based on data of a similar process

As the availability of data on the subject under consideration is quite limited the procedures of simplification and estimation including the types of data 'secondary data' (e.g. Environmental Product Declarations (EPDs) according to ISO 14025 (ISO, 2006c)) and 'quantitative estimations' are going to be used. If possible 'primary data' is gained through own measurements and calculations will be made in addition.

The methodology resulting from this does not comply with the quality of an LCA, which is in accordance with the objectives of this project.

Inaccuracies and Uncertainties in Data Sources and Data Quality

For the estimation of emissions of single inputs, the GHG Protocol recommends a conservative approach. If no data is available, maximum emissions will be assumed (Hottenroth, Joa and Schmidt, 2013: 32-35, 50). This approach will be chosen for all further considerations such as cut off criteria, system boundaries or allocations[8].

Due to these estimations, the gained CFP is fraught with uncertainties. Therefore, estimated CFPs should be seen as blurred areas of possible values rather than exact ones. For practical purposes, it is usually sufficient to have an idea of these uncertainties, e.g. if the estimated CFP was defined with an uncertainty of ± 5 %, ± 20 % or even ± 100 %. Therefore, it is usually accepted to determine the most important sources of uncertainty and at least to estimate their influence on the overall outcome roughly (Hottenroth, Joa and Schmidt, 2013: 70).

2.3 Developed Methodology

As tests are yet to be made, the methodology and the estimated values described below might be adapted. The final results are going to be published on https://www.ifaf-berlin.de/projekte/carma.

3 CARBON FOOTPRINT OF FACILITY SERVICES

3.1 Types of Facility Services

Facilities can be divided into many different types. These vary in size, form and function (Seidl, 2012). Consequently, the amount and variety of resulting facility services is high.

The GEFMA Standard Service Catalogue (Version 4.0) lists 161 services, which can be clustered into 18 groups. Three of these groups (with 37 itemised service descriptions) can be assigned to service-specific management (from now on referred to as overhead). Fifteen groups (with 124 itemised service descriptions) can be assigned to the actual facility services. Some of the listed services are further subdivided. This is especially the case if the corresponding group was only divided roughly or not at all. Table 2 shows an overview of the service groups and their detail of subdivision including the service description (GEFMA and RealFM, 2019: 2-5).

Table 2 GEFMA Standard Service Catalogue Facility Services – Version 4.0

Service Group	Number of Services listed in Catalogue	Allocation
One-time Services	19	Overhead
Management of the Facility Services	13	Overhead
Documentation and Reporting	5	Overhead

[8] If a process has at least two products as output, the in- and outgoing energy and material flows have to be allocated to these products (Hottenroth, Joa and Schmidt 2013: 45).

Service Group	Number of Services listed in Catalogue	Allocation
Operational Management / Facility Operations	2	Facility Service
Inspection and Maintenance	3	Facility Service
Repair	1	Facility Service
Follow-up of claims for defects	1	Facility Service
Energy and Media Management	6	Facility Service
Cleaning	47	Facility Service
Grounds Keeping	29	Facility Service
Building Services	2	Facility Service
Security and Reception Services	9	Facility Service
Waste Management	2	Facility Service
Mail Service / Logistics	2	Facility Service
Conference Rooms and Event Services	5	Facility Service
Transport Services	3	Facility Service
Space Management	9	Facility Service
Management of Vacant Property	3	Facility Service

Due to the variety of different services like “Cleaning”, “Inspection and Maintenance”, “Security and Reception Services” and services like “Catering” that are not further divided and described, it is a challenge to develop a consistent methodology, which can be applied equally to all kind of services. This is possible only by simplification, which should be as rough as possible but as detailed as necessary. The procedure is described in the following.

3.2 Modular Approach

As facility services are very different regarding the use of equipment and operating consumables like vehicles, devices, energy, etc. (Pelzeter and Sigg, 2019) module groups are defined out of which specific calculations and estimations per service are gained. For these module groups representative or average values are identified according to availability.

The following four module groups for the determination of CO_2-eq emissions related to facility service are set:

Equipment (work wear, devices, vehicles, etc.),

Operating Consumables (consumables, energy, water, etc.),

Transportation (of persons, goods, etc.),

Overhead (office space, vehicle fleet, management of the services, etc.).

3.2.1 Equipment and Operating Consumables

The CFPs and other key figures for equipment and operating consumables are gained from databases like the ones mentioned above or from the manufactures directly. A full LCA approach (also known as cradle-to-grave approach (Business Directory, 2019)) should be chosen. In case the needed product data is not available, a quantitative estimation on the basis of a similar product is made (UBA, 2017: 25). If there is no data for similar products as well, the estimation is done as follows.

The full life cycle of the product includes the steps “raw material extraction”, “production”, “usage”, “transport” and “disposal” (ISO, 2006b: 5). Any estimation has to be explained transparently and estimated values have to be labelled accordingly. The part of the estimated value has to be added as a coefficient to the final value (Hottenroth, Joa and Schmidt, 2013: 70).

Raw Material Extraction: CFP of the Material Used

The estimation is made by using the weight of each material used in a product (Blepp, Bommer and Quack, 2013: 30). Each component listed in the spec sheet of the used product is multiplied by the CFP for its raw material extraction and then added up. If the spec sheet does not list the weight of the components, the total weight of the product is – according to the conservative approach – multiplied with the CFP of the most CO_2-eq-intensive material used.

Production

For the production the same value as for the raw material extraction is used and a surcharge of 50 % is added.

Disposal

Similar to the approach described above the determined values for the disposal of the components are chosen and a surcharge of 50 % is added. In case of CO_2-eq credits for recycling the value is reduced by 50 %.

Energy Used by Facility Services

The approach of determining CO_2-eq emissions regarding the use of external energy services (power consumption) is handled differently in the examined methods like GHG Protocol and VERUM 2.0. Partially, either the national power mix or sometimes the information of the supplier is taken (Klöpffer and Grahl, 2014).

The energy consumption of services can be determined through measurements (UBA, 2017: 25). If this is not possible, the maximum possible consumption is assumed. This means the maximum possible power consumption multiplied by the maximum possible operating hours.

Transportation

The calculation of GHG emissions of the transportation of equipment and operating consumables is described in the next section.

3.2.2 Transportation

The preceding case study showed that the transportation of persons has a relevant impact of about 13 % of the service provision (Pelzeter and Sigg, 2019: 15).

Depending on method and assumptions (like occupancy, age and size of the vehicle) databases give different values, which vary slightly in most cases, but in some up to 100 % (UBA, 2019).

For calculating the CFP of facility services, CarMa distinguishes between one-time transportations and regular ones.

The one-time transportations mainly include the one-time delivery of equipment and operating consumables to the facilities. If the manufacturer of these products does not give a CFP or only a CFP without transportation, additional CO_2-eq emissions for the transportation from plant to facility have to be estimated.

Regular transportations include e.g. the work staff's travel or regular deliveries like postal services.

In the modular approach, the one-time transportations are allocated to the CFP of the equipment and operating consumables while the regular transportations are allocated to the module group "Transportation" itself.

The CFP is determined through the distance and the key figures (see special databases for transportation like EcoTransIT (Ingenieurgesellschaft für Verkehrs-und Eisenbahnwesen [IVE], 2019)) for the used transport vehicle. When the distance is unknown, the maximum possible distance is chosen.

For one-time transportations, this is the distance from the place of manufacturing to the facility based on the weight of the transported goods. For regular transportations, this should be the regaular distance within the city with the corresponding transport vehicle. If distance and/or vehicle are unknown, the worst values are to be chosen.

3.2.3 Overhead

In EPDs according to ISO 14025, the overhead is not taken into account for the determination of CFPs. The preceding case study shows that this is a relevant factor though (Pelzeter and Sigg, 2019: 15).

In the relevant literature there was no standard procedure discovered for the determination of the overhead. In this project, two different sorts of overheads are distinguished. The service-related overhead (e.g., management of the service through quoting, invoicing, scheduling, quality control) and the general overhead that primarily includes the management process of the general and strategic alignment of the company. Due to the reasons mentioned above, the general overhead is not considered in the methodology.

For the service-related overhead the same module groups – equipment, operating consumables transportation – are used like for the service itself. The quantitative estimation for the CFP is done as follows.

The standard procedure assumes a workplace for a customer advisor and an on-site facility manager. If the CFP for the workplaces is unknown, the worst possible CFP for a workplace of the corresponding country will be taken. The CFP of the equipment (like PC, telephone, printer, smartphone, tablet and company car) and operating consumables as well as transportation is determined as described above.

By an allocation formula, the CFP of the overhead is added in proportion to the CFP of the service. The ratio "spent working hours of the customer advisor and/or facility manager for the respective service to his or her working hours in total" is recommended. If a ratio cannot be determined it should be set to 1:1.

3.3 System Boundary

3.3.1 Life Cycle

If not already defined in the description of the module groups, the system boundaries for the module groups mentioned above are set as follows:

Equipment: Full life cycle including maintenance, data according to manufacturer (depending on availability),

Operating Consumables: Full life cycle, data according manufacturer (depending on ability and availability),

Energy/Electricity: According to national power mix,

Transportation (of staff and material): See section 3.2.2,

Overhead: See section 3.2.3.

Discrepancies have to be justified and need verification.

3.3.2 Time Boundary

Regarding the time boundary, ISO 14067 says:

"The time period for which the CFP is representative shall be specified and justified.

The choice of the time period for data collection should consider intra- and inter-annual variability and, when possible, use values representing the trend over the selected period. Where the GHG emissions and removals associated with specific unit processes within the life cycle of a product vary over time, data shall be collected over a time period appropriate to establish the average GHG emissions and removals associated with the life cycle of the product (ISO, 2018: 17)."

To take annual fluctuations (seasons, holidays, absence rates, etc.) into account, the time boundary of the service delivery is set to the period of one year (see also next section).

3.4 Functional Unit

The functional unit strongly depends on each service. An area of 1 m² (e.g. cleaning or grounds keeping) considered over the period of one year has been widely established (EPD International AB, 2016: 6).

The functional units for the four services considered in more detail in this project are as follows:

Cleaning > Maintenance Cleaning: 1 m² kept clean during a period of 1 year,

Inspection and Maintenance: Inspection and Maintenance of a technical facility during a period of 1 year,

Security and Reception Services > Gatekeeping: Service delivery of gatekeeping during a period of 1 year,

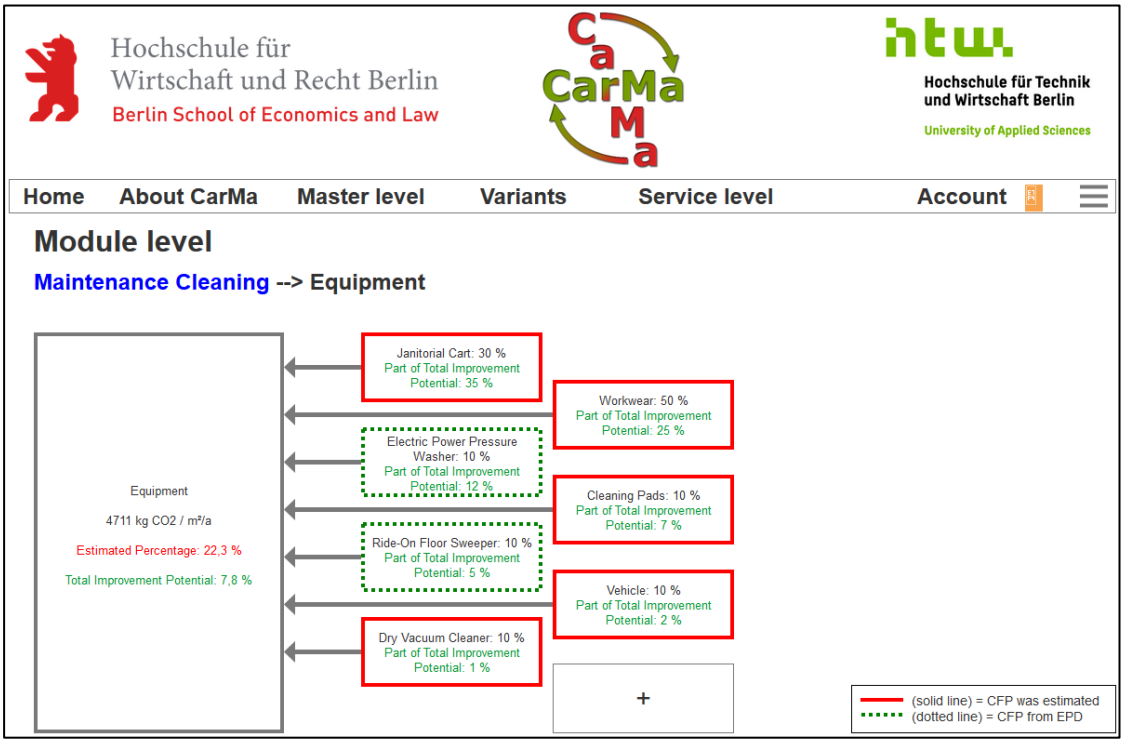
Catering: To cater one person during a period of 1 year.

4. CARMA TOOL

The CarMa IT tool is an open web-based software system enabling companies and their employees to determine CO_2-eq emissions through facility services on an approximate basis. The tool supports users by collecting all necessary data and calculating the CO_2-eq emissions.

On the one hand, the necessary amount of data is kept as small as possible enable fast and approximate results, while on the other hand the tool drives its users to provide more detailed data to gain results that are more precise.

Figure 1 Mockup of user interface: CO_2-relevant data of equipment in a cleaning process



As the method described above collects a variety of data, the software tool will present relevant information and draw the user's attention to the relevant details. Figure 1 shows a mockup of the user interface which is currently being implemented and tested by the practice partners of the project. It displays exemplary equipment used in service maintenance cleaning. On the left part the equipment's CO_2-relevant data is summarised by:

The total CO_2-eq emitted by this service,

The functional unit,

The total percentage of estimated emissions in the equipment and

The total potential for improvement of the equipment.

On the right part the figure shows seven parts of the equipment with

Their percentage of the total CO_2-eq emission contributed by this service and

Their percentage of the total potential for improvement of the equipment.

This quick overview tends to drive the user to deliver more detailed data and helps him or her to identify the details (drivers) with the most influence on the overall outcome.

The CarMa tool provides a variety of functions. They were developed in workshops with representatives from industry and research. Some of these product functions are:

Generate a variant to calculate the CFP for a service,

Compare results between different variants and

Results are to be presented by combining color-coding and percentage values, which show the potential for improvement.

The tool uses various levels of precision for the CFPs of elements that are useful for the calculation, e.g., vehicles for transport, cleaning equipment for cleaning surfaces or use of equipment for maintaining equipment. With these levels of precision, a user has the opportunity to generate a result quickly without deeper knowledge of elements used in those services.

The tool is developed independently of a specific software operationg system (OS). It can be used in an actual web browser (e.g., Mozilla Firefox, Google Chrome, Apple Safari) with activated JavaScript.

A first prototype of the CarMa tool will be available by May 2019 and then be tested by the project's practice partners. The tool is intended to interface with relevant data sources and systems (e.g. CAFM and IWMS), because relevant data necessary to operate the CarMa tool is already available in those type of systems.

5 CONCLUDING REMARKS

With climate change on the rise, decarbonisation is becoming the new directive for all industries. Unfortunately, there are no guidelines and standards yet for facility services on how to determine and to estimate the drivers of GHG emissions and on how to reduce them. The CarMa methodology and tool will be a first substantial step to remedy this.

The FM sector would benefit from the current research if the methodology was adopted with the help of national FM associations (e.g. GEFMA) and if one or more companies took over the CarMa methodology and tool to set up a business model which later on may result in a CarMa certificate.

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The legacy from construction projects to facilities management in Denmark: The good, the bad and the ugly

Helle Lohmann Rasmussen
Technical University of Denmark
helr@dtu.dk
+45 40604764

Poul Henrik Due
Sweco
poulhenrik.due@sweco.dk

ABSTRACT

Purpose: When construction projects are handed over to facilities managers who are in charge of operating the new facilities, things are not always as easy as could be expected. The scientific literature describes examples like discrepancy between the expected and the actual energy consumption, disappointing indoor climate and continuous troubleshooting after hand-over.

These issues are causing facility managers difficulties in new buildings. This is problematic as it has a negative impact on the costs, the people and the environment. Studies have been carried out on each of these important aspects. However, most studies have a specific focus on one issue.

The purpose of this study is to explore a broader range of FM difficulties in new buildings, with the aim of ranking which difficulties are most and least experienced by facility managers in new buildings in Denmark.

Methodology: Our study is based on a national web-based questionnaire survey among FM practitioners in new buildings in Denmark. The identified FM difficulties in new buildings are ranked by mean value to find the most and least experienced.

Key findings: The study shows that most frequent experienced difficulties are related to the quality of operation and maintenance material and drawings handed over from construction to operation. Unexpected high energy consumption due to lack of commissioning of the technical installations, and indoor climate difficulties are other often experienced issues. The least frequent experienced difficulties concern the layout and functionality of both FM space (as kitchen, cleaning room and technique rooms) and core business space (as offices, meeting rooms, and teaching rooms).

Intended impact of the study: The study informs building clients, design teams and facility managers about which difficulties they need to pay extra attention to in future building projects. To researchers, it suggests further research to find solution for the most experienced difficulties. Furthermore, our research suggest further research to investigate in the consequences of these frequently experienced difficulties and how they can be avoided in future construction projects.

Paper type: Research Paper

Keywords: FM, Facilities Management, FM difficulties, performance gaps, construction projects, building performance.

1 INTRODUCTION AND BACKGROUND

Construction of new buildings are heavily resource consuming, regarding both financial, human and natural resources. In Denmark more than 110 billion DKK (14.5 billion Euros) went into construction of new buildings in the year 2017 (Danmarks Statistik, 2018). Operating the new buildings are even more resource consuming, both financially (Hughes et al., 2004) and environmentally (Maslesa et al., 2018). New buildings offers a unique possibility to optimize the operation stage, by taking operation into consideration during design and construction (Boge, 2017). However, when a new building is handed over to facilities management (FM), responsible for the operational stage of the building, previous studies show, that operation is not always as unproblematic as could be expected. We will shortly introduce some of these challenges addressed by research. They include energy consumption, operation and maintenance (O&M) cost, impact on core business, end user satisfaction, and indoor climate.

A large pool of scientific literature describe a discrepancy between the expected and actual energy performance of new buildings, known as the energy performance gap (Gram-Hanssen & Georg, 2018; Mallory-Hill & Gorgolewski, 2018; Sunikka-Blank & Galvin, 2012) or the reliability gap (Mills, 2011; Ornetzeder et al., 2016).

Sustainability is the main focus of Building Performance Evaluation (BPE) which takes into account not only energy consumption but also other aspects such as water consumption and Indoor Environment Quality (IEQ) (Vischer, 2018). Also the concept Total Building Performance (TBP) (Loftness et al. 2018) goes beyond energy consumption by introducing six critical parameters in new buildings. They include IEQ, spatial quality, visual quality and building integrity.

Boge et al. (2017) adds further parameters to be considered in building projects. Referring to Bjørgberg, he mentions the risk of 'unnecessarily high operation and maintenance cost, increased replacement rate and negative impact on core businesses'. Borgstein et al. (2018) describe a number of performance failures in new Brazilian buildings. They include higher energy consumption, poor indoor environmental quality and lack of occupant satisfaction.

In a study of the hand-over process from construction to operation, Lindkvist (2018) finds that an overlap of the construction and operation phases is causing FM difficulties, as contractors continuously need to fix problems during operation. The finding, that there is a need for continuously 'fine tuning' after a building has been occupied, is supported by recent study by Mallory-Hill & Gorgolewski (2018).

Clearly, research has already identified a large number of challenges that FM face during operation of new buildings. As it seems that the term 'building performance gap' is considered to concern only energy performance, we use the term 'FM difficulty' as an overall term to address a broad range of challenges.

Although work has been undertaken on different types of FM difficulties in new buildings, no prior research is found gathering a broader range of FM difficulties in one study. Looking at different FM difficulties together offer an impression of which difficulties are least and most experienced in new buildings. With this knowledge, building clients, design teams and facility managers involved in building projects are given the opportunity to learn from the past and discuss how FM difficulties outlined in this study can be prevented in future projects.

To guide our research study, we formulated this research question: Which difficulties do facility managers in Denmark most frequently experience in new buildings in Denmark? And which difficulties are least experienced?

2 METHODOLOGY

In order to answer our research question, we applied the methodology outlined by Burns et al. (2008), suggesting the following steps.

Sampling

We applied a nonprobability sampling where individuals where selected because they met the sample criteria of being employed in a FM organization managing a newly built or rebuilt building. Since this population is not accessible as a unit, we distributed the questionnaire trough different channels reaching a broader population of facility managers (and potentially others). The size of the population (employees in a FM organization with a newly built or rebuilt building) is unknown to us, thus is the respondents rate unknown. Distributions channels were: 1) e-mails to the research team's professional network of FM practitioners, 2) newsletter (by e-mail) to the members of Danish Facilities Management Association, 3) newsletter (by e-mail) to members of the FM network of the Danish Association of Marine Engineers, 4) Linked-in posts.

Item development

To start the generation of items to include in the questionnaire we conducted a literature study. This resulted in 21 items spread on 6 categories. We consider an item 'a FM difficulty in new buildings', for example 'poor indoor climate – too cold'. We discussed the 21 items found in the literature with FM practitioners attending a FM course at the Danish Technological Institute. They were within the intended population and contributed with additional items based on their experience.

The final number of items were 35, spread on the initial 6 categories as shown in table 1. Since short questionnaires are more likely to have an increased number of respondents than longer ones (Burns, 2018), we only added 2 background question.

Table 1: Categories of FM difficulties in new built buildings.

No.	Category	Number of items
1	Indoor climate	5
2	O&M of technical systems	5
3	O&M of buildings	7
4	Sustainability	6
5	Functionality	5
6	Others	7

Response format

The questionnaire consisted of 4 parts: First a background question to verify if respondents were within the intended population, yes or no. Second, the 35 difficulties spread on 6 categories (one category on one page). We asked respondents to indicate their experience with each of the 35 difficulties on a four-point Likert scale: 1: Never experienced, 2: Experienced to a lesser degree, 3: Experienced to some degree, and 4: Experienced to a high degree. A fifth choice was "Do not know/not applicable (N/A)". Furthermore, we included a "free text" option at the end of each category, where respondents had the opportunity to describe other

experienced difficulties. In the third part, we asked respondents to describe in free text what they found most successful in their new building. Finally, we posed the second background question (figure 1) asking respondents to indicate by multiple choice which statement best described their work tasks.

We allowed respondents to move on to next question without having answered previous questions.

Questionnaire composition and testing

The software Qualtrics ® was used to publish and administer the web-based questionnaire. The questionnaire was pilot tested by the same group who had been part of identifying the 35 items (course participants). Another five persons with experience with FM in new buildings tested the questionnaire. The testing resulted mostly in correction of unclear language. Moreover, test persons were asked to record the time they spend on completing the questionnaire. Questionnaires completed as part of testing were not included in the results.

As introduction to the questionnaire, a brief text described the purpose of the study, the length of the questionnaire, and stated complete anonymity for respondents. The questionnaire was open for answers from October to December 2018. Both introduction text and questionnaire were in Danish.

Analysis

To answer our research question, we calculated the mean value of the respondents' indication on the likert scale of each of the 35 items. N/A answers were not included in the mean value. We then organized the items by their mean value (table 2). We interpret that items with the highest mean value (nearest '4: experienced to a high degree') are the most frequently experienced and thereby "the bad or the ugly", whilst items with the lowest mean value (nearest '1: Never experienced') are the least frequently experienced and thereby "the good".

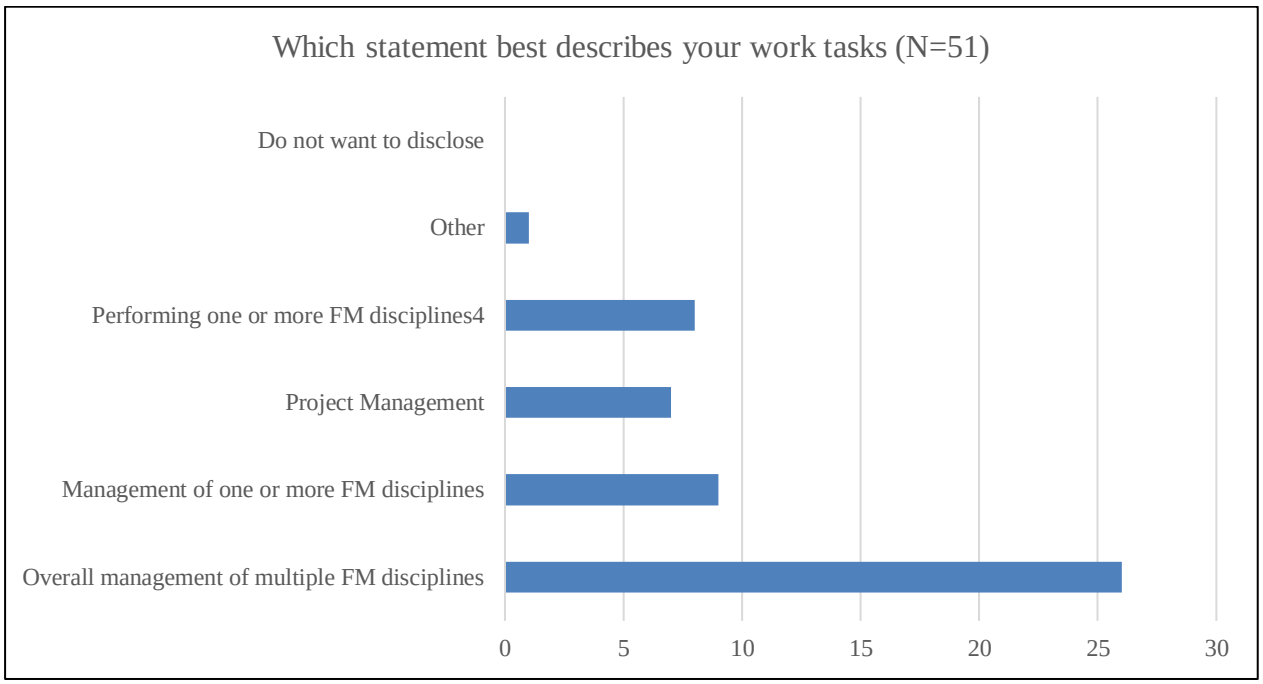
3 RESULTS

Respondents

Answers to the first background question showed that 76 FM practitioners in new buildings (or old buildings recently substantially rebuilt) filled in the questionnaire. Furthermore, 29 respondents (105 in total) outside the intended population completed the questionnaire. Due to the limited number of background questions, we do not know to what extend they are similar to the other 76 respondents (Burns, 2008) and we omitted their answers from the results.

The second background question, posed in the end of the questionnaire, shows that the majority of the respondents who answered this question (N=51) has FM responsibilities of one or more FM disciplines as shown in figure 1.

Figure 1: Respondents' work tasks



Ranking of the 35 difficulties

Table 2 shows the 35 difficulties ranked by mean value (see 3.5 Analysis). Number one (top of table 2) is the difficulty with the highest mean value whereas bottom row, number 35, is the least experienced difficulty. The number in the first column refers to the rank (by mean value), second column refers to the six categories (see table 1). Third column is the specific difficulty, translated to English. Fourth column is the number of respondents who ranked the specific difficulty, in parenthesis the number without N/A.

Table 2. The 35 difficulties ranked by mean value

Rank	Category /No.	Difficulty	N=	Mean value
1	6.3	Inadequate or poorly structured O&M material e.g. missing information in the O&M software/ lack of upload of information to the software	51(47)	3,36
2	4.6	Unexpected high energy consumption due to the lack of commissioning of the technical installations	52(51)	3,24
3	6.4	Inadequate or not updated blueprints to the FM-staff	51(49)	3,18
4	3.2	Unexpected costly og difficult cleaning of windows externally og internally due to lack of accessibility	52(48)	3,06
5	6.1	Unexpected operating investments due to the change of costs from Capex to Opex	51(49)	3,04
6	1.1	Poor indoor climate – too hot	58(56)	3,04

7	1.4	Lacking or difficult coordinated control of heating and cooling	59(57)	3,00
8	3.7	Damage to doors and windows forced open by the users using e.g. wedges	52(50)	2,98
9	1.2	Poor indoor climate – too cold	59(57)	2,86
10	2.2	Unexpected costly O&M of technical installations due to limited access or costly spare parts	54(52)	2,83
11	4.1	Higher energy consumption than expected	52(40)	2,83
12	3.1	Unexpected costly cleaning of surfaces due to choice of materials, e.g. on floors and walls	52(46)	2,80
13	2.4	Inappropriate or expensive options for changing light sources and servicing light fixtures	54(49)	2,78
14	3.6	Difficult or expensive change of building components – e.g. windows and façade panels	52(48)	2,75
15	2.3	Floors in wet rooms with incorrect or defective slope and / or drainage	54(52)	2,62
16	2.1	Limited possibility to use auxiliary tools such as lifts due to interior design or construction	54(48)	2,60
17	1.3	Poor indoor climate - draught	58(57)	2,60
18	1.5	Poor acoustic indoor climate - noise from people, machines, surroundings	59(57)	2,60
19	3.3	Unexpectedly rapid wear and tear of floors due to inappropriate material selection	52(48)	2,58
20	5.1	Inappropriate location and / or layout of kitchen, cleaning room, waste room	52(49)	2,43
21	5.2	Inappropriate location and or layout of rooms with technical installations	52(49)	2,41
22	5.5	Restricted adaptability of office spaces to changes e.g. during to organizational changes	52(45)	2,40
23	4.2	Too few energy og water meters	52(44)	2,40
24	5.4	Lack of opportunity to use rooms for multiple purposes during the day	52(47)	2,36
25	6.2	Lack of compliance on regulatory requirements, fire prevention demands, safety requirements etc.	51(50)	2,32
26	4.4	Difficult waste handling	52(45)	2,31
27	2.5	Poor physical working conditions for the FM-staff. E.g. reduced ceiling height og poor daylight conditions	54(53)	2,30
28	3.4	Unexpected or fast discoloration/ patina of *internal* building components	52(49)	2,27
29	4.3	The lack of bicycle parking, poor accessibility of the bicycle parking and/or lacking shower facilities for the bikers	52(45)	2,24
30	3.5	Unexpected or fast discoloration/ patina of *external* building components	51(47)	2,23
31	6.5	Unexpected need for double operation due to delay in the construction project	51(46)	2,22

32	4.5	Lack of automatic control of the light	52(51)	2,06
33	5.3	Inappropriate location or interior design of the core facilities of the enterprise e.g. class rooms, offices, meeting rooms and production facilities	52(49)	2,00
34	6.7	The architecture does not fulfill the function or mirrors the culture of the enterprise	50(47)	1,89
35	6.6	The architecture is not aligned with the brand of the enterprise	50(43)	1,72

The good

Starting from the bottom, the three least experienced difficulties concern architecture and layout design (table 2, rank 35, 34 and 33). This is supported by the free text answers to the question "What do you consider to be most successful in your new building?" where 6 out of the 17 statements, described successful architecture or layout. Examples are *"Creating a completely new unity"* and *"Super nice and functional building; new and fresh without being showy".*

"Lack of automatic control of the light" (table 2, rank 32) and "Unexpected or fast discoloration/ patina of both *internal* and *external* building components" (table 2, rank 30 and 28) are also little experienced. So is "Poor physical working conditions for FM staff: too low ceiling height, poor daylight conditions, etc." (Table 2, rank 27).

"Unexpected need for double operation due to delay in the construction project" (table 2, rank 31) is another little experienced difficulty.

Within the ten least experienced difficulties 3 are in category 4 (Sustainability), 3 are in category 6 (Others), 2 are in category 3 (O&M of buildings). Only one is in category 2 (O&M of technical installations) and in category 5 (Functionality). None of the least experienced difficulties concern category 1 (Indoor Climate).

The bad and the ugly

The first and third most experienced difficulties concern the quality of documentation and drawings from the construction project (table 2, rank 1 and 3).

"Unexpected high energy consumption due to the lack of commissioning of the technical installations" is the second most experienced difficulty (table 2, rank 2).

Another three of the most experienced difficulties concern indoor climate: too hot, too cold and lack of - or poorly coordinated control - of heating and cooling (table 2, rank 6, 9, 7).

Unexpected operating investments due to the change of costs from Capex to Opex is also high on the list (table 2, rank 5).

Within the ten most often experienced difficulties are 3 in category 1 (indoor climate), 3 are in category 6 (others), 2 are in category 3 (O&M of buildings). Only one is within categories 4 (Sustainability) and 2 (O&M of technical installations). None is in category 5 (Functionality).

Additional difficulties

Respondents were given the opportunity to add difficulties they had experienced, which were not already included in the 35 difficulties identified by us. 8 difficulties were added to the first category, Indoor Climate. They were spread on light, noise, smell, lack of individual control, dry air, and lack of fresh air.

Less difficulties were added to the other categories: 3 to category 2 (O&M of technical installations), 2 were added to category 3 (O&M of buildings). 2 difficulties were added to category 4 (Sustainability), nothing was added to category 5 (Function), and finally 2 difficulties were added to category 6 (Others).

4 DISCUSSION

Documentation from construction projects to FM

The quality of documentation from the construction project was ranked as number 1 and 3, showing that this is highly problematic. In our opinion, this is worrying, as documentation about the building and it's technical installations in many cases is a prerequisite to operate and maintain the new building legally and satisfying. A Norwegian standard has recently been published (Standard Norge, 2018), to aid Norwegian building owners, design teams and facility managers in preventing such difficulties. This could possibly serve as inspiration in other countries, including Denmark, too.

Successful architecture and layout

Due to the limited background questions, we do not know the educational background and experience of the respondents. However, we know from other studies (Kolarik et al., 2017), that facilities managers in Denmark on a managerial level with responsibility for one or more FM disciplines (as the majority of the respondents of our study), are likely to have a technical background. Consequently, there is a possibility, that the respondents having a technical background are more critical regarding technical issues than they are regarding architecture.

Indoor climate

The study shows, that indoor climate is causing FM difficulties. The large research focus on indoor climate further confirms indoor climate to be problematic. Building commissioning is a process, which focuses on the coordinated performance of the building and technical installation throughout a construction project (Mills, 2011). It is gaining momentum in Denmark (Ágústsson & Jensen, 2012), possibly as the result of the many experiences of poor indoor climate in new buildings in Denmark.

Start-up loss

We are surprised to find 'Unexpected high energy consumption due to the lack of commissioning of the technical installations' ranked as number two. The large pool of research concerning the energy performance or reliability gap supports this finding. However, previous research has limited focus on the peak of consumption in the first years of operation. In regard of energy efficient buildings, this frequent experienced 'start-up loss" is possibly overlooked.

5 CONCLUSION

In conclusion, our research demonstrates that facility managers of new buildings experience difficulties in operation due to the legacy from earlier phases of the building's lifecycle. The study was limited to a Danish context, but based on the literature, we have reason to believe, that this is also the case in other countries.

Most experienced difficulty is poor quality of documentation from the project to FM. Difficulties in controlling the indoor climate is another frequent experienced difficulty, resulting in poor indoor environment.

The scientific literature has a large focus on the energy performance gap. In this study, a high number of respondents experienced an unexpected high consumption due to lack of commissioning of technical installation. This poses a problem, as such 'start-up loss' have negative impact not only on the economy and occupants, but also on the planet. We recommend both researchers, the industry and policy makers to focus on this loss.

Limitations

We kept the questionnaire short with the aim of an increased number of respondents. However, a limited numbers of questions poses obvious limitations to the study. Omitting 29 completed questionnaires was a result of the lack of background questions. This lead to another limitation of the study, which is the limited number of respondents.

To follow up on some of the unanswered questions derived from this study and to validate the results presented here, we are supplementing the study with in-depth interviews during 2019.

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Relationship of emerging technologies and their influence on Facility Services

Alexander Redlein and Claudia Höhenberger
Vienna University of Technology
IFM – Real Estate and Facility Management
1040 Vienna, Austria

ABSTRACT

Purpose: Macro economic studies estimate that in general 47% of all jobs will be automated due to digitalization (Stopajnik und Redlein 2017), (Chotipanich 2004), (Selinger, Sepulveda und Buchan 2013), (Čas, Rose und Schüttler 2017). Around 10% of all employees in the EU as well as in the US work in the Facility Services (FS) industry. FS will be notably affected by the megatrend digitalization as it consists of an immense number of routine tasks. As current studies only analyse the macroeconomic changes, this paper aims to answer the following more detailed research questions: Which smart building technologies are relevant for FS? Which services will be affected? What is the relationship between smart building technologies and the services they affect?

Methodology: As a basis for the current research 50 German Speaking Facility Managers were asked about the technical and economic feasibility of new technology in the FS sector. Based on a qualitative pre-study identifying the smart building technologies relevant, the authors carried out a quantitative literature analysis. This analysis included not only publications about the usage of smart building technologies in the FS industry, but also considered use cases on the technologies identified as relevant in other industries. In total 520 cases were analysed. Based on the literature review a research database was set up to explore in detail the relevant technologies and the affected services. The next research step was to analyse the relationship between services and technologies that effect these services.

Key Findings: This paper outlines the relevant technologies and services, and also the relationship between services and the technologies affecting them. It shows that services like Maintenance and Operation and Safety are highly affected by automatization.

Intended impact of the study on either research, education, or practice: This study shows the status quo of smart building technologies within Facility Services and how they influence each other. The results are the bases for in depth research about the relation of technology usage and services. It also provides practitioners support to select the proper technologies and use cases to optimise their service provision.

Paper type: Research Paper

Keywords: evaluations of smart building technologies, internet of things, artificial intelligence, data mining and machine learning, augmented and virtual reality in buildings.

1 INTRODUCTION

Several international consulting companies like EY recently published reports on the progress of digitalization in the real estate industry (Herrenkohl, et al. 2017). All of these stated that the industry is not really taking care of, nor properly preparing itself for the changes (Nagl, Titelbach und Valkova 2017). Two years ago, the TU Wien started a research project to analyse

the impact of digitalization on the real estate and Facility Management industry. According to the research, digitalization has impacts in two main areas:

1) The changes in the core business, like new ways of working, modify the demand for infrastructure and services changes dramatically.

2) Emerging technologies like Internet of Things (IoT), Big Data and Artificial Intelligence (AI) allow for disruptive and much more efficient ways of service provisioning. Therefore, the service provision itself is changed by digitalization.

This paper focuses on the second area: the use of new technologies to optimize FS provision.

Another fact is that in Europe as well as in the US around 10% of all employees work in this sector. Therefore, the outsourced FS industry is the 4th-biggest industry regarding employment in the EU (Stopajnik und Redlein 2017). In Europe in 2016, around 14.5 million people work in this industry. In the United States, more than 9 million workers are employed in this sector. Due to the demographic changes and the lack of skilled people, the application of smart building technologies like IoT, AI, and Machine Learning (ML) becomes an important factor (Selinger, Sepulveda und Buchan 2013)

Many studies are analysing the impact of digitalization on work processes. These studies assume that digitalization will have the greatest effect on routine-tasks. They predict drastic changes and so shifts in skills will be required (Nagl, Titelbach und Valkova 2017) (Stopajnik und Redlein, Current Labour Market Situation and upcoming Trends in the European Facility Service Industry 2017) (Frey und Osborne 2013). The study of Frey and Osborne (2013) determined the probability of computerization for over 700 occupations in the US. They estimated that 47% of all jobs would probably be substituted by computers. The background for their study was an analysis of the technological progress in Machine Learning and mobile robotics. Furthermore, the study of Stopajnik et al 2017 (Stopajnik und Redlein, Current Labour Market Situation and upcoming Trends in the European Facility Service Industry 2017) pointed out the huge impact of digitalization on the FS Industry. Typical FS activities (Österreichisches Norminstitut 2007) are more likely to be automated than other activities. E.g. for installation, maintenance, repair work Frey and Osborne determined a 50% probability of automation, janitors and cleaners have a probability of 66%, and the probability of being substituted by computers for first-line supervisors of housekeeping and janitorial workers is 94%. (Stopajnik und Redlein, Current Labour Market Situation and upcoming Trends in the European Facility Service Industry 2017) (Frey und Osborne 2013).

The existing studies show the changes by digitalization on the whole FS industry and whole economy, but not on the necessary tasks of employees or new technologies for companies (Stopajnik und Redlein, Current Labour Market Situation and upcoming Trends in the European Facility Service Industry 2017) (Stopajnik und Redlein, The Development of the Outsourced Facility Service Industry in Europe 2017) (Frey und Osborne 2013). So they cannot be used for an estimation of the changes due to digitalization. Especially the proof of the feasibility of technologies in the area of FS cannot be done (Nagl, Titelbach und Valkova 2017). But an estimation of relevant technologies is necessary to determine how these technologies will change the industry. The paper is based on the results presented at IEEE. The research objectives of this paper are to provide an updated evaluation of the relevant smart building technologies.

The research questions are:

1. Which smart building technologies are already widely used?
2. Which services are mainly affected by these emerging technologies?
3. What is the relationship between smart building technologies and the services they affect?

2 METHODOLOGY

There are currently three major research paradigms: quantitative research, qualitative research and mixed-method research. The characteristics of qualitative research are induction, discovery, exploration, and theory/hypothesis generation. The researcher acts as the primary "instrument" of data collection and qualitative analysis. The major characteristics of quantitative research are a focus on deduction, confirmation, theory/hypothesis testing, explanation, prediction, standardized data collection, and statistical analysis (Johnson, Onwuegbuzie und Turner 2007). Quantitative and qualitative methods have particular lacks of strengths (Johnson und Christensen 2007) . The authors used the research method "Mixed Research". It is a type of research in which qualitative and quantitative methods, techniques or other paradigm characteristics are mixed in one overall study (Johnson und Christensen 2007). Its logic inquiry includes the use of induction (discovery of patterns), deduction (testing of theories and hypotheses) and abduction (uncovering and relying on the best of a set of explanations for understanding one's results). The goal is to draw from the strengths and minimize the weaknesses of both research methods (quantitative and qualitative) in single research studies and across studies. Taking a mixed position allows researchers to mix and match design components that offer the best chance of answering their specific (research) questions (Johnson, Onwuegbuzie und Turner 2007). Based on the Mixed Method Research, this study includes quantitative and qualitative research phases.

The methodology used consists of three research steps.

1) Qualitative pre-study: Based on a literature review, a questionnaire was developed to determine the technical and economic feasibility of the technologies. In spring of 2017 fifty Facility Managers were interviewed to define a list of relevant smart building technologies and give an estimation of their respective feasibility.
2) Quantitative literature analysis: The results of the pre-study were validated and updated by a profound analysis of more than 520 international cases published in scientific journals, in strategy documents of well-established consultancies, and also in companies' white papers. The results were validated to safeguard the data quality.
3) Definition of relationships between services affected and technologies: Using a database the cases were analysed with regard to which services are affected and which technologies were used. This enabled the researchers to analyse the relationship between services and technologies.

2.1 Qualitative pre-study

The fifty expert interviews from the pre-study showed that some technologies (IoT, Mobile Apps, Building Information Modelling (BIM), Robotics and Drones, Big Data, AI including ML) are already technically feasible or will be shortly. According to the experts, Augmented and Virtual Reality will be technically feasible at a later time. The technologies mentioned were the basis for the further analysis and used as categories for the technologies.

2.2 Quantitative literature analysis

To validate the technologies defined as relevant in the pre-study, a quantitative literature analysis was carried out. The goal was to analyse and evaluate international use cases of smart building technologies already implemented or to be implemented in the near future within different Facility Services. The goal was not only to forecast the impact of digitalization in the FS sector, but also to provide best practice use cases. Due to a high sample of more than 520 international cases an objective perspective and a valid data basis was ensured.

The authors analysed:

- scientific studies published in peer-reviewed journals,
- strategy documents (scientific & strategy consultancies),
- white papers and business project descriptions (incl. press articles, promotion reports, project descriptions from councils and communities).

In order to take into consideration the rapid development of smart building technologies, it was accepted that publications of technology companies and journals are important sources, as they are very up to date, whereas scientific papers need a longer time till they are approved. All publications date from 2010 to March 2019. A lot of cases originated from sources like IEEE Xplore digital library, Harvard Business Review or Researchgate. This procedure resulted in n = 520 records.

To broaden the scope and to make it possible to forecast future developments, reports from other industries using the technologies identified as relevant in the pre-study were also included in the analysis. This was done to enable Relocating: changes of the location and production methodology (Hammer und Champy 1993), (Servatius 1985), (Kröger 1994). The "Grounded Theory" (Glaser und Strauss 1967) was used to systematically analyse the reports and identify codes (Strübling 2014), (Corbin und Strauss 1990). First, these reports were open coded. Then similar codes were clustered into categories. As the EU standard 15221-4 is the only standard accepted by more than one country, the occurring FS categories were aligned accordingly. The smart building technology categories were coded at a very detailed level first and then clustered into the technologies derived as relevant from the pre-study.

For each of the sources the following data were collected:

- ID
- Short description
- Client and supplier of case
- Current FS in which it is applied (Österreichisches Norminstitut 2007)
- Smart building technologies used
- Link to reference
- Date of publishing

Then the data was inserted in a Microsoft Access database in order to compare the different types of reports in a traceable and transparent way.

Fig. 1 shows the data structure of the database. Beside the main table 'cases' including the attributes mentioned above, four other tables are in use. The table "services" and the table "technology" were set up as own tables. This was done to enable a m:n relation. That means several services and/or technologies can be linked to one single case. During the grounded theory based analysis of the cases, it was ensured that this m:n relation of services and technologies is used properly. That means after the coding it was safeguarded that all services that were identified in the case are supported by all technologies identified and vice versa. This enables the authors not only to determine the relevant smart building technologies and the effected services due to the use of emerging technologies, but also to conclude which services are affected by which technologies. The last table validity was used to cluster the type of publications according to their validity. Scientific papers were rated the highest followed by strategy documents. White papers were rated lowest.

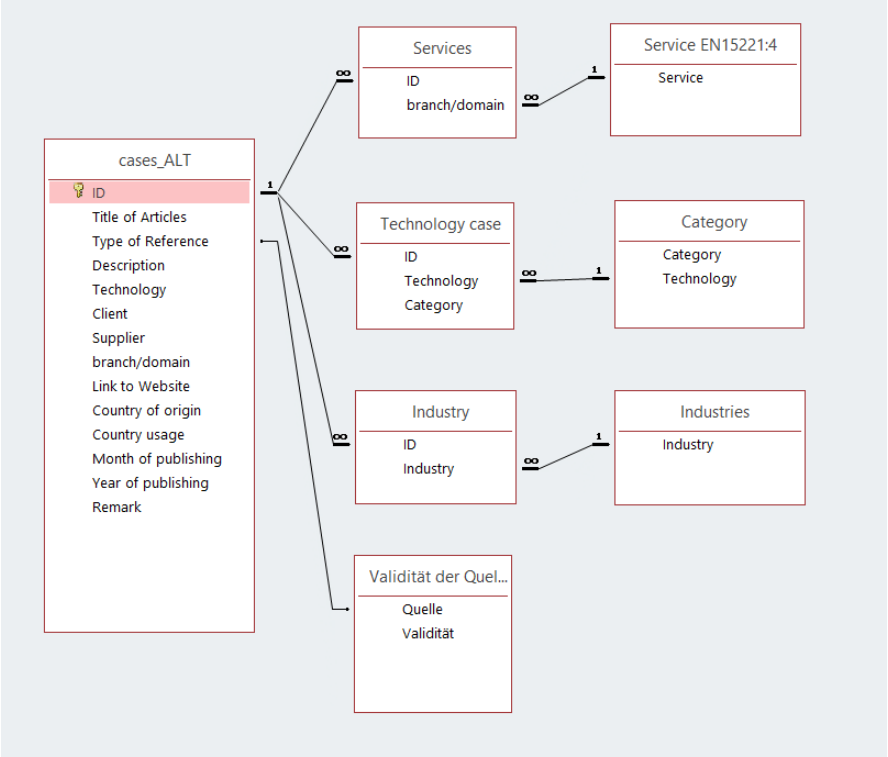


Figure 1. Structure of database

2.3 Definition of relationships between services affected and technologies

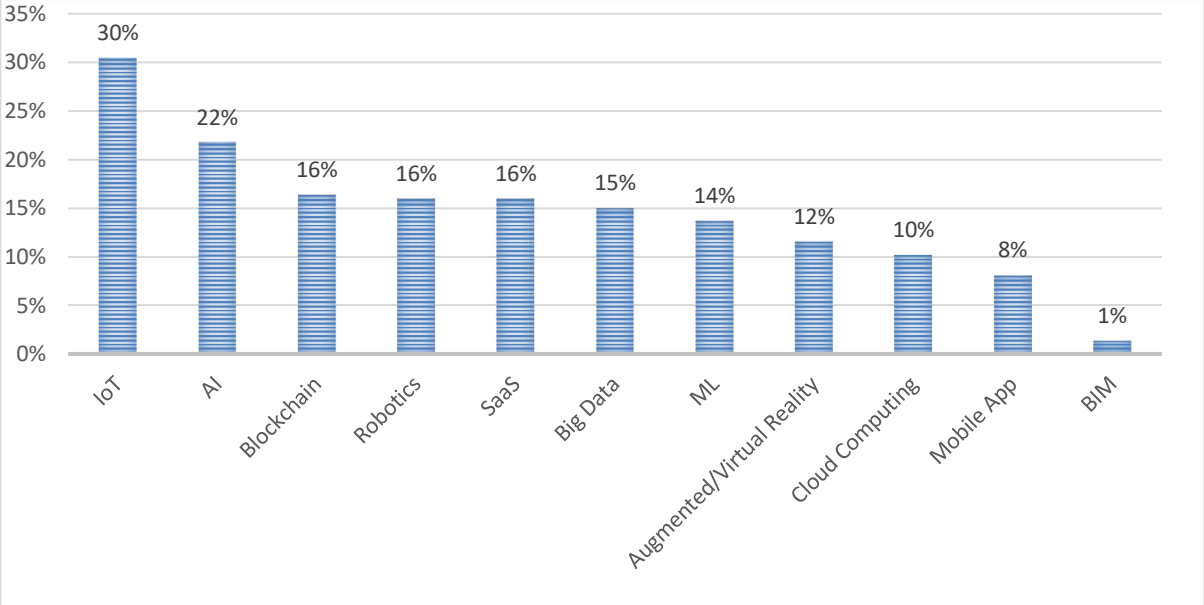
As a last step, the database was used to cross-reference which technologies were in use and which Facility Services they were applied in. This enabled the researchers to analyse the relationship between services and technologies.

3 RESULTS

3.1 Relevant technologies

The results of the quantitative literature analysis regarding the relevant smart building technologies are shown in Fig. 2. The figure shows the occurrence rate of the smart building technologies within all the reports analysed as a percentage of all analysed use cases.

Figure 2. Technologies grouped by category and occurrence within the case studies as a percentage of all use cases analysed (520)



Technologies with less than 26 overall occurrences were left out of the above graphic, as they occur in less than 5% of use cases. BIM was included to show that while the experts stated it to be a prevalent smart building technology, this claim could not be supported by the data gathered. Software as a Service (SaaS) and cloud computing were not within the scope of the pre-study as it is more a way to provide software, rather than a tool in itself. In the following analysis the two software platforms SaaS and cloud computing are not included as they support all smart building technologies, while here only the technologies themselves are analysed.

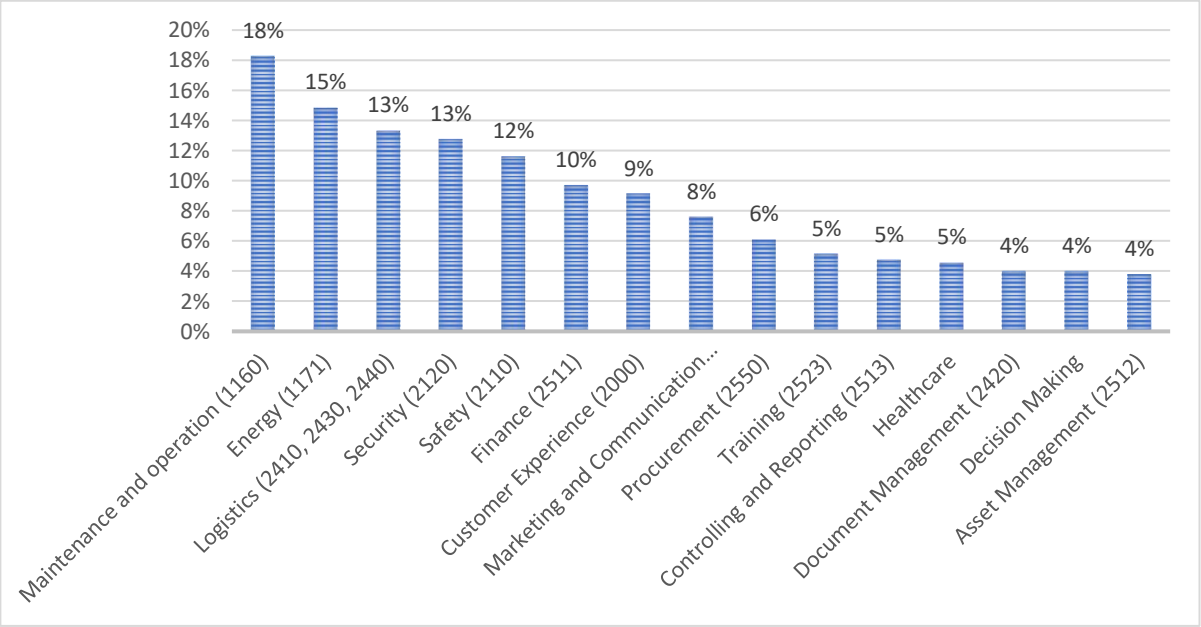
In all the publications the smart building technology IoT is mentioned the most. The reason for this is the enormous price reduction of sensors and IoT devices within the last years. The availability of self-sufficient devices that produce the energy they need by themselves and can be easily connected to the WIFI of the buildings, also enables the use of IoT (Xu, He und Li 2014).

In general, AI is mentioned very often. In the last years AI/ML tools have made great progress. They are mainly used to analyse the data generated by the IoT devices and identify patterns (Moreno, et al. 2014). The capabilities of Big Data and AI/ML tools in this area has increased. Several device producers like Fujitsu include AI/ML features already in their devices. An example is the automatic recognition of patient statuses, which in case of an emergency informs relevant people automatically (Fujitsu 2014). The availability of AI/ML over SaaS platforms like IBM Watson increased, while at the same time their costs decreased. Robotics take the fourth place in the analysis. Robotics and drones are mainly used to carry out repetitive work. New versions are more flexible and can cooperate with the FS personnel.

Blockchain is mainly in the focus of strategy documents. This technology provides many use cases in the area of FS. AR and VR were often discussed in white papers but not in the other sources. BIM was in the top two mentions regarding feasibility according to the FM experts, but in the quantitative analysis only 7 cases could be found.

3.1 Affected services

Figure 3. Affected services according to number of occurrences in publications as a percentage of the number of cases analysed (520)



The results of the quantitative literature analysis regarding the affected services are shown in Fig. 3. The analysis showed that use cases not only use numerous technologies but are also applicable to multiple services. The figure shows the occurrence rate of the affected services within all analysed cases as a percentage of the overall cases analysed (n=520). Maintenance and Operation is featured most in the use cases, followed by Energy, Logistics, Security, and Safety. These services partly consist of repetitive tasks and are therefore highly susceptible to automatization.

3.3 Relationship between the services affected and technologies used

In order to assess which services are utilizing which technologies, the two data fields were cross-referenced. This showed which technologies were prevalent in the respective Facility Service categories as defined by EN15221:4.

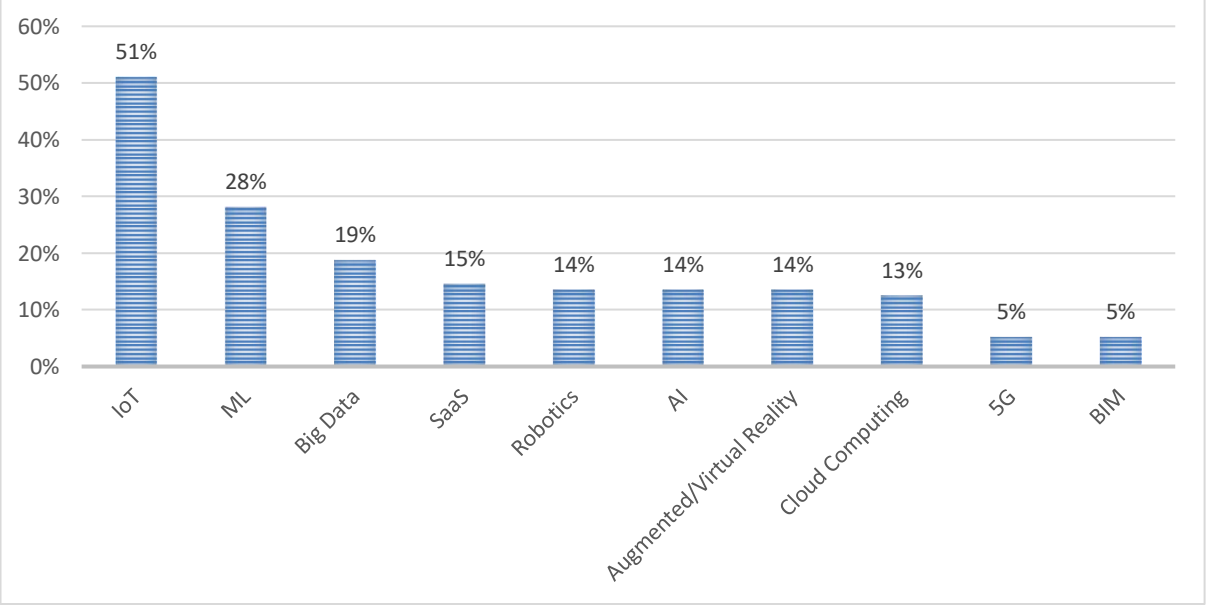
IoT sensors help to improve energy consumption as they provide an accurate data of the usage and therefore deliver information to carry out optimization. Logistics, Safety and Security, and the customer experience can be enhanced by the use of Big Data, AI and ML. The use of these technologies for customer experience is gaining in importance to create the desired “WOW” effect. Jointly with Blockchain the tools mentioned above optimize Security, Finance, and Procurement. Two examples for this technology in the area of Facility Services that were mentioned often are smart contracts and trusted data about equipment and maintenance.

To further illustrate the relationship between technology and services, two services are analysed in more detail here.

3.3.1 Maintenance

The service “Maintenance and operation” is pointed out to be affected by smart building technologies the most. As shown, IoT is the most important technology affecting this service. IoT devices are used as providers of data about the current status of equipment and the building itself. This data is then delivered to Big Data, AI and further processed by ML to recognize patterns, mainly to support predictive maintenance and to derive actions based on these patterns (Johansson und Vogelgesang 2016). , (Glawar, et al. 2016). In one case, the AI/ML software even includes the scheduling of the maintenance employees (Bonomi, et al. 2012) (Sun, et al. 2016). Therefore, beside IoT, Big Data, AI and ML are also often mentioned. Several new product offers of large FS companies (e.g. Kone, ISS) are based on these technologies (KONE Press Release 2018). KONE has partnered with IBM to make elevator and escalator operations worldwide more efficient by combining AI, Big Data gathered from IoT devices, ML, and cloud computing to predict and - when possible - resolve equipment breaks in order to ease maintenance efforts and gather information about usage and performance (IBM Corporation 2017). This type of predictive maintenance, based on machine status and use data, helps to secure availability, predict failure moments, and identify quality deviations by transitioning some reactive maintenance tasks to more proactive ones (Matyas, et al. 2017) This development shows the increasing importance of AI, ML, and Big Data in combination with IoT devices within Facility Management. Augmented and virtual reality can be used to support and train maintenance employees. Drones and robots help to reduce hazardous and risky tasks for humans, by carrying them out instead. Examples for use cases are mower and cleaning robots (Min Moon, et al. 2015). Several of the cases describe a combination of robots and drones (Wang, et al. 2010). This is why these technologies are also mentioned in the area of safety and security.

Figure 4. Used technologies according to number of occurrence in publication as a percentage of the number of cases in FS “Maintenance and Operation” (96)



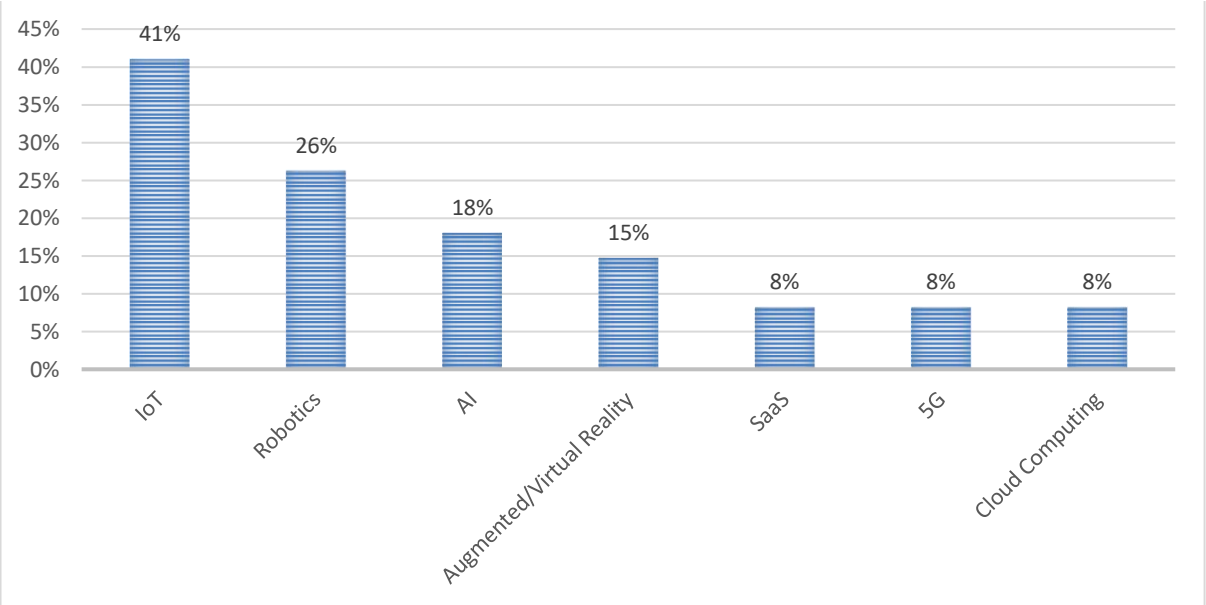
3.3.2 Safety

IoT affects the service “Safety” to a high degree. Robotics can be used to take over dangerous work from human workers and carry them out instead. These encompass obviously dangerous tasks like defusing bombs which are being automated successfully (Robotics at Penn - Real-World Applications 2014), but also for more covertly hazardous tasks like cleaning the windows

at home (Choi und Jung 2011), as well as in high rise buildings (Wang, et al. 2010). Robots are often used in tandem with IoT devices in order to prevent accidents and injuries. In addition to the 3D rule of automatization, robotics can be used for tasks that require extraordinary precision, stability, and dexterity even in confined and hard to access environments. This greatly reduces the risks for live and health of Facility Service employees.

As mentioned above augmented and virtual reality can be used to train employees and support them in their daily work. AI, ML and Big Data are also important, as they analyse the data gathered from IoT devices, recognize patterns, and use these to predict upcoming events such as machine failures or even more. An example are surveillance systems that automatically can inform security personnel of dangerous and unusual events. An example are cameras that detect when a person leaves its luggage somewhere unattended and goes away. The camera then sends this information per SMS to the security personnel. Another technology that has been gaining in significance is 5G network technology, to further enable sensors as IoT devices.

Figure 5. Used technologies according to number of occurrence in publication as a percentage of the number of cases in FS "Safety" (61)



4 CONCLUSION

The quantitative literature analysis showed that smart building technologies are already widely used. IoT use cases are extensively spread. Due to a significant reduction of price and the availability of self-sufficient systems, their usage is widely spread. The literature analysis also identified Big Data, AI, ML and Blockchain as important smart building technologies. Whereas a lot of FM publications stress the importance of BIM, its impact according to the literature research is rather limited. Other technologies are mentioned much more frequently. The data gathered makes it possible to identify the effected services and the relationship between services and technologies. The services mostly affected are Maintenance and Operation, Energy optimization, Safety and Security, Logistics, Finance, and Procurement.

The use cases show that smart building technology not only automatizes certain aspects of various Facility Services but changes the way these services are provided, by shifting actions from reactive to predictive ones.

In contrast to these results, most of the Facility Service companies still use a lot of standard technology to provide FS. Technologies like IoT, AI, ML, and Blockchain develop rapidly, but for now they are mainly used by start-ups or technology companies. “Classical” companies are not yet taking up on these developments. They mainly lack best practice case studies that can directly be implemented in their companies. This postulates the need for further research and the application of smart building technologies in practical use cases to especially prove their economic feasibility.

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Changing the engine while driving – How a mature internal FM organization managed imposition of VAT neutrality

Line Bøe Skreosen and Knut Boge

Oslo Metropolitan University
line.skreosen@outlook.com

Oslo Metropolitan University
kboge@oslomet.no

ABSTRACT

Purpose: Until January 1st, 2017, most Norwegian government hospitals' internal FM organizations lead a protected life behind a wall of 25 percent value added tax (VAT). After removal of this VAT armour, exposure to competition has become a reality for many services provided by the hospitals' internal FM organizations. For some services, outsourcing has become a credible option, and jobs might be at stake. Some of the big questions for facility managers at Norwegian government owned hospitals, have thus been how to change their employees' mind-set, and transform and adapt the organization to increased competition. This paper investigates how the internal FM organization at one of Norway's government hospitals, a de facto total FM provider deeply integrated with the hospital's provision of medical services, has responded to removal of the VAT armour, a significant external shock. How has this internal FM-organization's cleaning and food and catering units transformed and adapted?

Methodology: The present research is a comparative case study. Data have been collected during spring 2018 among others through observations, semi structured interviews with managers and focus group interviews with employees.

Key findings: Some of the most important measures aimed at changing the internal FM organization's culture, among others through change management, systematic benchmarking, implementation of Lean, and hiring of managers and employees with experience from commercial service providers. Other measures are training of employees, smarter use of the available resources, and better dialogues with the FM organization's various customers.

Intended impact of the study for practice and research: This study provides ideas concerning how to transform mature internal FM-organizations that suddenly face external competition.

Paper type: Research Paper.

Keywords: Change Management, Culture, Facilities Management, Hospitals, Lean.

1 INTRODUCTION

A hospital never sleeps. The employees usually work 24/7 to provide highly specialized and adequate medical services. Hospitals are usually associated with medical doctors, surgeons and nurses, but a hospital's provision of highly specialized and adequate medical services very much depends on buildings, critical infrastructures and a long list of non-medical support services. These buildings, infrastructures and services are usually provided by a Facility Management (FM) organization.

ISO 41011 (ISO, 2017) defines FM as an "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". FM is often the difference between success and failure in hospitals' provision of medical services (Featherstone and Baldry, 2000; Heng et al., 2005, Shohet and Lavy, 2004). Imagine a hospital with electrical power failures, food poisoning of employees, patients or visitors, poor cleaning services that prevent infection control, or faulty internal logistics.

FM at hospitals face challenges found few other places (Heng and Loosemore, 2013; Moy 1995; Price 2004). FM has great influence on the patients' perception of their stay at a hospital (Heng and Loosemore, 2013; Whitehead et al. 2007; Moy 1995; Yousefli et al., 2017). At most Norwegian hospitals, FM is a recognized profession (Boge and Aliaj, 2017).

The Norwegian health care system is based on "universal access, decentralisation and free choice of provider" (Norwegian Medicines Agency, 2016). Until 2002, when the government took over the hospitals, Norway's 19 counties owned, managed and operated most hospitals. One reason for the government's takeover, according to former Prime Minister Jens Stoltenberg (2016), was the fact that the counties did not have financial muscles to modernize the health care system. Since 2002, Norway's publicly owned hospitals have very much imitated and implemented practices established by the UK's NHS. The Norwegian Ministry of Health has delegated ownership and operation of hospitals to four Regional Health Authorities. These Regional Health Authorities and their subsidiaries very much operate like private enterprises. Most Norwegian hospitals spend approximately 6-10 percent of their annual budgets on FM related services.

Until January 1st, 2017, most Norwegian government owned hospitals' internal FM organizations had a relatively comfortable life. 25 percent value added tax (VAT) on top of the price for services bought from external service providers literally served as armour against competition and outsourcing of non-medical services. However, after the government January 1st 2017 introduced a compensatory scheme that de facto abolished the VAT armour, exposure to competition has become a reality for many services provided by the hospitals' internal FM organizations. For some services, outsourcing has become a credible option, and jobs might be at stake. One of the big questions for Norwegian government owned hospitals' facility managers has thus been how to transform and adapt their internal FM organization and the provision of services to this new situation. How to change their employees' mind-set?

This paper investigates how the FM organization at one of Norway's government hospitals, an internal de facto total FM provider deeply integrated with the hospital's provision of medical services, has responded to removal of the VAT armour. How has this hospital's internal FM-organization's Cleaning, and Food and Catering Sections transformed and responded to this external shock?

2 LITERATURE

There are numerous definitions of organizational culture. Bang (2013) defines organizational culture as "a set of common norms, values and perceptions of reality developed in an organization when the members interact with each other and the surroundings, and which is expressed through the members' actions and attitudes". Thus, organizational culture is those norms, values and perceptions of reality jointly held by the members of an organization, and which are expressed through their attitudes and behaviour.

Large organizations often have subcultures; i.e. that different departments, professions or teams have their own culture (Cameron and Quinn, 2006). There are often significant differences between various groups or professions' cultures (Jensen and van der Voordt, 2017). Most hospitals are hierarchies with several levels and departments. There are many reasons for cultural differences, but education, profession, hierarchical position, and length of service are some factors that influence organizational culture (Bellou, 2008).

In an FM organization, there is often three hierarchical levels, namely strategic, tactical and operational level (Standard Norge, 2007). In this study, the FM organization's operational level is of interest, because those working on the floor are often the most visible service providers (Chotipanich, 2004). The operational level employees' efforts have significant impact on the end users. Alignment of these employees' practices is thus desirable. However, in a large FM organization this is not necessarily easy (Atkin and Brooks, 2014).

In the 1950s, Toyota's Chief Production Engineer Taiichi Ohno established the predecessor to what is currently known as Lean. Lean production means elimination of waste, among others through studies of which activities that actually create value for the customers (Womack, et al., 1991; Womack and Jones, 2003). Ohno defined seven kinds of waste, such as unnecessary production, waiting, unnecessary movements, unnecessary transport, faulty processes, unnecessary inventory and defects or faulty production (Bicheno, 2008).

The Lean philosophy was initially developed for production of physical goods but has later also been implemented in production of services. It is not explicit, but the Lean philosophy is evident in some of the FM literature. Van der Voordt, Prevosth and van der Zwart (2012) present eleven areas where FM can improve hospitals' value creation. These are increased satisfaction, promotion of innovation, cost reductions, increased productivity, supporting culture, good reputation, risk control, flexibility, alternative financing, healing environment and sustainability. All the eleven areas can be linked to Lean's fundamental ideas. Even the European FM standard EN 15221 is influenced by Lean. A very good example is EN 15221-7 (Standard Norge, 2013) about Benchmarking, which promotes a systematic methodology for identification of possible improvements, priority of problem areas, identification of best practice, and process improvements.

Implementation of Lean in service production means implementation of a system and process thinking, focus on the totality rather than on details, and emphasis on deliveries from start to finish (Bicheno, 2008). Kaizen or continuous improvements is another important component in the Lean philosophy. Quality begins with the customer or end user, and continuous improvements are necessary to keep up with the customers' changing expectations (Bicheno, 2008). Practical implementation of Kaizen typically takes place through involvement of all employees and numerous small but important and cost-efficient improvements. Board meetings, where the employees actively identify and implement improvements is a typical example of implementation of Kaizen.

Continuous improvements and respect for humans who are involved in the processes are particularly important in production and provision of services, according to Cervone (2015) emphasizes five goals for service production: Increased value for customers, less waste, adaptive management, involvements of all employees, and continuous improvements. Typical examples of waste in service production are delays, duplication, unnecessary movements, unclear communication, incorrect attitudes, lost opportunities and faults or defects (Bicheno, 2008). Thus, implementation of Lean in production and provision of services given the customers' needs means maximizing value creation and minimization of waste.

5S is most likely the most popular Lean tool for services. The purpose of 5S is to reduce waste and variation to facilitate improved productivity (Bicheno, 2008). 5S stands for Sort, Straighten/Set, Shine/Sweep, Standardize and Sustain. To sort means removing tools and other items no longer needed. To straighten/set means organizing those items needed in a best possible way. To shine or sweep means to clean the areas to make it easier to identify possible problems. To standardize means to establish consistent procedures, to maintain the first three S's. To sustain means to sustain and maintain what has been established (Bisheno, 2008). Cleaning and catering at hospitals also often include a sixth S, according to Bicheno (2008), namely Safety.

Successful implementation of Lean and Kaizen depends on active management (Suárez-Barazza and Ramis-Pujol, 2010). Active management means involved management who believe in the principles and procedures communicated, and who also act according to these. The employees always look at the managers' behaviour, and that is why the management has a crucial role in implementation of Lean (Kane-Urrabazo, 2006; Cervone, 2015). An active manager should not correct but empower the employees. Lean is not only about the individual, but also how to facilitate teamwork. A team is two or more persons who must cooperate to achieve a common goal (Bang, 2008).

Organizations that implement Lean are recommended to establish a system for measuring the service processes' deliveries (Suárez-Barraza and Ramis-Pujol, 2010). Most Norwegian hospitals use the Nordic standard NS-INSTA800 to establish and assess cleaning quality (Standard Norge, 2018). Cleaning at hospitals is also regulated by several laws and bylaws concerning control of infectious diseases. Norwegian cleaners can qualify for a trade certificate in cleaning, which among others documents the candidate's knowledge about important rules, regulations and principles of importance for cleaning, hereunder cleaning tools and methods. Even food and catering services are regulated by several laws and bylaws concerning health, hygiene, food safety and internal control procedures. The food and catering providers' internal control procedures are based on the HACCP (Hazard Analysis Critical Control Point) framework (Mattilsynet, 2016).

3 METHODS

A case study is usually the researcher's preferred choice when the aim is to describe how or why if the researcher can't control the phenomenon subject to study (Yin, 2009). This paper is a comparative case study (Gerring, 2004), based on a most similar sample, where the two cases from the hospital's FM-organization have similar background, but with different outcomes (Gerring, 2012). Organizational culture, implementation of Lean, management and leadership, cooperation, and training of the staff are possible explanations concerning how the FM organization's Cleaning Section and Food and Catering Section responded on the government's de facto abolition of VAT when the hospital buy services from commercial service providers.

The study was approved by the hospital and reported to and approved by Norwegian Centre for Research Data (NSD). To get the project approved, a project description, declarations about informed consent and interview guides were made. Most of the data are collected through four interviews; two personal interviews with the leaders of the Cleaning Section and the Food and Catering Section, and two focus group interviews with five employees from the two sections. The employees who took part in the focus group interviews were recruited by their section leaders. Some data were also collected through observations. The interviews were semi structured and based on interview guides. To avoid electronic storage of personal information,

and to protect the informants, all interviews were documented by field notes. These field notes were transcribed immediately after each interview, and the data were organized in main categories concerning culture, Lean, management and training. All data have been made anonymous.

4 RESULTS

In this section we present the main findings from studies of the FM organization's Cleaning Section and Food and Catering Section. Table 1 provides an overview of these section's responses to the government's VAT reform that removed their protection against competition from commercial service providers.

Table 1 Outcomes after the 2017 VAT reforms

	Cleaning Section	**Food and Catering Section**
Leadership and management	Active leadership Leader with 20 years' service at the hospital	Active leadership Leader with few years' service at the hospital, but formal FM education and long career in private enterprises
Organizational culture	Both leader and employees have developed competitive mind-sets	Leader has a competitive mind-set; the employees are satisfied with status quo
Implementation of Lean	5S Board meetings Team Work	5S Board meetings Giveaway of surplus food
Employee cooperation	Focus on cooperation and development of a community	The leader wants more cooperation
Training of the employees	Rules and procedures Cleanliness and hygiene control Use of INSTA800 Focus on trade certificates	Rules and procedures Cleanliness, hygiene and food safety

The Cleaning Section's leader has been employed at the hospital for about 20 years and has worked systematically during the last four to five years to develop the section's culture, hereunder communication of the importance of continuous improvements and preparation for increased competition. The Cleaning Section's leader also emphasise feedback to the cleaners. Both the Cleaning Section's leader and employees have developed competitive mind-sets. The Food and Catering Section's leader work hard to convince the employees about the necessity of being more competitive, but the employees seem to be satisfied with status quo. The Food and Catering Section's leader, who has been only a few years at the hospital, but has a long career in private companies and as self-employed is an educated Chef with a Bachelor's degree in Food and Catering Management. Food and Catering Management is one of Norway's oldest and most common FM educations. Most of the Food and Catering Section's employees have long careers in the section. The Food and Catering Section's leader has worked hard to convince the employees about the necessity of being more competitive, but the employees seem to be satisfied with status quo.

The Cleaning Section has implemented several Lean tools and methods. 5S permeates most of the section's work. Cleaning is rather standardized, but the leader encourages experimentation with different methods to motivate the employees' involvement and to develop their

productivity. Hygiene and infection control are also high on the agenda. The Cleaning Section uses board meetings governed by the employees, and where the leader has a coaching role. The Cleaning Section has introduced something named Team Work, which means that several employees clean an area if one of the employees are absent. Both the leader and the employees are positive to Team Work. 5S is not mentioned explicit in any of the interviews with the Food and Catering Section's employees, but 5S seems to permeate many of the activities. The leader is very concerned about these principles, to improve the section's competitiveness. Even the Food and Catering Section rely on board meetings governed by the employees, and where the leader has a coaching role. Some of the employees keep a low profile during these board meetings. The Food and Catering Section's leader has also implemented other Lean methods. One measure, which has become rather popular among the employees, is to give away surplus food. Giveaway of surplus food has motivated the employees and reduced food waste.

Cleaning has traditionally been a rather autonomous task, but the Cleaning Section's employees cooperate. Both the leader and the employees emphasise development of a community. Many of the Cleaning Section's employees are immigrants. To include everyone in the conversations, Norwegian is the preferred language. Many tasks in large household and restaurant kitchens are teamwork. Most of the Food and Catering Section's employees are women, and they stated that cooperation, teamwork and humour are natural parts of working in a large household kitchen. However, to improve their productivity, the leader would like to see more cooperation.

Cleaning at hospitals is governed by several rules and regulations. The customers; i.e. the hospital's other employees, the patients and their visitors are most important for the Cleaning Section's leader and employees. The employees emphasised to do something extra for the customers every day. Both the leader and the employees are aware of the costs. The Cleaning Sections uses INSTA800's quality procedures and participate in a benchmarking program. Benchmarking has shown good cleaning quality but there are possibilities for cost improvement. The leader encourages the employees to qualify for a trade certificate in cleaning, but that takes time. Most of the hospital kitchens' cooks have trade certificates as restaurant cooks or cooks for institutional households, but most canteen workers have no formal vocational education. Both the Food and Catering Section's leader and employees have cleanliness, hygiene and food safety high on the agenda. However, neither the leader nor the employees were particularly concerned about new technology.

5 CONCLUSION

Since organizational culture is expressed through employees' behaviour and attitudes, the two sections most likely have different cultures (Bang 2013, p. 327). The Cleaning Section's employees seem to be more concerned with the Lean philosophy than the Food and Catering Section's employees. Subcultures is thus normal in large organizations with subdivisions (Cameron and Quinn, 2006; Jensen and van der Voordt, 2017). Compared to the Food and Catering Section, many of the Cleaning Section's employees have relatively short careers in the hospital's FM organization. Length of service can influence organizational culture, and short careers may facilitate changes (Bellou, 2008).

Both the Cleaning Section's leader and the Food and Catering Section's leader do their best to implement a competitive mind-set and Lean philosophy among their employees. They practice active leadership, which is considered fundamental to succeed in implementation of Lean (Cervone, 2015; Kane-Urrabazo, 2006; Suárez-Barazza and Ramis-Pujol, 2010). Both leaders considered change a necessity. 5S is the foundation for improvements in both sections, and both sections also use board meetings where the leaders have a coaching role (Cf. Bicheno,

2008). One significant difference between the two section's implementation of Lean is the Cleaning Section's use of Team Work to reduce costs and to increase employee cooperation (c.f. Cervone, 2015). Thus, the Cleaning Section has managed to establish a collective responsibility for the section's competitiveness. The Food and Catering Section give away surplus food that otherwise would have become food waste, and this measure has improved the Food and Catering Section's reputation (c.f. van der Voordt, Prevosth and van der Zwart, 21012).

Different degrees of formal training may also influence the employees' perception of the need for improvements. The Cleaning Section's employees have more trade certificates than the Food and Catering Section's employees. Suárez-Barraza and Ramis-Pujol (2010) recommended use of measurements systems when implementing Lean. The Cleaning Section has implemented INSTA800 as measuring system for cleaning quality, and both sections' professional principles for hygiene can be considered a part of a measuring system of the service delivery and are crucial when implementing Lean.

The conclusion is thus, the VAT reform has had different impact on the two section's culture. All other things equal, it seems easier to change the culture in a section where the employees have few years of service, compared to sections where the employees have many years of service and the culture is deeply entrenched. In the Cleaning Section, introduction of VAT neutrality has led to increased focus on customers' needs and competitiveness. The two sections' rather similar implementation of Lean may indicate orders about implementation from strategic level, as a first line of defence against VAT neutrality. The government's VAT neutrality has also led to greater emphasis on on-the-job training as well as formal education. Thus, VAT neutrality has made this hospital's internal FM organization more competitive. In other words, this hospital's FM organization managed to change engine while driving.

This case study is limited to two sections at one Norwegian governments hospital's internal FM organization. These findings cannot be generalized, but it would be interesting to study other cases to investigate responses to VAT reforms.

ACKNOWLEDGMENTS

Thanks to the hospital's management who permitted the study, and to the FM organization's managers and employees who took their time as informants. Thanks also to the reviewers for constructive comments that improved the paper.

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Digitization of FM: Experiences from Norwegian property managers

Marit Støre-Valen
Dep. Of Civil and Environmental Engineering, Norwegian University of Science and Technology (NTNU)
marit.valen@ntnu.no
+47 91897967

ABSTRACT

Purpose: Explore how Norwegian property managers practise and organize their Operation & Maintenance (O & M) tasks, and study their attitudes and experiences with Digitalization Technology (DT) and Building Information Modelling (BIM) in the O & M tasks.

Methodology: A descriptive approach is used, conducting a brief literature review to identify the benefits and challenges of the digitization of property management and 14 semi-structured interviews among a selection of Norwegian public property managers. The benefits and challenges are analysed and discussed with the topics "Organization & Competences" and "DT and BIM in O & M".

Key findings: The findings indicates that when new construction projects use BIM in the construction phase, a BIM version adapted for the operational phase is likely to be developed. The hospitals studied show that they are developing new in-house competences among the property managers, as they have already been highly involved in both the design and execution phase. The findings underpin the importance and value of their involvement to influence the decision-making of the details for the enrichment of the BIM for the operational phase. They also enhance the benefit of increased collaboration across the disciplines of the health-care staff through the use of DT for a better demonstration of the use for the space and requirements of O & M. However, there are also challenges among the hospitals when transferring information from the Building Automation Systems (BAS) into BIM. The Norwegian municipalities report that they use DT, but mainly BMS/BAS (2D systems) for the O & M tasks, because many of the O & M tasks are working well in 2D. Even so, they have many different databases and systems that do not necessary convert well. Other DT, such as sensor technology and hand-held devices, are more widespread. A major challenge reported is to approach the existing building stock that does not have "digital twin" representation. Yet, this is expected to develop in the future, as the literature underscores that the application and availability of FM products will increase, which is also confirmed by the FM suppliers.

Intended Impact: This study show the value of organizing competences in teams, rather than the traditional way of doing property management. This study confirms the value of a collaborative approach, and that DT assists in better understanding the possibilities and the use of the facilities. This study can motivate other municipalities and public owners to integrate BIM into FM, and become involved in the enrichment of the "digital twin".

Paper Type: Research paper

Keywords: digitization, Facilities Management, property management, BIM technology and digital technology

1. INTRODUCTION

In the last few decades, Building Information Modelling (BIM) and Digitalization Technology (DT) have revolutionized the construction industry (Gao & Pishdad-Bozorgi, 2019). In Norway, BIM technology in new public construction projects has become common through all stages of the building process. This gives an opportunity to develop a "digital twin" of the physical building that can be beneficial in the operational phase. A *"digital twin"* is a digital representation of the physical assets that provides the possibility for conducting a virtual tour of these assets when carrying out O & M planning. However, such a digital model is not automatically compatible with other digital systems, like Building Automation Systems (BAS) or Building Management Systems (BMS), which are both widely used to handle the operation and maintenance of the building. The Norwegian construction industry has a strategy to achieve a vision for the digitization of all phases in the construction process by 2025 (BNL, 2017). The strategy pinpoints that a "digital twin" for use in the operation phase should be a demand in the tender document to be delivered at the handover. If the contractors are using DT under the construction phase, it becomes low hanging fruit to develop a digital twin for the benefit of the operation phase.

The aim of this paper is to explore how Norwegian property managers practise O & M, and study their attitude and experiences with DT and BIM in the user phase of the building. The research questions (RQ) explored in this study are:

RQ (1): How are property management tasks organized and practised today? and RQ (2): What are their experiences with digital technology (DT) in their daily O & M work?

2. LITERATURE REVIEW

Recently, several researchers conducted a literature review on the use of digital technology associated with FM and Property Management. They state that there is limited research and studies of BIM-FM topics (Eastman *et al.*, 2011; Carbonari *et al.*, 2015, 2016; Araszkiewicz, 2017; Ashworth & Tucker, 2017; Alnaggar & Pitt, 2018; Dixit *et al.*, 2019; Gao & Pishdad-Bozorgi, 2019; Koch & Hansen, 2019). The major benefits and dilemmas reported are described in the following.

A survey done by Ashworth and Tucker (2017), with 256 respondents in 28 countries, indicated that 39.8% had some experience with being involved in a BIM project, while 20.5% had experience with using BIM technology in the user phase as a tool for solving Facilities Management tasks.

The literature highlights the need for developing a "digital twin" for use in the operation phase that can interact with BAS/BMS in a way that contributes to added value of the FM organization (Volk *et al.*, 2014, Gao & Pishdad-Bozorgi, 2019). The benefits of BIM in FM are further explored.

2.1 Benefits with BIM in FM

Many researchers, suppliers and practitioners believe that there is a promising potential to integrate BIM into FM. One promising benefit is the potential for saving time because the information is easy to access. Gao and Pishdad-Bozorgi (2019) talk about *"BIM-enabled FM"* as the digital BIM model of the facilities that gives easy access to and effectively store life cycle information about the facilities (e.g. where hazardous materials or components are located).

Other benefits, such as collaborative means, lowered costs for quality checks and a reduction in the time to collect information, are highlighted by researchers (Fuglesang, 2017; Jaspers, 2016; Volk *et al.*, 2014). However, the benefits of BIM depend on the use and how the organization further develops the BIM in FM, as well as dedicating resources to keeping the model updated (Volk *et al.*, 2014; Fulgesang, 2017; Jaspers, 2016; Bilad *et al.*, 2016). According to Eadie *et al.* (2013), collaboration aspects produce the highest positive impact of using BIM, with clients and facilities management benefitting the most financially.

Aziz also highlights the collaboration possibilities, but state that the quality of life (QOL) in the workplace will improve when adopting BIM in FM, and argue for these six benefits: 1) effective operational costs, 2) shorter time for decision-making, 3) resources for decision-making, 4) better documentation systems, 5) collaboration and work flexibility, and 6) updated information and clash detection.

Carbonari *et al.* (2015, 2016) discussed the benefits of using BIM as an opportunity to understand the building, its behaviour and its future opportunities. They conclude that BIM offers FM an opportunity as a process tool to enable a more informed decision-making process. They also suggested that cultural and behavioural aspects should be integrated into the BIM.

Alnaggar and Pitt (2018) looked for ways to collect a complete Cobie data set to be delivered at the handover phase. They also proposed a conceptual framework that provides a standard project management process to systemize the data flow among all stakeholders.

2.2 Dilemmas and challenges

One dilemma is to exchange data between the BAS/BMS and the "digital twin", as these systems primarily handle 2D drawings. In order to update or develop the "digital twin", one dilemma of using external consultants versus in-house resources depends on the development and use of the BIM in the operation phase, as enhanced by Koch and Hansen (2019) and Volk *et al.* (2014). This affects the development of competence within the organization, in addition to how the organization realizes its potential in the use of the model.

Araszkiewicz (2017) suggests possible directions for further research related to digitization in property management, and its impact on the process of implementing the concept of intelligent and sustainable construction engineering, saying that:

> *A substantial part of the analysed publications concerned with FM in smart buildings refers to the use of digital tools and technology in the monitoring and management of building energy balance.* (Araszkiewicz, 2017)

Dixit *et al.* (2019) reviewed 54 studies and conducted a survey among FM professionals in the US. The most important issue was the lack of FM involvement in the project phases in those projects in which BIM was involved. Araszkiewicz (2017) also recommend this in order to detail the scope of the necessary information collection to a BIM in the operation phase.

One important question is to look at how digital technology (DT) can be integrated into several actions associated with FM. The goal of using an integrated BIM is to contribute to regulating the data supply and stating the ownership of the data, as well as helping to provide an easy acceptance of the information of the building (Pishdad-Bozorgi *et al.*, 2018).

Combined with sensor technology, a "digital twin" can help the property manager to communicate and collect information that can be useful for decision-making in the operation and maintenance (O & M) planning.

Augmented Reality (AR) helps to share a way to handle the relevant information of operational and maintenance (O & M) planning. Eadie *et al.* (2013) also pinpointed the need for strategies

to specify a deliverance of the BIM model for the operation phase as a part of the contractual tender document.

Pishdad-Bozorgi *et al.* (2018) highlighted the necessity of a seamless and practical process of collecting information through the construction phases, and creating an FM-enabled BIM that can be a useful tool together with Facilities Management systems. However, in order to collect the Cobie information needed in the user phase, Jaspers (2016) pinpointed the need for engagement of the Facilities Managers in order to synchronize the BAS or CAFM systems, since it is natural that some of the FM tasks are handled either in the BIM or BAS system. However, one challenge reported is to get the FM staff engaged in both the design and construction phase to help decide what relevant information needs to be adopted into the FM BIM. Jaspers (2016) recommends that the facilities managers approach the BIM adoption as an information exercise to be sure that the BIM model and CAFM systems are synchronized both ways.

One dilemma reported is whether external consultants should do the development of BIM in FM, or if the property management organization takes responsibility and develops this knowledge in their own organization, which would be beneficial in the long term (Koch & Hansen, 2019). Others report that using BIM in the user phase should be looked upon as a cultural change that changes the way of working, rather than thinking that BIM in FM is a "software thing" that you can buy (Carbonari *et al.*, 2016). A summary of the benefits found in the research literature follows (Gao & Pishdad-Bozorgi, 2019; Bilad *et al.*, 2016; Jaspers, 2016; Volk *et al.*, 2014; Eadie *et al.*, 2013):

- BIM supports the automation of operation and maintenance tasks
- Time saving, accessibility to information
- Collaborative aspects and visualizations
- Monitoring and managing energy consumption
- Enables a more informed decision-making process
- Better documentation system
- Cultural and behavioural aspects

3. RESEARCH METHODOLOGY

This research is based on qualitative research, using a descriptive approach as described by Fellow & Liu (2015). Firstly, to find what the literature says about the benefits and challenges regarding DT and BIM technology in the operational stage, a short literature review limited to the current decade (2010-2019) was conducted. The reason for this limited period is that before 2010 there was little documentation on the experiences with BIM and DT in the operational stage.

The literature search was conducted in Google Scholar, the Web of Science, Scopus and Oria by searching for academic journals, conference papers and master theses using a combination of search keywords related to the Digitization of FM and property management: *Digitization, Facilities Management, Barriers and BIM, BIM in FM, BIM and operation, BIM and Operation and Management.*

Secondly, the research questions (RQ 1 and 2) were explored through using semi-structured interviews of 14 property managers and FM suppliers involved in public property management. The interviews were conducted in two periods. The first period was conducted by Flaa (2018) between January to April 2018, and the second period by the author, between January to March 2019. The interviews were prepared using a semi-structured interview guide introduced to the informants in advance, with the interviews lasting 60–90 minutes. The interviews were then

transcribed and analysed according to these topics: *1) Organization and Competences and, 2) Digitization Technology (DT) in O & M*. Other topics were also explored, but not presented in this paper. The questions asked are presented in Table 2, with the main findings presented and discussed in Chapter 4 and Table 3.

The role of the informants varied among public property managers involved in two new hospital projects and six municipalities with the responsibility of schools and kindergartens, sports halls and cultural buildings. The number of informants and their roles are presented as follows in Table 1:

Table 1: Number and role of informants

Role of informants	**Number of informants**
Property managers of public buildings (schools, kindergartens, administration, sports and cultural halls)	8
Property managers of hospitals	4
FM suppliers	2
Total number of informants	14

Table 2: Questions asked in the semi-structured interviews (Flaa, 2018 and author's work)

Research topics and questions asked in the semi-structured interviews within O & M planning	
Organization and Competences	1. How are the Real Estate and Property Management tasks organized in order to provide good FM services to the users? 2. What are the goals of the property management organization? 3. Do you have the competence needed to deliver the accepted quality of the services?
DT in O & M	4. How can DT be beneficial in your daily work? 5. What methodology and tools are used in order to collect information on the O & M needs of the building stock? 6. How do you collect the needed information from the facilities to input into decision-making for O & M planning or Space Planning? 7. Do you use any digitization technology (DT) to solve your daily work? 8. Do you use sensor technology to some extent? If yes, how?
Benefits and Challenges	9. What challenges do you experience in your daily work? 10. Do you see any benefits of using digitization technology (DT) in your daily work?

4. EXPERIENCES OF NORWEGIAN PROPERTY MANAGERS

The data of the informants from the hospitals and other public municipality buildings, are categorized into the topics Organization and Competence and DT in O & M. The main findings are presented in Table 3, followed by a discussion of the benetifts and challenges of each topics.

Table 3: Main findings of the interviews (Flaa, 2018 and author's work)

Topics	**Benefits**	**Challenges**
Organization and Competences	Organized as a multidisciplinary team Cross-disciplinary collaboration with architects and planners in the municipality Dialogue with the users FM role involved in the construction process of the project	Time and resources to implement new knowledge Lack of motivation and engagement
DT in O & M	Accessible information Overview of the building portfolios Technical condition and functionality Internal Control	Lacking BIM of existing buildings Exchange of information between the BIM and BAS, BMS or similar databases

4.1 Organization and Competences

In general, an impression of the maturity of the property management is that they had good competences and were well organized according to their O & M tasks.

One of the city municipalities had reorganized their property department three years ago. One informant said:

> *The work environment and the way we work now is much better than before. It's much more structured and efficient. We sit in the same physical location and are interacting with each other and have good colleagues to solve daily challenges.*

They organized PM teams divided into four geographic zones. Each team has two people from management, two from maintenance and two from operations. The team does inspections as a team, discusses challenges and needs with the user/client, and procures the janitorial services that have the main responsibility at the building. The janitor handles deviations and checking errors, and is also an important contact point with craftsmen suppliers that the PM team required. The PM teams were happy with this arrangement.

Another medium municipality organized a cross-disciplinary group to use for their planning of new development projects (architects, engineers and project managers and construction leaders). Their competences were also drawn into bigger PM projects. This was reported as a success that provided valuable knowledge to the organization and important planning skills.

The two hospitals have a similar organization with a property department of buildings (O & M), a real estate department (Management & Development) and a FM department for logistics, food services and so on. They organized the O & M planning around a dialogue meeting that they had with the clinic departments. The Property Management and Real Estate department met with the clinic leaders two times a year where they sat down around the table and shared experiences and challenges perceived with the facilities. Here, they had to bring to the table their ideas and needs of what had to be changed, and how they experienced the services provided. Bigger investments were handled at the owner level, but in this way they could discuss and engage in a dialogue with the staff as to whether there was room for small or bigger changes. For example, if some clinics obtained new medical equipment that needed a special space or a special adaption of the space, they would discuss how to solve this in a good way.

One of the municipalities also had yearly meetings with the owners (politicians in the municipality's council), where they discussed the state of the building stock, presented a

maintenance plan and investments needed to be done. The decisions made were then integrated into the budget to be handled later on.

Challenges

In general, all six municipalities felt that they had a good group of people with good competences and knowledge to handle day-to-day tasks. In the long run, they felt that they lacked the resources to develop new competencies, as they reported that they saw the need to implement new methods and tools for improving their daily work more efficiently. However, they felt that they did not have the time to educate and develop the staff.

One of the challenges for the hospitals is always being short of space. Among the clinics, there was an attitude that they felt they owned their space and were not always willing to ask the Real Estate department if they could expand their space. The Real Estate department attempted to teach the clinics that this had to go via the Real Estate department instead of the clinics making decisions based on finding available space and just moving into it as they thought was best. Again, the key here is dialogue and trust.

4.2 DT in O & M

The benefits of DT and their attitude towards DT were explored among the property managers. To maintain an overview of the building stock, basic information, the technical condition and maintenance needs and legal demands, the municipalities mainly use some kind of a BMS or a BAS system. Some also use an SD to govern the building stock. This seems to have worked well. Several municipalities use mobile units for the cleaning planning and internal control.

Both the hospitals and one municipality reported that BIM was a central part of the early phase of planning, design and construction. This allows the Property Management organization to develop a BIM model for the operational phase. Since the Property Management organization was much involved in the design and construction phase, where the benefit of BIM was demonstrated, they had a great motivation to develop a "digital twin" for the operational stage. However, they are not yet clearly aware of how they will be using the model to optimize the operation in the long run, though the property managers were clear in confirming that a "digital twin" enriched with the FM documentation was needed for O&M planning. They confirmed that this would strengthen the Property Management organization and the information needed for doing O & M planning.

The property managers from the municipalities did recognize the benefits of collaborative aspects, and that an integrated BIM in FM can save time in finding accessible information valuable for the O & M planning. In particular, they see some obvious clear benefit in developing an integrated system between the BIM and a BAS/BMS. One of the municipalities said:

> *We have started to use sensor technology at one of our administration buildings, measuring the temperature and air quality, and the need for cleaning the toilet. We think this can give us some valuable information that we can use in future operation of the building.*

Challenges

The project leader of the hospital project reported that there had been a challenge to engage and motivate the operation staff to be involved in the COBIE enrichment to accomplish the "digital twin". However, they explained that they were busy in their daily routines and needed time for being part of this process.

A challenge of the property managers is also that they are managing a large proportion of existing buildings that do not have a "digital twin", or are integrated into the BIM in FM. Several FM suppliers and DT suppliers are working with methodologies to approach this dilemma so that existing buildings may be adapted and reused for a lifetime in the future. The FM suppliers interviewed confirmed that they are developing techniques to use on existing buildings, such as laser scanning and other simple web-based tools. More research is therefore needed to integrate existing buildings into the FM BIM, as well as using it as a communication platform to demonstrate and easily educate the FM staff.

Nonetheless, this study shows that Norwegian public property managers are aware of and see the benefits of developing the O & M towards digitization processes in the future.

5. CONCLUSIONS

This paper has studied the organization and competence of Norwegian public property managers among two new hospital projects and six municipalities, as well as their experience with digitization technology (DT) in O & M.

Both the literature review and practice highlight the need for the FM role to be a part of the decision-making process. When the FM role is involved in the early phase planning, as well as the design and construction stages, it helps the decision-makers and the property managers to be aware of the benefit of integrating BIM into O & M (Dixit *et al.*, 2019; Araszkiewicz, 2017). The property managers in the hospital organizations confirmed this, as they had been involved in the construction phase and also contributed with valuable information to finding good solutions, in addition to enrichment of the BIM. The hospital projects have the benefit that BIM and DT were used through the construction phase. The involvement of the Property Management organization has increased the knowledge of the benefit of using BIM. The fact that they were involved also enhances the possibilities to succeed with the integration of the BIM since they are better prepared for it.

The attitude of the property managers of the municipalities was positive towards developing a more digitized practice of O & M, and were aware of the benefits of using BIM and DT. They highlight the need for a process tool for improved collaboration, better decision-making and the benefit of accessing information for better O & M planning. This is in line with the benefits stated by the researchers (Gao & Pishdad-Bozorgi, 2019; Dixit *et al.*, 2019; Bilad *et al.*, 2016; Jaspers, 2016; Volk *et al.*, 2014; Eadie *et al.*, 2013). Still, half of the municipalities reported a lack of resources, especially time, in order to develop good and compatible solutions for BIM and DT. The author believes that the use of DT in FM has a great potential in the future. The research is still scarce, so further studies are highly recommended.

ACKNOWLEDGMENTS

We wish to acknowledge the time and knowledge of the informants who contributed to this research, as well as the master's thesis of Anders Flaa, who collected valuable data and conducted several of the interviews.

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Exploring the roles of facility management for liveable cities

Yan Xue
Carmel Margaret Lindkvist
Alenka Temeljotov Salaj

Norwegian University of Science and Technology, Trondheim, Norway

email: yan.xue@ntnu.no

ABSTRACT

Purpose-The paper aims to explore the roles of facility management on urban life quality in Norway based on Pådriv. Pådriv is a network of volunteers and businesses from various industries. Facility management plays a key role in integrating different stakeholders within this project by helping people who lack the resources to realize their projects, by connecting them to relevant groups. This paper determines potential roles for facility management in urban planning, and how these roles can contribute to enhance the quality of citizens' lives.

Methodology-The main methods will be literature review and a case study. The literature review will focus on finding the ideas for what can be done from the facility management perspective for liveable cities in terms of urban planning and built environment. The case study will explore the different roles of facility management in the Hovinbyen case in Pådriv and analyse their effect to determine which roles are crucial for liveable cities.

Case Study- The project contribute to either social, economic, or environmental sustainable growth in an area of the city of Oslo called Hovinbyen. This collaboration moves close to creating a more liveable environment and achieving citizen well-being supported through facility management practices. The results showed that the main roles in this case provide a platform for different stakeholders to participate in a project, coordinate the different participants and combining the strengths and resources of the relevant groups.

Findings- In the case study, this approach to the overall effect of cooperation between different stakeholders were positive.

Intended Impact- This study supports the added value of Urban FM in Norway in order to achieve liveable cities. The case study may also serves as guidance for future applications of facility management in urban environments.

Paper type: Case Study

Keywords: roles of facility management, liveable cities

1. INTRODUCTION

There is increasing focus on human health and well-being in urban environment. This focus deals with different environmental pollution factors such as exposure to pollutants, as well as noise, disasters, stressors and diseases, urban density, lack of physical activity, degraded ecosystems and erosion of natural capital. All these factors affect the living conditions of citizens and affect the liveability of a city.

The term liveability has to do with the local standard of living, and often appears in global rankings, most notably 'Mercer's Quality of Living Ranking'. Note that this is different from quality of life or happiness. While there is research showing correlation between standard of living and subjective well-being (SWB) (Okulicz-Kozaryn and Valente 2019), i.e. people's evaluation of the quality of their own life, in the context of this paper, the term liveable cities refers only to their living standards.

Among the most important criteria used in the interview with Bunkholt, the representative of Padriv, are safety, culture, environment and recreation, factors, which are all closely linked to the design of public spaces. Furthermore, the Habitat III New Urban Agenda states that public spaces play a crucial role in urban interaction and systemic urban innovation. Thus, public spaces need to be designed and managed sustainably and equitably to ensure a positive impact on citizens' health and standard of living, enhance resilience to disasters and climate change, and reduce the environmental footprint of the cities. Urban FM is a discipline, which can achieve a positive impact on public spaces.

Roberts (2004) introduced Urban FM viewing it as a need to outsourcing community management to professional services while Alexander and Brown (2006) focuses on Urban FM in terms of residential community. These were both examined as separate entities, but increasingly with ideas around Public Private People Partnership (PPPP), we see a need to link both community initiatives with private enterprise where FM is the catalyst on an urban scale. One approach to shaping of public spaces that is seeing increased popularity is co-creation, where the citizens, the public sector, and private sector cooperate.

There are, however, many challenges for co-creation. Lovrić and Lovrić (2018) in there study of network approach to participatory theory found that the main barriers are:

1) ability to design innovative methods to enable efficient multi-participation of all stakeholders;
2) agencies or persons with systematic knowledge of urban planning, data modelling, value capture, finance, communication and spatial statistical methods;
3) close relationships among different stakeholders.

Urban FM extends FM to the urban area level. FM encompasses multiple disciplines to ensure functionality, comfort, safety, security and efficiency of the built environment by integrating people, place, process and technology (ISO, 2017). Facility manager roles include: occupancy and human factors; operations and maintenance; sustainability; facility information and technology management; risk management; communication; performance and quality; leadership and strategy; real estate; project management; and finance and business (Meng 2014). We can conclude that FM has a systematic knowledge, which can solve the second barrier to co-creation very well. At the same time, as an intermediator between the strategic city needs and local needs of a district, facility managers can build close relationships with citizens, business companies and public institutions. Hence, they connect between different partners and create a network for stakeholders. Furthermore, due to their knowledge, experiences and skills, they are the most likely to design the creative methods for efficient multi-participation. The ambition of Urban FM approach is similar as urban ecosystem, with the focus on sustainable development of urban area, as well as integrating the environment, buildings, and social-economic aspects.

Therefore, the aim of the paper is to explore the enlarged role of FM to cope with the problems of urban environment. Firstly, a short literature review from the fields of urban development, partnership models, social security, technology and FM is shown. Secondly, a very interesting case of Pådriv active participation is presented. Finally, the challenges for urban facility management is given. Specifically, the research questions are:

- What roles can be played from the facility management perspective in urban planning?
- How can these roles contribute to enhance the quality of citizens' lives?

This literature review and a case study explore the idea of activating FM to aim co-creating liveable cities, with the focus on urban planning and built environment.

2. THEORETICAL BACKGROUND

The term 'liveable urban environment' express the idea of a place with a high quality of life. In accordance with Major City Unit definition (2010) '*Liveable cities are socially inclusive, affordable, accessible, healthy, safe and resilient to the impacts of climate change. They have attractive built and natural environments. Liveable cities provide choice and opportunity for people to live their lives, and raise their families to their fullest potential'*.

Health approach consider, measure and integrate different indicators of physical, psychological, community, social-economic and environmental health. From physical perspective, Bolden et al. (2014) mentioned 'open space' liveability indicators, which contribute to social determinant of health and well-being: green space, accessibility, variety, quality, frequency of use, playgrounds and walkability. The focus is on both quality and quantity of the public places, which can be measured by accessibility and usability variables (Zhang et al, 2017). In order to enable citizens to be more active and engaged in physical activities, as one way of influencing their well-being and health, urban FM task is to help co-designing and co-creating urban public places, which are accessible, equitable and environmentally oriented, and increase mobility opportunities.

The ideas behind sustainable urban development and smart cities appear as a result of the desire to continue living a high-quality life and to enhance competitiveness in a society where the increasing globalization is a large issue. Smart cities are considered necessary to meet challenges regarding economic growth, social development, improved mobility, participatory governance, health, and safety, as well as optimization of natural resources (Mosannenzadeh and Vettorato, 2014). Smart city is the solution to sustainable urban development that embraces collaboration, ICT infrastructure, new planning systems, and social innovation. Moreover, it encompasses a more interactive and responsive city administration, safer public spaces and meeting the needs of the entire population. The critical challenge for contemporary urbanism is to develop the knowledge, capacity and capability for public agencies, the private sector and multiple users in city regions systemically to re-engineer their built environment and urban infrastructure in response to climate change and resource constraints (Eames et al. 2014 by Lindkvist et al, 2018). FM role could be valuable for facilitating an effective, collaborative and interactive governance for co-creation, co-finance and co-ownership of urban public spaces to improve citizens' sense of attachment, commitment, trust, inclusion and integration. As stated by Gohari (2019), the participatory process enable citizens using their own knowledge, capital and asset to build their own place, rather than simply solving their isolated health problems.

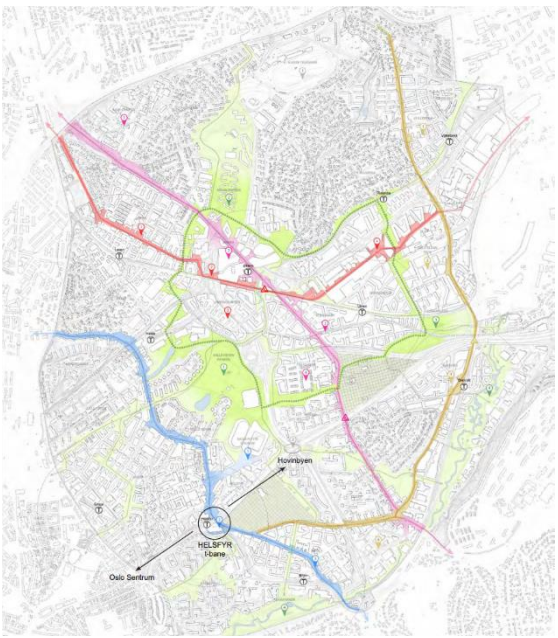
A transition to sustainable behaviour in cities cannot be achieved without deep engagement of all local stakeholders, as they have to approve the proposed changes, adapt their behaviour and share the financial burden of investments. For that reason, the concept of Public-Private-People-Partnership (4P) plays a very important role in the governing philosophy of this transition. One of the challenges is to put forward as a solution that is sustainable as well as convincing, both to the public, private and people. Therefore, the opinions from all the stakeholders should be taken into account in the planning process. The traditional process is said to be sequential and information often get lost. The 4P-based process is interactive and includes direct formal and informal relations between all Ps, not only formal participation. The most interesting part of the 4P process is the interface between the Private-People, the potential end-users of the new development (Majamaa et al., 2008; Kuronen et al., 2008). To conclude, the 4P process is interactive with direct relations between all the actors in the planning phase.

The focus of urban FM is on putting citizen's needs first (Lindkvist et al, 2019). Urban FM studies have considered the concept in terms of social enterprise for social and/or environmental improvement (MohD et al., 2013); regeneration of communities through strategic considerations of place design and corporate social responsibility within FM (Larsen et al., 2011); community-based FM, which focuses on the long-term presence of built assets in a community (Alexander and Brown, 2006); scaling services on city level (Lindkvist et al, 2019); applying to the urban neighbourhoods (Temeljotov Salaj et al., 2018); modelling an implementation of the multi-sector participation process (Xue et al., 2019).

The next section will consider the approaches to urban FM from the possibility to extend its role to actively participate in co-creating liveable neighbourhood. The paper analyses the real case study of Pådriv network and project Hovinbyen from different perspectives of urban health and well-being: Sustainable communities and safety, Walkability, 4P challenges, People participation in planning and Smart city. The research is designed as an interview with Åsmund Bunkholt, the chairman of Pådriv, with a semi-structured questionnaire based on literature review findings. For which question, the literature findings were presented to Bunkholt and discussed his reflections, standpoints and real interventions.

3. RESEARCH - PÅDRIV CASE STUDY

Pådriv is an interesting case, as it acts as a volunteer-network of 5 individuals and 38 organizations, whose goal is a liveable environment. It is a type of FM, which focuses on managing a network of different stakeholders. Its focus is providing a platform for different partners to participate, create problem-solving strategies and share resources. In the Pådriv case, we will look at some of projects they have been involved in, and explore the role that facility management has played. In one of the projects, 'Vollebekk fabrikker', Pådriv aided a company in transforming a factory into a local community centre. They did this by providing a platform connecting businesses and volunteers with specific knowledge and arranging meetings, which corresponds well to the role of a facility



manager. The roles played by FM are as follows: Providing a platform for different partners, coordinating their activity, and gathering and combining resources. In the case of Pådriv, a network manager fills the role of the facility manager, and is responsible for the daily management of Pådriv. Network manager is subject to the management group and must report to it. The network manager must be present at meetings of the management group. Network manager must work with the workgroup and together they form the network management. Network manager can also engage external resources to solve tasks that fall on the Network Manager.

What follows is a discussion based on literature review findings with a combination of a semi-structured interview with Åsmund Bunkholt, the chairman of Pådriv, in November 2018. The project Hovinbyen is analyzed from five perspectives of urban wellbeing: Sustainable communities and safety, Walkability, 4P challenges, People participation in planning and Smart city.

Sustainable communities and safety

The development aspect of social sustainability is addressing basic needs, social capital, justice and equity. Bunkholt emphasized the importance of bridging sustainability focus on changes, with the mindset referring to the sustained outcomes. For Bunkholt, alignment of sustainability goals is key for success. From his perspective, a balance between social, environmental and economic goals is important to achieve sustainable development, but he thinks there has historically been a lack of focus on the social aspect within urban development. The Pådriv and the "Hovinbyen A til Å" illustrate the importance of "friendly" streets and safe public spaces to create sustainable urban development, such as new cafés, green spaces and walking districts (Carrus et al., 2015; Gilje, 2015).

Vandalism, polluted streets, lack of windows towards the street, poor street lights and grey environments, make an impression of an unsafe environment. The feeling of security and safety in a neighbourhood is related to community sustainability, and a crime free neighborhood facilitates social interactions and participation in community activities (Dempsey and Power, 2011). Bunkholt emphasized that the mind-set of the people living in a community are the main contributor to changes for that community. Weingaertner and Åsa Moberg (2014) addresses the importance of involvement, community feeling and pride to develop unity in a sustainable community. Within this description of such a community, a local democracy, participation and empowerment, cultural heritage, a certain sense of place and belonging and an attractive public realm must be in place. All of these aspects relate to the real or perceived safety in a society, and it all starts with the mindset and commitment to engage in the community.

Walkability

Research done by Gilderbloom et al. (2015), states that neighborhoods with higher walkability have lower rates of crime, more specifically property crime, murders and violent crime. According to Boyce (2010), The International Charter for Walking (Walk21, 2006) looks upon walking as a contribution to "social inclusion". This is due to the fact that areas tailored for walking are usually more universally designed, meaning public areas and spaces will appear as more accessible to most people. In the interview with Bunkholt (2018), he declared that walking and the way people choose to transport themselves, is mainly a mind-set issue. A suggestion by Bunkholt, in order to increase walking and change people's mind-set is to encourage all inhabitants of a district to walk at least 1.5 km per day and appeal to the reduced pollution and health benefits. Increased accessibility for all inhabitants contributes to a more

lively community, where people easier get in contact with each other and where random incidents of people connecting are more likely to occur.

4P Challenges

In order to promote sustainability in such a way that the end-users can perceive the benefit from it, the people should be an equal stakeholder in the project. However, this adds an even higher complexity to an already complex situation. Applying the 4P method can actually result in relationship-disputes and inefficiencies in the different phases and processes of the project, counteracting why they were brought in initially. In order for this cooperation to be beneficial, Majamaa (2008) identified some key attributes that should be present in 4P. This includes trust, coordination and information transparency. It is also important for all the stakeholders to recognize and make use of each other's differences. Therefore, some coordination is needed, that includes regular meetings, nourishment and a clear plan for approaches regarding innovation through 4P. Such methods can be transitional organizations and innovation platforms that enable innovation in this type of partnership (Ojasalo and Kauppinen, 2016). If implemented correctly, the inclusion of the end-users has the potential of increasing the value as well as creating new innovative solutions (Schaffers et al., 2011).

Carayannis and Hanna (2016) claim that the biggest challenge is the bureaucracies in city governments, and that politicians need to challenge existing practices to be able to redesign governmental processes. Furthermore, Riera Pérez et al. (2018) claim that successful sustainable urban development is dependent on implementation on a neighbourhood scale, in order to adapt to the existing society and its inhabitants, which is aligned with Pådriv's plans regarding Hovinbyen. The objectives of this strategy are to "ensure the viability of the urban renewal project, provide housing to a large number of inhabitants, balance the supply of jobs and housing, save energy resources, upgrade local environments, and foster a balance between density and urban quality" (Riera Pérez et al., 2018).

People's participation in planning

Through a literature review and a semi-structured interview, it is found that the focus on public participation is concerned with aspects as 1) main factors that affect participation; 2) degree of participation; 3) role of stakeholders; 4) power between participants. Swapan, (2016) found six key factors that affect the respondents' willingness to participate, namely: (a) economic condition; (b) awareness of the planning process; (c) effectiveness of communication strategies taken by the planning agency; (d) trust in planning agency; (e) sense of urgency (i.e. whether or not they were personally affected by the plan) and (f) status of social capital. The level of participation from low to high is information, consultation, discussion, co-design, co-decision and decision-making. Information can be regarded as that non-participatory, consultation and discussion belong to medium-level participation and co-design, co-decision and decision-making may be classified as citizen control (Liu et al., 2018).

The role of stakeholders in organizational decision-making is gaining more and more attention, which varies, from merely being the client of the model output to participating in workshops. In the initial level of participation, the participant's role is basically self-management, then it gradually becomes informing. As the participation methods and models improve, the participation roles gradually become partnerships and empowerment. According to social exchange theory and resource dependence theory, the power of actors in a network depends on their control on related resources. Stakeholder value network approach proved to be an efficient model to assess the relative power of symbiosis stakeholders and identify key resources in the decision-making process (Hein et al., 2017). Bunkholt explained that sustainable development

needs to balance social, environmental and economic goals, and in order to do that, people needs should be included in the decision making processes.

Smart Cities

The focus and interest in smart city approaches have been called the "Smart City Movement" (Carayannis and Hanna, 2016). The movement finds it's motivation in a rapid technological evolution, as well as challenges such as "global competitiveness, economic restructuring, pressures on public finance, increasing premium for knowledge and innovation-driven economic activities, younger and fast-growing populations in many developing countries, aging populations and growing demand for advanced services, and climate change and growing environmental impact of cities". To utilize the potential of urban development, cities need to focus on efficiency, integration, inclusion and smart solutions. For a successful smart city approach, however, we cannot forget how the solutions need to be organized, implemented and managed (Kobal Grum, 2017; Visvizi et al., 2018).

Bunkholt supports these claims. He explained how smart solutions sometimes can be too smart. In this lies the argument that a smart solution is not necessarily smart, it is the users and how it works in the society that defines whether the solutions are smart or not. In addition, Visvizi and Lytras (2018) state that "a smart city is only as smart as its inhabitants (...)". Bunkholt thinks that smart city is based on the interaction between technology and people, and on the partnership between public and private organizations. That means that both users, owners and organizations need to contribute to achieving the best results in developing a sustainable smart city. Pådriv in Hovinbyen emphasizes the importance of cohesion as well as the social pillar of sustainable urban development.

To make a smart city smart, the solutions need to apply to its users (Silva et al., 2018; Carayannis and Hanna, 2016; Mosannenzadeh and Vettorato, 2014). Digital participation is a crucial success factor in this context. Whether it is to supply citizens with real-time information, to support feedback to the system developers or the local government, or to ease the daily tasks, the city needs to interact with its inhabitants in a new way (Silva et al., 2018; Carayannis and Hanna, 2016). It needs to balance top-down strategies with bottom-up strategies, i.e. to balance city governance with community initiatives. The smart solutions need to be adaptive and dynamic to meet current and future challenges, but they also need to be user-friendly.

4. DISCUSSION AND CONCLUSION

The paper explored the challenges for FM to help increasing sustainability in an urban environment. From the literature review and discussion with Åsmund Bunkholt from Pådriv, very interesting findings can be discussed and concluded. The research has identified a variety of social challenges connected to the problem of liveability, especially from sustainable urban development. Findings from literature and the interview elaborates solutions for enhancing sustainable urban development by addressing a balance between social, environmental and economic goals. Resource scrutiny, increasing globalization and urbanization, collaboration and involvement of inhabitants, perceived safety, poor public health, social hierarchies, user interfaces of ICT, bureaucracies, and last but not least laws and regulations are all challenges facing Hovinbyen.

What roles can be played from the facility management perspective in urban planning?
Pådriv network has a vision of developing cities that future generations will be proud of. Pådriv succeeded to activate the public sector to collaborate with citizens, private and voluntary actors and in this way define problems, challenges, strategies and solutions. Pådriv shows that this type of collaboration is beneficial, and that a large degree of interdisciplinary knowledge, trust and a dynamic organization is needed. Mind-sets of people living in a community are found to be one of the main contributors to push a community in a more sustainable direction. Nevertheless, decision-makers also have to take responsibility for implementing changes by involving the inhabitants in the decision-making process by balancing a top-down with a bottom-up strategy. Literature reviews show smart cities to have the technological infrastructure to support future social needs and to facilitate social interactions and participation in community activities.

An urban facility manager can become the main enabler and implementer of improvement of social, economic and environmental sustainability of urban areas. Urban FM is seen as the one to help creating an urban ecosystem, which has people and environment as the main driving forces. To meet this goal, the FM term should be extended from the building space to the urban space. The enlargement of responsibility of Facility Manager to the Urban Areas, the level of complexity of duties increases and multi-disciplinarily approach is required. The role of FM is seen in collaboration with all stakeholders of 4P.

Therefore, current knowledge areas of FM (EN-15221-4) on strategic, tactical and operational level need to be enlarged with: (a) urban planning, (b) data modelling, (c) PPPP, (d) financial and (e) multi-criterion optimization models, (f) social infrastructure in dynamic development, (g) forecasting methods, (h) demographic models, (i) communication methods, (j) spatial statistical methods, and (k) visualisation methods. Therefore, various methods and tools need to be developed, based on the theories of (a) value orientation, (b) sustainability, (c) motivation of owners and users, (d) community engagement, and (e) behavioral changes.

How can those roles contribute to enhance the quality of citizens' lives?
The aim of the new role is to orientation on citizens' needs to stimulate citizens' well-being, healthy living and sustainable lifestyles through active co-creation and use of liveable places. Bunkholt emphasized that mind-sets of people living in a community are the main contributor to changes for that community. Pådriv uses a social platform for changes, thus urban FM should develop an innovative tool to support citizen's sustainable engagement in the neighbourhood regeneration projects. It shall also be developed as a data-managed tool to facilitate modelling of human behaviour in response to data captured by the environment monitoring system based on smart devices with embedded sensors.

As mentioned by Carayannis and Hanna (2016) the biggest challenge is the bureaucracies in city governments, so the role of urban FM (public role) could be focused in analysing intergovernmental relations, urban social sustainability, sustainability management, and municipal sustainability performance measurement. That kind of innovative sustainability self-assessment tool could incorporate cutting-edge knowledge on many technical issues and provide a framework for municipal sustainability self-assessment to help municipalities evaluate their situations honestly and pragmatically.

"Hovinbyen A til Å" illustrates the importance of "friendly" streets and safe public spaces to create sustainable urban development, such as new cafés, green spaces and walking districts. Urban FM can play a significant role with urban service orientation, understanding and

representing the community needs. innovative ways to capture opinions and make it easy for local residents to influence urban development using a spatial crowdsourcing tool. With co-designing and co-creating urban spaces citizens' feeling of trust and co-ownership is stronger.

Walkability, perceived safety and involvement of community members to enhancing changes is discussed and found to be a necessity and important aspects to utilize the potential of urban development. Urban FM can play a huge role in creating a safe physical space for the community with easy accessibility through walkability. Furthermore, urban FM can include people in the decision-making process, and utilize innovative solutions which address social inclusion. By focusing on the suggested solutions, findings show that achievable effects are lowering poverty, erasing differences in social classes and civic engagement.

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The influence of personality on preferred workplace characteristics

Ilse Toonders
JLL Amsterdam
IToonders@tetris-db.com
+31 630244156

Bert Smit
Breda University of Applied Sciences
Smit.b@buas.nl

ABSTRACT

Purpose: Theory and practice show that users differ in their satisfaction with the workplace environment. This paper is an outcome of a bachelor thesis written for the bachelor International Real Estate & Facility Management at Breda University of Applied Sciences and presents the results of research conducted on behalf of JLL. The paper discusses the influence of personality on preferred workplace characteristics in relation to activity-based working environments. For this research a sample of over 2.000 respondents in two organisations in The Netherlands were invited to complete a questionnaire, leading to 913 respondents. Each respondent has indicated the importance of workplace characteristics for different activity types based on the WODI-toolkit.

Methodology: The research has a quantitative and explanatory research approach to collect structural and statistical data. The research consists of three components: personality, activity and the importance of workplace characteristics. This research adopts the Five-Factor Model from McCrae & Costa to research personality, which is seen as the most valid and reliable model on personality. This model takes five personality profiles into consideration: openness, conscientiousness, extraversion, agreeableness and neuroticism. The relationship between personality traits and preferences in workplace characteristics has been tested using the one-way ANOVA.

Key findings: This paper introduces the relationship between personality and workplace preferences. Several statistical significant differences were found between opposite personality profiles regarding the importance of workplace characteristics. Regularities in results were recognised concerning the characteristics ‘diversity’ and ‘interior design’. The research reveals that the characteristics ‘ability to concentrate’ and ‘acoustic privacy’ are of great importance regardless of which activity performed. Moreover comfort and the ability to adjust the workplace are crucial characteristics when performing individual concentrated work.

Intended impact of the study on either research, education or practice: Companies more often try to include a human-centric approach in workplace strategies and therefore the insight presented in the paper can trigger companies to develop a more personalised and suitable workplace for every employee.

Paper type: Research paper

Keywords: Workplace management, human-centric design, personality, activity-based working

1. INTRODUCTION

Activity-based working (ABW) remains a 'buzz word' in corporate real estate, with many European offices making a shift towards this flexible and dynamic working concept (De Been, et al., 2015). The development of this workplace concept has continued despite user satisfaction being below expectations and research showing that the impact on job satisfaction and organisational outcomes is questionable. Consequently, activity-based workplaces as a one-size-fits-all solution for workplace design does not meet its objective yet (Hoendervanger, et al., 2016). As our personality surrounds us everywhere we go, also at work, personality has emerged as a key factor when trying to understand particular actions, behaviours and preferences of employees (Christiansen & Tett, 2013). In order to develop a more human-centric workplace we need to improve our understanding of how personality, behaviour and satisfaction with the workplace are related (Hoendervanger, et al., 2016). Over the past years, a number of authors have already researched this topic, for instance with respect to personality traits and satisfaction with workplace (Hartog et al., 2018). However, there seems to be a lack of research on this relationship in the context of ABW environments. Therefore, this paper focusses on understanding the relationship between personality, activities performed and design preferences for work environments during particular activities. This approach provides a more detailed insight into the needs of users in ABW environments instead of more generic information on satisfaction with the workplace.

The following paragraphs provide a literature review, a conceptual framework, methodology, findings, conclusions and implications for the future workplace design.

2. LITERATURE REVIEW

The current paper focusses on the relationship between personality, design characteristics of workplaces and activities in ABW environments. The central premise of ABW is that end-users look for the right type of environment for various activities he or she performs throughout the day. In many modern businesses this is a mix of environments offered for several activities. The central hypothesis in this paper is that end- user preferences for workplaces are to some extent depending on personality. What is more, these end-user preferences are predicted to be different for different activities. This could be an explanation for the differences in satisfaction with the workplace between different employees, not only because of differences in personality but also as a result of the (importance of) a activities they perform as part of their job. This literature review provides an overview of the central constructs of this research to explain the measurement instrument developed.

Personality

Early in the 20th century, individuals were experiencing rapid societal changes due to the industrialisation, urbanisation, immigration and mass education, which led to fear of depersonalisation. Personality became an evident concern and a focus in businesses, academic and professional fields. It was studied along with intelligence, interests, motivation, differences, and similarities within and across individuals (Almlund, et al., 2011). ABW environments and other modern forms of workplace design seem to create a similar fear of depersonalisation. In this research personality is defined as a set of personality traits that are patterns of thoughts, feelings and behaviours which have the tendency to vary and fluctuate depending on the situation or circumstances (Roberts, 2006).

This research adopts the Five-factor model (FFM), as the central framework for understanding

personality. The FFM is widely accepted and is considered the most valid and reliable research model on personality over the past decade (Palaiou & Furnham, 2014). The FFM encompasses the following five personality traits; openness, conscientiousness, extraversion, agreeableness and neuroticism. Each of these traits have a number of sub traits that are discussed below.

Openness
Intellect, imagination, culture and openness to experience are labels that can be used to indicate an original, imaginative and creative individual (Jones & Hartley, 2013). It is argued that open people have a broad interest and are willing to invest in novel ideas (Homan, et al., 2008). Open individuals score high on statements like "Is fascinated by art, music, or literature", "Is complex, a deep thinker" and "Is original, comes up with new ideas" (Soto & John, 2017).

Conscientiousness
Conscientiousness individuals are described as both proactive and inhibitive (Costa, et al., 1991). Conscientious individuals feel the need for achievement and are very hardworking and business-like (Jones & Hartley, 2013). This will show in perseverance, self-discipline, and orderliness (Costantini & Perugini, 2016). But also in impulse control, which results in behaviour such as thinking before acting, delaying gratification and following norms and rules (John & Srivastava, 1999).

Extraversion
Primarily, extraversion is a trait that is defined as energetic, cheerful, and sociable (Mooradian & Swan, 2006). Watson and Clark in the Handbook of personality Psychology (1997, p. 771) describe extraverted persons as *"[…] those of Ascendance and Sociability—in all of these views, extraverts are gregarious, friendly, dominant and socially facile".* Ascendance in this context, refers to the fact that extraverts often act as leaders, which can be done in an outgoing, spontaneous and dominant manner (Soto & John, 2017).

Agreeableness
Agreeableness is identified by trust, straightforwardness, altruism, compliance, modesty, and tender- mindedness (Costa, et al., 1991). A statement in the BFI is "Assumes the best about people" (Soto & John, 2017). In the end, the attitude of agreeable individuals can be associated with the desire of maintaining positive relations with others (Graziano, et al., 2007).

Neuroticism
Neuroticism is strongly related to distress and poor well-being (Costa, et al., 1991; Steel, Schmidt, & Shultz, 2008). Individuals who score high on neuroticism are more receptive for negative environmental stimulation. Generally, individuals who encounter neuroticism experience nervous tension, guilt, and low self-esteem (Matzler, et al., 2005). The opposite of this trait is emotional resilience.

The FFM manages the overwhelming number of traits and sub traits which have been cross-culturally validated (Pytlik Zillig, et al., 2002). Over the years several inventories were developed, including the BFI- 2, a 60-item questionnaire based on the original instrument. Soto and John (2017) developed a 15-item extra short form (the BFI-2-XS) that was proven to be reliable and valid and therefore useful to use in research (Soto & John, 2017). In this research the BFI-2-XS was adopted to create a survey with optimal response.

Activity patterns in activity-based working environments

In the workplace various activities can be observed and defined. In ABW environments, the activity at hand determines which space is the most suitable to work in. Table 1 shows an overview of literature informing this research of the most performed activities in the

workplace. From this overview the six most common activities were selected: (1) concentrated individual work, (2) calling/virtual meeting, (3) internal meeting, (4) meeting with externals, (5) private or confidential work, and (6) creative work.

Steen, et al. (2005)	**Volker & van der Voordt (2005)**	**Beijer (2011)**	**Appel-Meulenbroek, et al. (2011)**	**Leesman Index (2015)**	**Kim, et al. (2016)**
Useful buildings for office activities	**WODI Toolkit**	**Activity wizard**	**Perspective on activity-based office concepts**	**The impact code**	**Ownership in the workplace**
Concentrated desk work	Desk work	Desk work that requires concentration	Behind the computer	Individual focused work, desk based	Desk work
		General desk work	Writing	Individual routine tasks	
				Individual focused work away from your desk	
		Reading (longer than 30 minutes)	Reading	Reading	
Telephone calls	Telephone calls	Telephone calls	On the phone	Telephone conversations	Telephone calls
				Audio conferences	
				Video conferences	
				Using technical/specialist equipment or materials	
Meeting	Formal meetings	Meetings	In a meeting (individual/group)	Planned meetings	Formal meeting
			Presenting	Hosting visitors, clients or customers	
				Larger group meetings or audiences	
Interaction/ad-hoc meeting at the desk	Informal meetings		Informal talk	Informal, un-planned meetings	Cross-departmental collaboration
		Desk work that requires interaction		Collaborating on focused work	
				Business confidential discussions	
				Private conversations	Private interactions
Practical/creative desk work				Thinking/creative thinking	Project/team activities
				Collaborating on creative work	
				Learning from others	
Archiving/ printing	Archiving, copying, faxing	Document management		Spreading out paper or materials	
				Informal social interaction	Interact with colleagues
Lunch break/coffee break			Lunch/coffee break/other break	Relaxing/taking a break	
			Toilet visit		
	Other	Other		Other	

Table 1: Overview of work-related activities (Steen, et al., 2005; Volker & Van der Voordt, 2005; Beijer, 2011; Appel-Meulenbroek, et al., 2011; Leesman Index, 2015; Kim, et al., 2016)

Workplace characteristics and user preferences

The workplace has many aspects that have to be taken into consideration while creating the ideal work environment. This research looks at characteristics of the physical environment that can add value for the end-user during particular activities. The WODI light tool, part of the Work Environment Diagnosis Instrument (WODI), has been used to define applicable variables as it is a frequently used tool in measuring employee satisfaction (Maarleveld and Van Der Voordt, 2009). Several KPIs of WODI light have been selected to investigate their level of importance in the physical work environment (table 2). Not all WODI light KPIs have been taken into account, as not all are directly related to specific work environments or activities, nor was it feasible to integrate them all in the survey. The selected workplace characteristics are stated in table 2 including the original KPIs where the characteristics are

derived from. Thus, table 2 only shows the selected KPIs.

Selected Workplace characteristics	Original KPI in WODI light
Comfort and ergonomics	Functionality and comfort of workplaces
User influence and adaptability	User influence
Diversity and availability of the workplaces	Number, diversity and functionality of the workplaces
Openness	Degree of openness and transparency
Transparency	Degree of openness and transparency
Appearance and ambiance	Interior design, appearance and ambiance
Interior design	Interior design, appearance and ambiance
Functionality and comfort of the workplace	Functionality and comfort of the workplace
Ability to concentrate	Concentration
Privacy: accessibility of others	Acoustics
Privacy of speech	Privacy
Privacy: visual distraction	Concentration & openness and transparency
Communication and social interaction	

Table 2: Overview of KPI's selected from the WODI light tool

For this research some KPIs have been reformulated in order to represent a preference for a design characteristic. The variable 'comfort' is the designation for the KPI functionality and comfort of the workplace. User influence is seen as the ability to adapt the workplace to personal wishes to stimulate productivity and satisfaction. Diversity and availability of workplaces relates to preferences for the same activity. The WODI KPI interior design has been split into two elements: interior design and appearance and ambiance. Furthermore, one of the biggest bottlenecks in a work environment is the ability to concentrate often in relation to privacy. These WODI KPI's have been reformulated to get a better understanding of user preferences.

Based on the above, a conceptual model of the relationship between the central concepts in this research has been developed to illustrate the hypothetical relations between them (figure 1). Personality traits are the independent variable that is expected to be related to the dependent variable, preferences for workplace characteristics. This relationship is moderated by the user activity. In this paper we present the variations in the preferences for the most time consuming activities of our respondents in relation to their personality traits. By doing so we are testing our main hypothesis:

H0: Personality traits are not related to preferences for workplace characteristics

H1: Personality traits are related to preferences for workplace characteristics

3. METHODOLOGY

This research has applied a quantitative research strategy in order to collect statistical data on the conceptual model presented below. We sent out a self-completion questionnaire to 2.000 individuals in two organisations, which resulted in a response of 913 questionnaires, equally divided over the two companies. The questionnaire was structured into three parts; personality was tested using the BFI-2-XS. User activities were established asking respondents for a percentage of worktime spend on six types of activities. For each activity respondents were asked to rate the importance of workplace characteristics using a 5-point Likert scale.

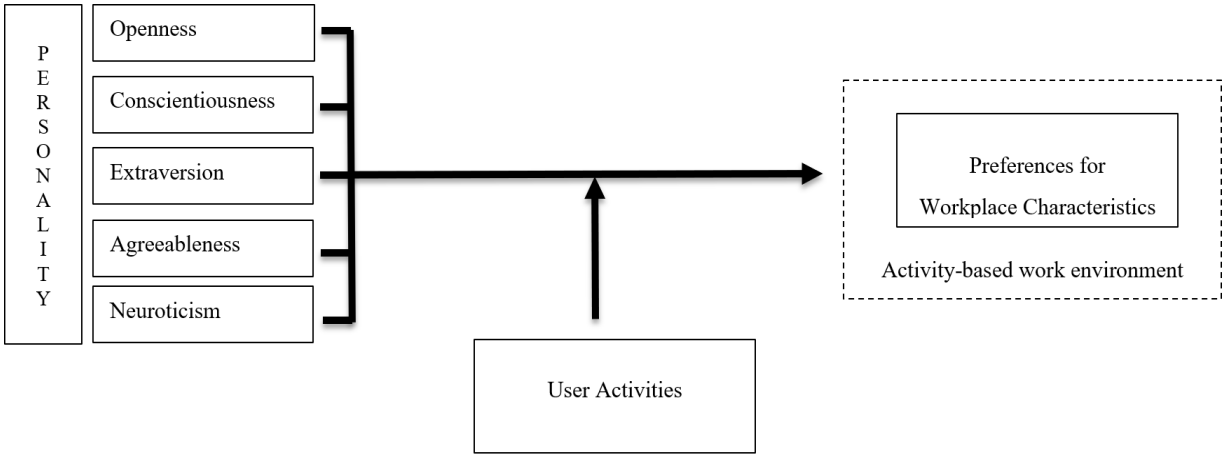

Figure 1: Conceptual framework

Possible relationships between variables were explored using IBM SPSS Statistics 19. After data collection the personality trait data was checked for construct validity. All traits had a sufficient Cronbach alpha's according to what should be expected (Soto and John, 2017). After that, personality strengths for each respondent were calculated using the BFI-2-XS format, resulting in a score between 3 and 15 for each respondent. The five continuums were scored on an axis from negative to positive for each trait. Personality trait strength was then transformed from ratio level data to categorical data, using four categories (table 3). Although trait strengths were normally distributed, they were all skewed towards higher values. To create categories with similar sample size we chose to use an unbalanced division of values for all traits.

One-way ANOVA was executed to test if differences in importance of workplace characteristics for three most prevalent activities, could be explained by differences in personality trait strength (cat.1 vs cat.4). Each one-way ANOVA that indicated a significant difference in importance of a characteristic, which was followed by a either a Tukey HSD or a Hochberg's' GT2 post-hoc tests to prevent type 1 errors (Field, 2018). The Tukey HSD has been chosen because it is powerful when testing large numbers of means (Field, 2018). The Hochberg's GT2 is known as a powerful post-hoc test should the sample sizes differ heavily. Therefore, this test is also applied in this research. The Hochberg's GT2 is used for openness (N=64 vs N=139), conscientiousness (N=13 vs N=433), agreeableness (N=15 vs N=372), and neuroticism (N=63 vs N=5) and the Tukey HSD is used for extraversion (N=120 vs N=113).

Category	Trait value
1	3 - 7
2	8 - 10
3	11- 12
4	13 - 15

Table 3: translation of personality trait strength to categorical data

4. FINDINGS

As indicated, this paper elaborates only on the three most performed activities in our sample: concentrated individual work, calling/virtual meetings and internal meetings. In our sample these three activities account for respectively 44%, 20% and 18% of time spend at work.

We have looked into relationships, not causality to test our main hypothesis. Should the null hypotheses be accepted, no significant differences are found between different personality trait strengths with respect to the importance of specific workplace characteristic (Sig. > 0.05).

However, should the null hypotheses be rejected there is a significant relation between the variables (Sig. < 0.05).

In total 36 statistical significant differences were observed after conducting the one-way ANOVA, of which 10 appeared to be statistically significant between categories 1 and 4 of the personality traits, after the post- hoc test. In the following section the 10 statistical significant differences are outlined.

Due to the high number of variables incorporated in the research, a condensed overview is shown below only displaying the statistically significant results after performing post-hoc tests.

Individual concentrated work

This section discusses importance of workplace characteristics during individual concentrated work in relation to the personality trait strength. A statistically significant difference was found for the importance of diversity of available different workplaces. This importance is higher for people that score high in the personality trait openness ($F(3,909) = 6,542$, $p = 0,000$) and / or agreeableness ($F(3,909) = 8.493$, $p = 0,000$). Moreover, persons that score low on the personality trait agreeableness (more competitive persons) find it less important to have an open work environment ($F(3,909) = 4.783$, $p = 0,003$) and a transparent work environment than persons with a high score on agreeableness ($F(3,909) = 5.599$, $p = 0,001$).

No statistical significant differences after performing the post-hoc test were found regarding the personality profiles conscientiousness, extraversion and neuroticism for the activity individual concentrated work.

Openness	**Sign. One-way ANOVA**	**Mean (category 1)**	**Mean (category 4)**	**Δ Mean (1 – 4)**	**Sign. post-hoc test**
Importance of diversity of different workplaces while working individually	0	3.13	3.67	+.544	0,003
Agreeableness					
Importance of diversity of different workplace while working individually	0	2.47	3.58	+1.109	0
Importance of an open work environment while working individually	0,003	2	3.08	+1.083	0,001
Importance of a transparent work environment while working individually	0,001	2.4	3.38	+.984	0,001

Table 4: Overview of significant differences (sig. <0,05) for individual concentrated work.

Calling and virtual meeting

The second most performed activity, calling and virtual meetings, shows two differences. Firstly, acoustic privacy is important to all respondents, however respondents that score high on openness find this characteristic significantly more important ($F(3,909) = 2,975$, $p = 0,002$). Secondly, persons that score high on the trait agreeableness attach significantly more importance to the characteristic ‘adjusting the workplace’ than persons who score low on this trait ($F(3,909) = 5,209$, $p = 0,005$).

No statistical significant differences in importance workplace characteristics were found

after performing the post-hoc test for the personality traits conscientiousness, extraversion and neuroticism for the activity calling and virtual meetings.

Openness	Sig. One-way ANOVA	Mean (category 1)	Mean (category 4)	Δ Mean (1 – 4)	Sig. post-hoc test
Importance of acoustic privacy while calling/having a virtual meeting	0,002	4.27	4.63	+.360	0,011
Agreeableness					
Importance of adjusting the workplace while calling/having a virtual meeting	0,005	2.73	3,57	+.839	0,024

Table 5: Overview of significant differences (sig. <0,05) for calling and virtual meetings.

Internal meetings

The third most performed activity, internal meetings, shows a number of interesting differences between respondents. For this activity, the importance of the workplace characteristics diversity and interior design stand out.

Persons that score high on openness and/or agreeableness attach significantly more importance to diversity of available workplaces. For openness the one-way ANOVA reported a difference between groups regarding diversity ($F(3,909) = 4.805$, $p = 0,003$) and for interior design ($F(3,909) = 5.590$, $p = 0,001$). Extraversion shows a statistical difference regarding interior design ($F(3,909) = 5.393$, $p = 0,001$) and agreeableness presents differences about diversity in de workplace ($F(3,909) = 5.898$, $p = 0,001$).

No statistical significant differences in importance workplace characteristics were found after performing the post-hoc test for the personality traits conscientiousness and neuroticism for the activity internal meetings.

Openness	Sig. One-way ANOVA	Mean (category 1)	Mean (category 4)	Δ Mean (1 – 4)	Sig. post-hoc test
Importance of diversity of different workplace while having an internal meeting	0,003	3.23	3.68	+.449	0,016
Importance of interior design while having an internal meeting	0,001	3.19	3.66	+.474	0.002
Extraversion					
Importance of interior design while having an internal meeting	0,001	3.39	3.79	+.396	0,003
Agreeableness					
Importance of diversity of different workplace while having an internal meeting	0,001	2.8	3.6	+.802	0,012

Table 6: Overview of significant differences (sig. <0,05) for internal meetings.

5. CONCLUSION

Personality can be defined as a complex mechanism of behaviour, thoughts and feelings that are formed by interacting personality traits. This is underpinned by research that describes personality as the explanation for responses in particular surroundings or situations. In the

research underlying this paper, we have applied this to workplace design preferences. The results show that also in this situation personality traits are related to specific preferences in workplace design. Table 7 provides an overview of the most notable findings: importance of diversity is significantly different between personalities, the importance of interior design is proven to be significantly different when having an internal meeting, comfort and the ability to adjust the workplace are highly important while working individually, and the ability to concentrate and acoustic privacy are characteristics which have to be considered when designing the ultimate human-centric workplace. Taking those results into account while designing a workplace, a more human-centric ABW environment can be established. Acknowledging these differences in the design of workplaces customized to the mix of people using them might counter the fear of depersonalisation and improve satisfaction and productivity. This is especially reflected in the importance of diversity of available workplaces for individual work and the importance of interior design for meeting spaces.

	Openness	**Conscientiousness**	**Extraversion**	**Agreeableness**	**Neuroticism**
Individual concentrated work	+ Diversity	x	x	+ Diversity + Open work environment + Transparent work environment	x
Calling / virtual meetings	+ Acoustic privacy	x	x	+ Adjusting the workplace	x
Internal meetings	+ Diversity + Interior design	x	+ Interior design	+ Diversity	x

Table 7: Overview of significant differences per personality profile, a + indicates a positive relationship in comparison to the opposing personality profile (openness vs observant, conscientiousness vs assertive, extraversion vs introversion, agreeableness vs competitiveness, neuroticism vs emotionally resilient).

6. IMPLICATIONS FOR FACILITY MANAGEMENT AND FURTHER RESEARCH

This research has shown that people with different personality traits have different preferences with respect to workplace design for their most executed activities. Facility Management (FM) organisations that have the ambition to improve satisfaction with ABW environments, will need to step away from one-size-fits- all, standardised concepts and acknowledge the differences between their users.

In order to get a more substantiated view of how to acknowledge differences in users, more research is needed. This particular paper has only focused on personality traits in relation to preferences; we have not been able to establish statistical relationships between personality profiles and preferences, nor have we incorporated other psychological and organizational variables that might explain differences in preferences. More research is needed to get a better understanding of how we can customize workplace design to its target users and still create efficient and effective work environments.

ACKNOWLEDGMENTS

The authors would like to thank JLL, Breda University of Applied Sciences and the two organisations involved in our data collection for their hard work and contribution. Without them this research would not have been possible.

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A total of 20 papers were finally submitted and approved for publication in this year's proceedings. The papers embrace the theme for this year's conference which is titled *"One Place, One Voice, One FM"*. The theme symbolises the impact that FM has globally, to which the research papers presented are not only relevant in a European Context, but a wider global context.

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Boeing Avenue 215,

1119 PD Schiphol-Rijk

Netherlands

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ISBN: 978-94-90694-10-4