Research Papers for

The 21st EuroFM Research Symposium

15-16 June 2022

Breda, The Netherlands

Editors:
Tuuli Jylhä
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Preface

It is our pleasure to invite you to be inspired and learn from the open-access proceedings of the 21st EuroFM Research Symposium. Due to special circumstances, the symposium has been arranged fully online in 2020 and 2021. This year we are extremely excited that we have the opportunity to meet the FM researchers also in person on 15-16 June in Breda, the Netherlands.

In 2022, EuroFM Research Symposium is part of the 'Stay connect' sessions of EuroFM Network as it was also in 2020 and 2021. The past year has not been pandemic-free year and organising the research symposium has required adaptability for several changes. Despite the uncertainties, the double-blind peer review process has been successfully finished. The review process was kicked off with 20 abstracts in December 2021 and this proceedings includes 11 full or short research papers. We have seen the after effect of the pandemic in the review process – after being extremely flexible in the past years, it is also time to rest and re-build our consumed buffers for more balanced life. Thank you to the authors and members of the scientific committee for your effort, patience and commitment in the peer-review process and in our EuroFM Research Network!

We have already started to work for EuroFM Research Symposium 2023 to offer the possibility for FM researchers to meet practitioners and students in a common event. Although this year is still a year with special arrangements, we are extremely enthusiastic to meet you all in person or online in the EuroFM Research Symposium 2022. Furthermore, we would like to express our deep gratitude to Breda University of Applied Sciences, which is hosting our symposium this year. Thank you for your hospitality, generosity, and willingness to contribute in the EuroFM research network! We would also like to thank Delft University of Technology for its support in organising this scientific event and publishing this proceedings. Furthermore, we would also like to thank the members of the best paper committee for their commitment and flexibility, as well as Danica Widarta, who has designed the cover of this proceedings.

Please pick a paper of your interest and share it with your colleagues, network and/or with your students. This way we can together share advanced FM knowledge and contribute in developing the FM field, education, research, and ourselves. Enjoy reading the proceedings!

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Improving organisational resilience to disaster events: an FM perspective

Keith Jones[1], Femke Mulder[2], Mariantonietta Morga[2], and Nadeeshani Wanigarathna[2]

ABSTRACT

Background and aim – Improving the resilience of business organisations and critical infrastructure providers to disaster events is a major challenge facing many European organisations. Recent floods in Germany, Belgium and the Netherlands and earthquakes in Iceland, Italy, Romania and Greece have demonstrated the need for organisations to adopt a holistic view of their vulnerabilities, adaptive capacities and resilience planning. This paper focuses on the role that facilities managers could play in the development of disaster management and business continuity and resilience plans.
Methods / Methodology – The paper draws on data collected through an interpretivist, observational action research study to identify the key factors that affect organisational resilience to earthquakes. Literature reviews, interviews and workshops with end-user stakeholder organisations were used to identify physical and operational mitigation interventions that could help organisations better prepare for, absorb and recover from an earthquake.
Results – The paper presents a hierarchical model of organisational resilience and a generic resilience assessment and risk management framework that can help organisations better understand and manage their disaster risks. The paper delineates the role of facilities managers in assessing the impact that the disaster risks could have on hard and soft facilities management and in identifying mitigation interventions to support primary service or product delivery following a disaster event.
Practical or social implications – The paper makes a valuable contribution to the literature on organisational resilience to disaster events by highlighting the little researched role of facilities management in this context.
Type of paper – Research paper (full).

KEYWORDS
disaster management, business vulnerability, adaptive capacity, organisational resilience, risk management, multi-criteria modelling.

INTRODUCTION
The role of facilities managers in supporting improved organisational resilience to disaster events is an under-researched area, even though their contribution to understanding an organisation's vulnerability, resilience, risk, and adaptive capacity to disaster events is clearly recognised (FEMA 141, 1993; FEMA 396, 2003). This paper addresses this gap in knowledge by exploring the role that facilities managers should play in the development of disaster management and business continuity and resilience plans. The paper discusses the concepts of resilience, vulnerability and adaptive capacity as they apply to business organisations and draws on a literature review of organisational resilience and primary fieldwork from the European Union H2020 TURNkey project (https://earthquake-turnkey.eu/) to identify the key factors that affect organisational resilience to earthquakes. The literature review identified the complex relationships between vulnerability, resilience and adaptive capacity and

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highlighted the need for organisations to take action to prepare for, respond to and recover from a disaster event. Such actions need to consider pre-disaster event interventions aimed at improving resistance of the organisation's built assets, processes and systems to the impact of a disaster event as well as post-disaster plans for managing immediate response (e.g., life safety and business disruption) and business recovery. In developing such plans organisations, including their facilities management teams, need to understand their inherent vulnerability and resilience to a disaster event and the strategic options available to them to reflect their organisational circumstances and context.

TURNkey is an ongoing H2020 project to improve earthquake resilience (at the critical infrastructure, business, and community level) through the use of a multi-sensor-based information system that integrates operational earthquake forecasting (OEF), earthquake early warning (EEW) and rapid response to earthquake (RRE) protocols into a cloud-based Forecasting, Warning, Consequence and Response decision support platform: the TURNkey FWCR Platform (Figure 1). This paper focuses on the results for business organisations.

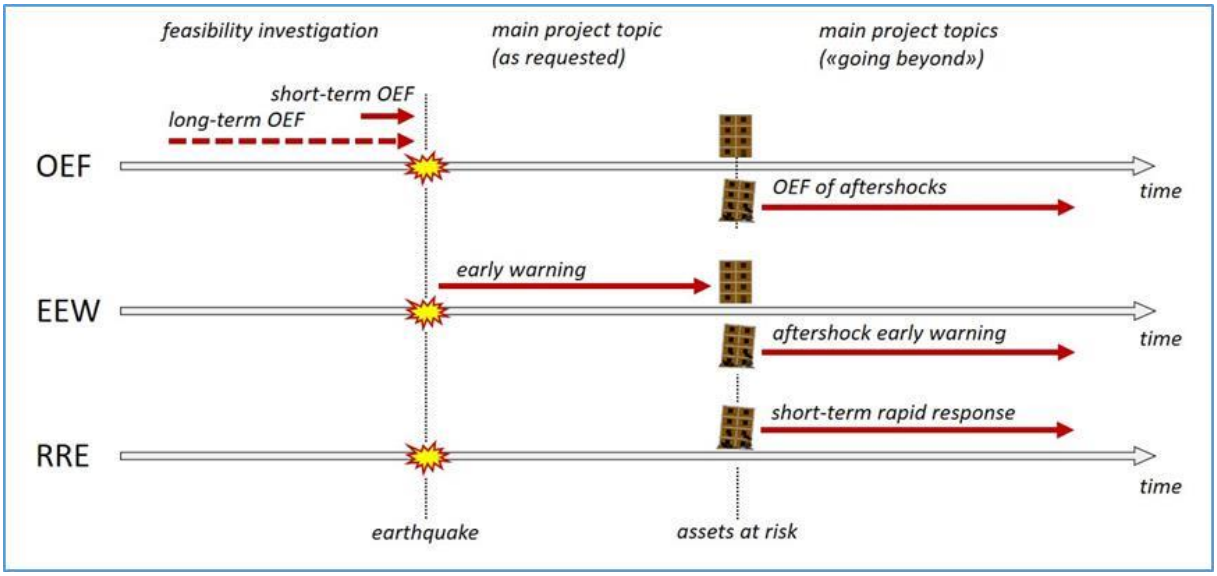

Figure 1 The TURNkey concept model (source: Jones et. al., 2021a).

The aim of the paper is to outline a conceptual resilience assessment and risk management framework to help facilities managers better understand the disaster risks that their organisation faces; the impact that these risks could have on hard and soft facilities management systems; and on the ability of these systems to support primary service or product delivery. The paper highlights the need for facilities managers to adopt a hybrid view of resilience when identifying and implementing adaptation and mitigation interventions to reduce disaster risks and/or improve organisational resilience. The paper first outlines the TURNkey project and positions it within a wider discussion of resilience before exploring the relationship between OEF, EEW and RRE and organisational resilience from a facilities management perspective. The paper then outlines a risk and resilience framework that facilities managers can use to help them better understand their organisation's vulnerabilities and resilience to a disaster event.

RESILIENCE, VULNERABILITY, RISK AND ADAPTIVE CAPACITY

The UNDRR (2022) defines resilience as ***"The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures***

and functions through risk management.". When unpacking this definition, the complexity of the different resilience perspectives proposed by Holling (1996, 2001) become apparent:

- Engineering resilience describes the behaviour of a system close to its equilibrium position. When an external stressor event pushes the system away from equilibrium, the inherent resilience of the system seeks to return the system to its equilibrium position once the external stressor is released (assuming the system's absorptive capacity hasn't been exceeded) with the speed of return to the equilibrium position used as a measure of inherent resilience.
- Ecological resilience describes the behaviour of a system away from its equilibrium position, where the strength of the external stressor is too great for the system to absorb and as such, the system reorganises to a new state of equilibrium. The magnitude of the external stressor that a system can absorb before reorganisation occurs is used as a measure of inherent resilience.
- Adaptive resilience (panarchy) describes the capacity (inherent potential) of a complex adaptive system to reconfigure (reorganise) to a desirable (transformational) or undesirable (destabilising) future state. Adaptive resilience is viewed as the opposite of the system's vulnerability.

The UNDRR (2022) defines vulnerability as ***"The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards."*** As such, vulnerability is related to risk, where risk is defined as the product of hazard, vulnerability, and consequence (Bakkensen et. al., 2016) and to resilience through the system's ability to resist and recover from the impacts (losses) associated with the hazard (Zhou et. al., 2016) through mitigation interventions to lower risk, losses, or impacts. To this end, Tiernan et.al. (2019) argued that resilience should be considered an umbrella concept that encompasses a range of responses to an external stressor that enables a system: 1) to remain stable when exposed to a stressor event; 2) to recover following the event; and 3) to adapt to new circumstances after the event.

Jones (2021) argued that business organisations should adopt a holistic approach to understanding their resilience to a disaster event that considers resilience as a hybrid concept viewed from multiple perspectives; with facilities managers contributing to this understanding through an assessment of the impact that a hazard event has on the organisation's hard (physical) and soft (socio-economic) facilities management systems to support primary business functions. This paper explores the role of facilities managers in supporting their organisation better understand its resilience, vulnerability, risk, and adaptive capacity to a disaster event through a generic risk and resilience framework.

FACTORS THAT AFFECT ORGANISATIONAL RESILIENCE TO DISASTER EVENTS

ISO 22316 (2017) defines organisational resilience as ***"…the ability of an organisation to absorb and adapt in a changing environment to enable it to deliver its objectives and to survive and prosper…"***. As such, organisational resilience is built on a combination of actions taken to prepare for an event (e.g., disaster management planning) and processes in place to expedite a rapid recovery following the event (e.g., business continuity planning) (Denyer, 2017; FEMA 141, 1993; Gibson and Tarrant, 2010). Actions include gathering and processing hazard information to assess (and if possible, forecast) the potential impact of the hazard on the organisation, its supply chain and customers. Processes include identifying mitigation interventions to either reduce the impacts of the hazard or increase the likelihood of the organisation recovering from disruptions in a timely manner. Disaster management and business continuity plans need to reflect the organisation's service or products, operating structure, regulatory and legal frameworks, and whilst they tend to be unique for any given organisation their general format follows the 'plan, do, check, act' structure outlined in ISO 22301 (2019). However, whilst the ISO

standard provides a framework for improved organisational resilience, it does not explicitly provide the tools for organisations to either assess their antecedent resilience to a range of disaster events or to develop adaptation and mitigation plans to improve resilience. The TURNkey project is addressing this issue by exploring how organisations could potentially use EEW, OEF and RRE as part of their disaster management and business continuity planning.

Tierney and Webb (2001) published an early study on business vulnerability and resilience to earthquakes that drew on a questionnaire survey of 5000 businesses to identify how business organisations prepare for and recover from an earthquake. Tierney and Webb (ibid.) found that whilst most organisations did very little to prepare for an earthquake event, those organisations that took action that directly aided business recovery, reduced exposure and mitigated damage and disruption, including to the supply chain, recovered faster than those organisations that primarily focused on workplace preparedness. In a subsequent study, Tierney (2007) expanded on the above and explored in more detail what made some businesses more resilient than others. Tierney (ibid.) explored the inherent resilience of business organisations (defined as the organisational characteristics/factors that mitigate the effects of disasters on business operations) as well as their adaptive resilience (defined as the organisational characteristics/factors that enhance business options and adaptability following a disaster), and suggested that inherent business resilience is related to reduced vulnerability (the fewer risk factors an organisation displays, the more resilient it will be to disaster events) and engagement with business continuity and disaster management planning. The idea of measuring organisational resilience through a series of operational factors and organisational characteristics was further developed by Han and Nigg (2011) who proposed an analytical framework against which organisations could assess their inherent vulnerability and resilience to an earthquake and inform the development of disaster management and recovery plans. Whilst some of the factors suggested by Han and Nigg (2011) now appear a little dated, their checklist approach still forms the basis of the majority of disaster management and business continuity planning toolkits (e.g., the UNDRR Disaster Resilience Scorecard for Industrial and Commercial Buildings, 2022).

The logic of measuring a range of attributes at a single point in time and equating these to a measure of resilience was questioned by Gibson and Tarrant (2011) who argued that, whilst measuring organisational attributes could provide an appreciation of an organisation's resilience capability, its actual resilience would depend on how these capabilities responded to the specific context at the time of the disaster event. In essence, Gibson and Tarrant (ibid.) argued that organisational resilience should be viewed as an outcome of a dynamic complex system where the interactions between factors (and subsystems) provide multiple perspectives on the assessment and management of risk within different organisational contexts (e.g., maturity levels) and strategic objectives. Gibson and Tarrant (ibid.) also argued the need for organisations to develop flexible business continuity and disaster management strategies that identify mitigation actions to enhance both the resistance and reliability of critical business functions to continue to perform at an acceptable level following a disaster event and provide redundancy and flexibility to increase the speed recovery from a disaster event. In essence, Gibson and Tarrant (ibid.) argued the need for organisations to demonstrate a clear understanding of their disaster risks, related vulnerabilities and mitigation actions from multiple perspectives across multiple systems. These arguments are similar to those presented by Deyner (2017) who identified the need for organisations to adopt a range of strategic approaches to organisational resilience; suggesting the need to think beyond defensive resilience behaviours to protect the organisation and return to a pre-existing equilibrium point (engineering resilience) and embrace progressive behaviours to adapt to new opportunities in terms of service delivery and market opportunities (socio-ecological resilience). The TURNkey project is exploring the challenges that this wider view of resilience places on disaster

management and business continuity planning decision-making before, during and after an earthquake event.

RESEARCH METHODOLOGY AND/OR METHODS

The TURNkey project is using an interpretivist, observational research methodology in the form of Participatory Action Research (PAR) to link the needs of the end-users of the TURNkey FWCR platform with those responsible for its design and development. The TURNkey PAR is running over 3 cycles where end-users engage with the TURNkey research and development team in the design, testing, evaluation and reflection of the platform as it develops (Figure 2).

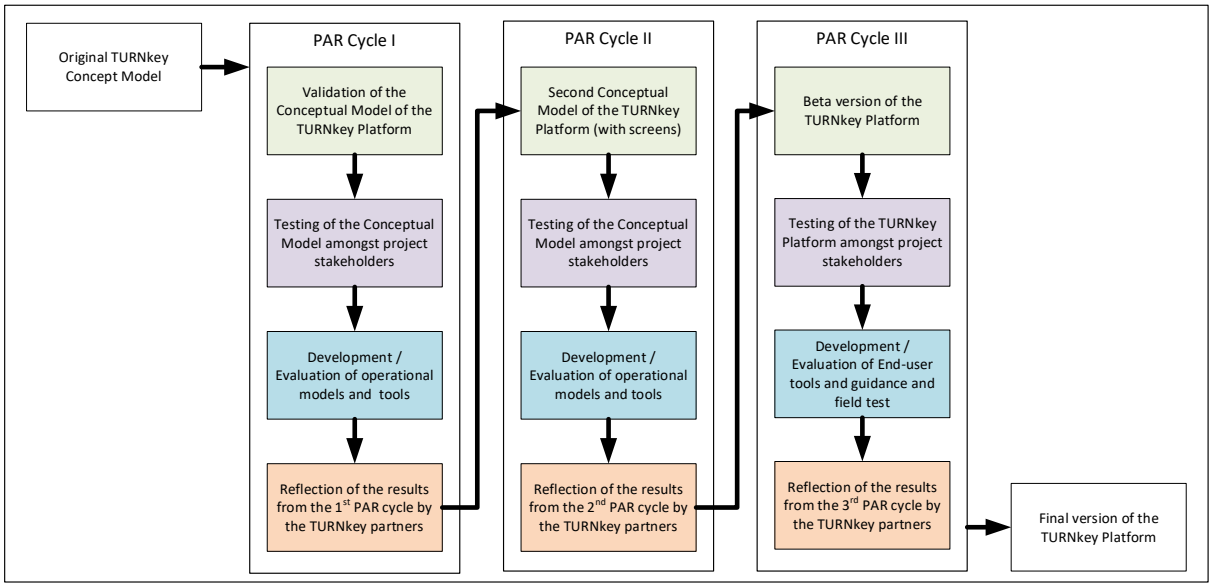

Figure 2 The TURNkey participatory action research methodology

The results of each PAR cycle are presented as a series of generic end-user use cases that describe how the platform could be applied to business organisations before, during and after an earthquake to improve the organisation's resilience to an earthquake. This paper focusses on the results from the 2nd PAR cycle where the generic use cases were mapped against current understanding of organisational resilience to a disaster (earthquake) event derived from a review of three internationally recognised resilience rating systems; REDi™; UNDRR's Disaster Resilience Scorecard for Industrial and Commercial Buildings; and the Relative Overall Resilience model.

REDi™ (Almufti and Willford, 2014) is a rating system for resilience-based earthquake building design that uses a four-category resilience framework to identify interventions that reduce earthquake risks (relative to code-designed buildings), support re-occupancy and rapid functional recovery, and reduce direct financial losses. The framework uses 64 resilience risk criteria grouped into 16 themes across 4 generic resilience categories: 1) building resilience which seeks to minimise damage to structural, architectural and engineering services components; 2) organisational resilience which seeks to support contingency planning for utility disruption (e.g., reduced repair times) and business continuity (reduced disruption to primary function); 3) ambient resilience that seeks to reduce the risks from external earthquake induced hazards (e.g., damage to surrounding buildings or infrastructure, cascading hazards); and 4) loss assessments that seek to evaluate financial losses and downtime as a way of justifying increased costs associated with mitigation measures (loss assessments are based on a modified version of FEMA's PACT methodology). In identifying potential mitigation actions, the REDi™ (ibid.) framework maps the criteria against different levels of occupant safety, downtime, and direct

financial losses; using threshold measures to categorise resilience as either platinum (the highest level), gold or silver (the lowest level).

The UN developed "The Disaster Resilience Scorecard for Industrial and Commercial Buildings" (UNDRR, 2020) to help building owners, operators and managers understand the resilience of their organisation to disaster events. The Scorecard uses 116 criteria grouped into 10 themes: 1) organise for resilience; 2) identify, understand and use current and future risk scenarios; 3) strengthen financial capacity for resilience; 4) pursue resilient urban development; 5) safeguard natural buffers; 6) strengthen institutional capacity for resilience; 7) increase social and cultural resilience; 8) increase infrastructure resilience; 9) ensure effective disaster response; and 10) expedite recovery and build back better. Whilst not all the criteria are applicable to all organisations, those that are, are scored on a 0-5 scale to give an indication of the overall resilience of the organisation to a disaster event.

Lee et.al. (2013) used the Relative Overall Resilience (ROR) model developed by McManus (2008) to develop a model of organisational resilience based around two factors (adaptive capacity and planning) represented by 13 indicators and 53 criteria that could be used as the basis for identifying an organisation's resilience strengths and weaknesses that need to be managed as part of a journey towards becoming more resilient. Full details of the review and mapping can be found in Jones et. al. (2021a).

The review of the scorecards (undertaken independently by the authors) was combined with a review of the role of OEF, EEW and RRE in earthquake resilience (see Jones et. al., 2021b for the review) to provide a conceptual framework against which the TURNkey FWCR platform's potential to enhance organisational resilience could be assessed (Figure 3). The framework was used in conjunction with 5 virtual demonstrators (videos explaining the potential application of the TURNkey FWCR platform before, during and after an earthquake event) in a series of virtual workshops (6) with end-user stakeholder groups to explore the potential relationship between the TURNkey FWCR platform and organisational resilience. Workshops spanned a range of organisations (manufacturing, service delivery, public authorities) from the private and public sectors. Workshops were semi-structured in nature, taking the form of conversations with various individuals responsible for disaster management and/or business continuity planning within their organisation. The results from the workshops were reviewed by TURNkey project members (researchers and end-user stakeholders) at the individual work package and overall project level as part of their reflection on the degree to which the TURNkey FWCR Platform was demonstrating its potential to improve organisational resilience to an earthquake. The 2nd PAR cycle took place between June 2020 and June 2021.

PRELIMINARY RESULTS

The conceptual framework presents organisational resilience to an earthquake as a hierarchy model grouped under physical resilience (where the goal was to minimise downtime through damage limitation and control); operational resilience (where the goal was to minimise disruption) and economic resilience (where the goal was to minimise losses). Physical resilience was further subdivided into structural, non-structural and production systems, which in turn were subdivided into vulnerability assessments, control protocols (to minimise cascading impacts – e.g., fire), and repair time. Operational resilience was subdivided into risk and contingency planning (subdivided into assessment, disruption, management), supply chain and external relationship (subdivided into backup systems, logistics, service contracts) and disaster management (subdivided into employee safety, scenario planning, emergency response, recovery plans). Economic resilience was divided into financial resilience (subdivided into insurance, liquidity, direct losses); corporate image (subdivided into safety, trust, corporate social responsibility) and adaptive capacity (subdivided into training, customer relationship, community

engagement). The consolidated organisational resilience hierarchy model and TURNkey FWCR Platform is shown in Figure 3.

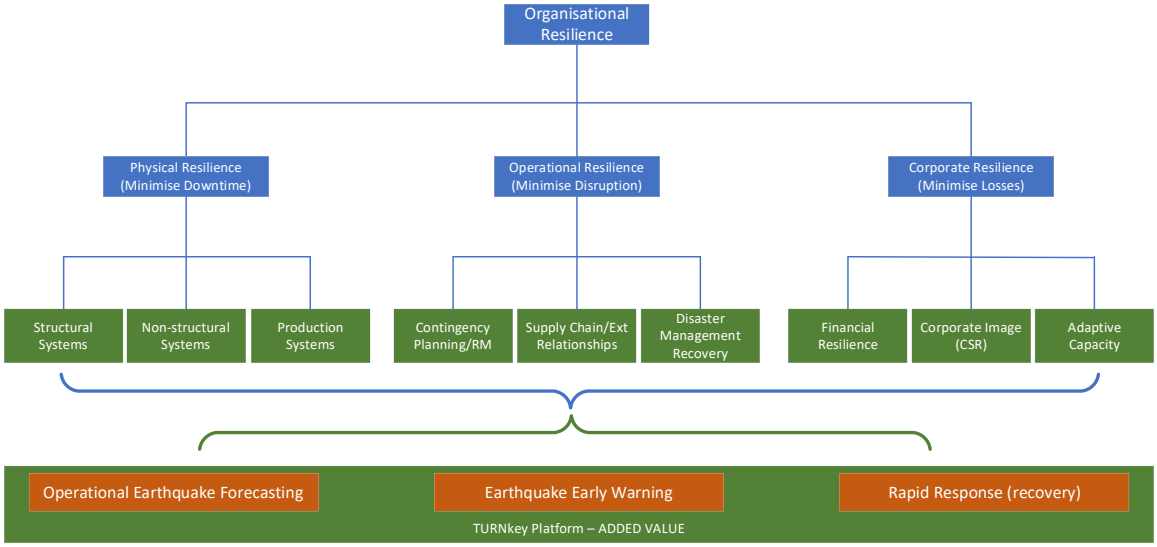

Figure 3 Organisational resilience model and TURNkey FWCR Platform (source Jones et. al., 2021b)

The mapping process and resilience hierarchy was used to inform discussions with end user stakeholders and develop a set of use cases that described the actions that could be taken to improve organisational resilience before, during and after an earthquake. As a consequence of these discussions, the TURNkey FWCR platform is expected to have a positive impact on organisational resilience at the physical, operational and economic levels. At the physical level TURNkey's ability to run dedicated earthquake simulation scenarios (part of the OEF capabilities) that reflect the physical attributes of an organisation will allow potential vulnerabilities to be identified and mitigation interventions investigated and actioned as part of built asset management plans. TURNkey's early warning capability would allow auto control of hazardous systems, reducing the potential for cascading impacts and TURNkey's rapid response capabilities would allow real-time inspection of damage levels and prioritisation of repair activities to minimise downtime. At the organisational level, TURNkey's simulations would feed directly into contingency management and risk planning, and when combined with training, could be used to test disaster management and business continuity plans. TURNkey's early warning system could impact employee safety through the issuing of an alert to take precautionary action and TURNkey's rapid response facility could issue automated emails activating disaster management and recovery plans. Also, if the TURNkey system is used within the wider community, two-way communication between the organisation and emergency responders and civil protection could ensure a coordinated response with external stakeholders. At the economic level, TURNkey's simulations can provide an estimate of economic losses, both as a direct consequence of the earthquake's impact on the organisation and, if the system is applied at a regional level, on its supply chain. This will allow more focused business continuity plans to be developed that, for example, address stock levels and recovery logistics. TURNkey's rapid recovery capability would also provide information to the organisation's customers and wider community, protecting its corporate image and adding to adaptive capacity. These potential benefits are currently being evaluated in the 3rd PAR cycle through a final set of workshops with key business organisations.

DISCUSSION

The review of the organisational resilience literature identified the need for organisations to consider resilience as a complex concept viewed from multiple perspectives that extends beyond the narrow

view of resistance and stability of the system to an external stressor to a wider consideration of the flexibility and adaptive capacity of the system to reorganise once the external stressor is removed. This view poses a number of challenges to facilities managers. From a physical resilience perspective, the facilities manager needs to understand the impact that an earthquake would have not only on the potential damage to building structures, infrastructures, and contents, but also, on the impact that such damage would have on the organisation's ability to deliver their primary function over the short, medium and long term. While such a statement might seem obvious, it is currently missing from many of the models used (e.g., loss functions) to predict an earthquake's impact. Further, in order to fully grasp the potential impact of an earthquake on the business's primary function, the facilities manager also needs to understand the organisation's nonphysical vulnerabilities, including its FM services (e.g., support logistics, security, outsourced contracts, maintenance/repair functions) and how these might be affected by local and regional issues (e.g., access to specialist contractors or supply chains) immediately following an earthquake event. Further, in addition to understanding the organisation's vulnerabilities to an earthquake, facilities managers also need to be able to identify and develop mitigation interventions (to both hard and soft FM systems) that can be implemented either as part of ongoing built asset management plans (through enhanced maintenance or retrofit refurbishment) or specific operational mitigation responses as part of the organisation's risk management plan. To help facilities managers understand their role in resilience planning, the authors have developed a generalised conceptual model of organisational resilience to a disaster event (Figure 4) drawn from discussions with end-users of the hierarchical model presented in Figure 3 and the strategic approaches to resilience modelling discussed in the literature review.

Facilities managers (and the wider organisation's management team) need to adopt a hybrid view of resilience that considers the impact that a disaster event could have on all the organisation's systems including: the organisation's hard FM assets (e.g., built assets); its soft FM assets (e.g., security assets); and its facilities services supply chain, which collectively enhance or inhibit the organisation's resilience and adaptive capacity. This holistic view reinforces the approach proposed by Tierney (2007) and Gibson and Tarrant (2011).

Assessing the antecedent vulnerability and resilience conditions involves identifying the level of risk of the asset set to the impact that a hazard event would have. From a facilities management perspective, this involves using the best available hazard information to understand the consequences of a hazard event on the functional performance of the asset measured against its ability to support the primary business function. Assuming that the loss of overall functional performance is not acceptable to the organisation, the facilities manager needs to identify potential mitigation interventions that seek to either lower the asset set's vulnerability, or improve the asset set's resilience, to the hazard threat. Such mitigation interventions could include actions to improve the resistance or stability of the asset set, for example identifying physical changes to existing buildings to bring them up (or as close as possible) to current design code standards (engineering resilience); changes to security assets (e.g., additional personnel) to manage disruption caused by a disaster event; or changes to supply chain service contracts to ensure flexibility in service delivery to meet changing (post-disaster event) demands (socio-ecological resilience) and reorganisation (panarchy). Such changes may be a direct result of the impact of the disaster event on the FM service model or as a consequence of a change in the way primary services are designed and delivered to make them more resilient. This forward-looking view to enhancing recovery and possible market re-orientation is in line with the strategic resilience strategies suggested by Deyner (2017).

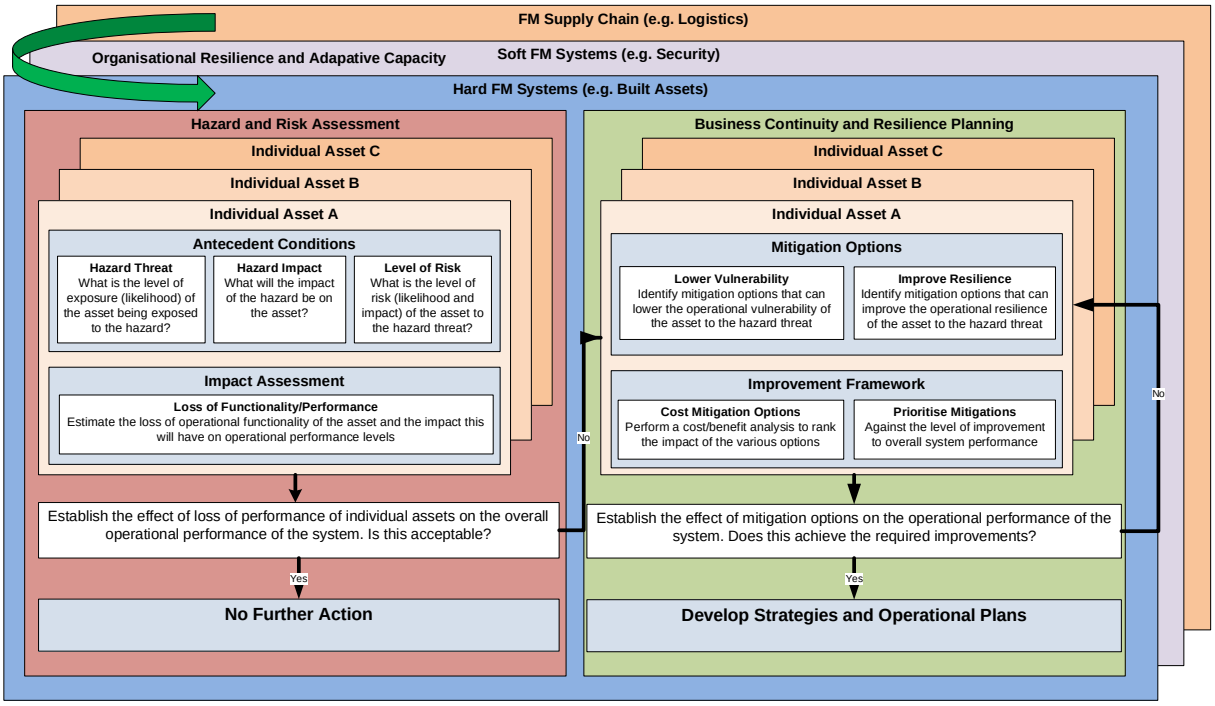

Figure 4 Organisational risk and resilience concept model from an FM perspective (adapted from Morga et. al., 2020)

It is likely that the hazard and risk assessment phase of the resilience improvement framework will generate a wide range of potential mitigation interventions, and these will need to be prioritised depending upon their costs and benefits to the organisation. Costs should include both the direct and indirect costs associated with the intervention, whilst the expected benefits should include reduced losses and if applicable, increased income (e.g., from more resilient ways of working during normal times) associated with the intervention. Those mitigation interventions that provide the greatest potential improvement to the organisation's operational performance can then be implemented through the organisation's strategic and operational plans (built asset management strategy, disaster management plans, emergency recovery plans and business continuity plans) which describe the actions that would be taken to prepare for, respond to and recover from a disaster event generated by the hazard threat as suggested in ISO 22316 (2017).

Finally, in applying the risk and resilience framework the facilities manager (and wider organisation management) needs to understand how the interaction/feedback between the different systems (complex adaptive system) affect each other to arrive at a holistic understanding of the resilience and adaptive capacity of their organisation to the hazard threat (Gibson and Tarrant 2011; Holling, 2001).

CONCLUSION

The TURNkey FWCR platform represents an attempt to draw together in a single location an earthquake forecasting/simulation, early warning and rapid response system. As part of the development of the system, the authors explored the potential impact that the TURNkey FWCR platform could have on organisational resilience to an earthquake. The potential impact was explored through a series of end-user use cases which identified a number of operational areas that overlap with the role of a facilities manager.

The authors have argued that business organisations should be considered as complex adaptive systems where resilience to disaster events is realised through a combination of the ability of their physical

systems, operational processes and organisational context to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner. Within this broad understanding of resilience, the authors have argued that the facilities manager's role needs to extend beyond a narrow consideration of the impact that a disaster event has on the ability of the organisation's physical assets to continue to support primary business function to encompass a wider understanding of the impact that the disaster event has on the ability of facility management operational and service processes to minimise operational disruption, increase speed of recovery and reduce losses. This paper has presented a simplified hierarchy model of organisational resilience derived from existing metric scorecards which helped inform discussions with potential TURNkey end-user stakeholders about the role that TURNkey could play in improving their resilience to earthquakes. The paper has presented preliminary results from these discussions that relate to the potential role that facilities managers could play in identifying mitigation interventions to reduce vulnerability, improve resilience and enhance adaptive capacity. To assist the facilities manager in this process the paper has outlined a resilience assessment and improvement framework that can act as a conceptual model at both the organisational (system) and operational (sub-system) levels.

In using the resilience assessment and improvement framework the facilities manager is required to consider the wider business and community context within which the organisation operates, and in particular to explore the impact that a disaster event could have on the organisation's hard (physical) and soft (socio-economic) systems and on the interactions between these systems that collectively supports the organisation's ability to absorb, adapt and recovery from a disaster event. However, to effectively address these issues facilities managers need adopt a hybrid view of resilience that encompasses engineering resilience, socio-ecological resilience and adaptive resilience.

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Principals and Suggestions for Sustainable Materials Management within Facility Management

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ABSTRACT

Background and aim – Many countries signed the Paris Agreement to mitigate global average temperature rise. In this context, Dutch government decided to realize a reduction of 50% using resources and raw materials in 2030. This paper explores how practice-based research into facility operations can contribute to this aim.
Methods / Methodology – Practice-based research which includes direct observations, desk research, and participatory action research.
Results – This explorative research presents principles and suggestions for facility managers and procurement managers on how they can embed sustainable materials management in the organisation and how to take control of waste. The proposed suggestions are derived from practice-based research and presented as topics of attention for facility professionals.
Originality – Within education of Dutch universities of applied sciences and daily professional facility practices, the phenomenon of materials management is underexposed. To contribute to the national and international climate objectives, (future) facility professionals need better support to reduce waste. Bachelor students were involved throughout this research. This approach gave refreshing insights into waste at the end of the supply chain (control separation units) that can improve informed decision-making at the beginning of the supply chain.
Practical or social implications – Facility management professionals have an important role to play in the mitigation of global average temperature rise, because of their leading role in procurement, service operations, and materials management. However, they struggle to find sustainable solutions. This paper seeks to inspire professionals with interventions that have proven effectiveness on the reduction of waste.
Type of paper – Short research paper.

KEYWORDS
Circularity, Facility Management, Materials Management, Procurement, Sustainability, Supply Chain Management.

INTRODUCTION
Climate change is a global emergency that requires immediate action: the Paris Agreement has been signed by many countries to tackle this emerging problem. In 2016 the Dutch government have launched a government-wide programme called “Nederland Circulair in 2050” to mitigate a quick transition towards a Circular Economy. The Dutch strategy is to realize a reduction of 50% of using primary resources and raw materials by 2030 as a stepping stone towards 2050 and to align the Netherlands with the ambitions of other countries (Rijksoverheid, 2016, p.7). With Dutch government

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playing an exemplary role towards businesses and consumers, they started the transition towards a Circular Economy by setting the goal to produce merely 35% residual waste within their business operations by the year 2020. Gradually it appeared harder to achieve these goals than initially suspected and many of these goals have yet to be accomplished (PBL, 2021). The delay in achieving these goals can (partially) be explained by the behaviour of the parties involved, the inconsistencies in ownership of these goals, and the lack of control on (sustainable) materials management within their business operations. A consequence is that the reduction of residual waste and the more efficient exploitation of materials remains a big challenge. Leaving Dutch government and facility professionals in particular with the question how they can change their business operations in such a way that they can meet the goals set for 2030 and onwards (Rijksoverheid, 2016).

With this paper we explore how facility operations can contribute to the Dutch strategy of 2030, with an explicit focus on sustainable materials management (SMM), and we investigate what is needed to incorporate SMM within organisations. In other words: *how can facility operations contribute to the sustainability goals of the Dutch government with the help of SMM?* For the purpose of this paper, we apply the definition of The Organization for Economic Cooperation and Development (OECD) in terms of SMM. SMM can be defined as "an approach to promote sustainable materials use, integrating actions targeted at reducing negative environmental impacts and preserving natural capital throughout the life-cycle of materials, taking into account economic efficiency and social equity" (Khorasanizadeh, 2018, p.18-19). Facility operations are focused on supporting the primary processes within organisations (Mobach, 2015, p.1). A facility department engages in facility services (cleaning, catering), housing (construction, maintenance), and procurement (tender, contract management). With the current pre-supposed lack of control on (sustainable) materials management within business operations and the potential of proper SMM with regards to reductions, facility professionals can become vital players in achieving the goals set by the Dutch government.

This paper is part of a two-year practice related research project which focuses on creating an action protocol for facility professionals to empower them to optimize the circularity of their business operations. The research project is funded by Regieorgaan SIA in cooperation with three consortium partners: Custodial Institutions Agency, FM Haaglanden, and The Hague University of Applied Sciences (THUAS), all in the Netherlands. This paper is organized in four sections, i) the theoretical framework, ii) the research methodology, iii) results and findings (case study THUAS), and iv) conclusion.

THEORETICAL FRAMEWORK

Before exploring the research methodology and the results we need to further elaborate on two questions: 1) How can facility operations contribute to the sustainability goals of the Dutch government? 2) Why use a SMM approach to enable facility operations in meeting these goals?

Sustainable Facility Management

In essence and in the sense of NEN 15221-1, Facility Management (FM) consists of two main tasks: 1) to deliver services which support and sustain the operations and activities of organisations and their staff and 2) to manage resources, work environments, and support services (Chotipanich, 2004, p.365, Pelzeter, 2013, p.1). Currently, with an urgent demand for more sustainable activities, new emerging technologies and following the ISO 41001 requirements, FM can transform into sustainable facility management (SFM) (Alfalah, 2020, p.1). SFM may be regarded as a new perspective which offers FM with vast opportunities to reduce the negative impact of organisations and staff on the environment. According to Alfalah (2020, p.1), SFM also includes materials management and the use of sustainable materials. As the goals set by the Dutch government are primarily focused on reducing primary

resources and raw materials within their business operations, SFM is pre-eminently suitable for meeting these goals. Hence, with this case study we investigate if SFM can be applied within THUAS.

Sustainable Material Management

The basic principles of SMM are: i) use materials in the most productive way with an emphasis on using less, ii) reduce toxic chemicals and environmental impact throughout the material life cycle and iii) assure we have sufficient resources to meet today's needs and those of the future (EPA, 2022). With SMM one can incorporate a systematic approach to promote sustainable materials usage and reduce the usage of (raw) materials. By gaining control of material flows and integrating actions targeted at reducing negative environmental impacts and preserving natural capital throughout the life-cycle of materials, more sustainable materials can be used. All whilst taking into account economic efficiency and social equity (Khorasanizadeh, 2018, p.18-19). As facility managers need more and more information in order to make capable decisions and manage their business (Twynstra Gudde, 2019) and material flows, SMM is an ideal method to enable SFM in meeting their information needs. Which is particularly helpful with information becoming such a vital factor within the business process (Steinau, 2017, p.2681). Therefore, in this study we explored the applicability and relevance of SMM within THUAS by investigating the current situation at THUAS through conducting interviews with different stakeholders. Additionally, we deviated from the general acknowledged path of big digitalized data and have embraced counting and weighing waste to explore its relevance as an important source of information for the effectiveness of procurement, service operations, and materials management.

For this study we investigated the applicability of SFM and SMM within THUAS by looking at the current situation within our case study. we studied how the principles of SFM and SMM are currently incorporated within the business operations of THUAS and give suggestions on how to embed SFM and SMM even further if needed. With the priority on: i) reducing the negative impact on the environment by ii) using materials in the most productive way and using less whilst iii) assuring we have sufficient materials to meet today's needs and those of the future.

RESEARCH METHODOLOGY

The current explorative study is a practice-based study, meaning we aim for positive impact on society in general (Candy, 2006, p.3) and professional practice in particular. In this study, we focus on reducing the use of primary resources and raw materials and on waste reduction. We used a mixed methods design in which we merged quantitative and qualitative data to provide a comprehensive analysis of the research question. Both types of data were collected at roughly the same time (Creswell, 2014, p.268). The majority of the research was conducted in cooperation with Bachelor students of different programs such as facility management, industrial design engineering, and information technology.

With our experiments we focused primarily on the supply chain: from procurement until waste production. We have investigated the following topics of the supply chain: i) the initial phase of procurement where we examined the role of contract and supplier management and how the reduction of various materials is incorporated within contracts; ii) the operational phase, where we studied the data infrastructure for managing material flows, and the cleaning process of collaborating partners; iii) the end of the supply chain where we studied the waste disposal by conducting control separation experiments on the different waste flows.

As this involves a process with many stakeholders, we implemented different types of experiments and data collection tools to get the most comprehensive result. First we collected data through interviewing different stakeholders. The interviews can be categorized in: 1) interviews with procurement- and contract managers regarding the initial phase of procurement, in total the students interviewed 13

respondents; 2) interviews with facility professionals regarding the operational phase, in particular to establish whether or not there is a data infrastructure in place to manage the material flows. In total the students interviewed 23 respondents; 3) interviews with the waste collector company, in total the students interviewed 3 respondents. All interviews were conducted using a semi-structured approach and were analyzed using open and axial data coding. Secondly, we collected data by conducting control separation experiments. During two periods we collected the waste which was produced within two locations of THUAS and manually post separated the waste into different fractions. We collected the waste during the period of i) the 18th of May until 15th of June '21 at the school of facility management and ii) during the 28th of June until the 2th of July '21 at the cafeteria area of THUAS. The waste has been fully and manually examined and separated. The reason for conducting this final experiment is because we expect that many organisations, our case study included, use this information as a reference point for managing and arranging their business operations.

RESULTS

As SFM and SMM requires an integrated approach we have collected data throughout the entire supply chain with regards to materials management. By doing so, we investigated the entire material cycle. We started with the waste production at THUAS by employees and students, and from there we investigated the entire circle. Starting with the procurement phase.

Procurement phase

In our case study, procurement- and contract managers reported an absence of a clear contract policy with regards to sustainable guidelines for procurement. Secondly, respondents stated that there are a large number of employees who are authorized to place orders. In addition, the responsibility of sustainable procurement is not clearly assigned, leading to an inconsistency in ownership when it comes to sustainable procurement. Furthermore, we determined that there is no suitable data infrastructure in place to manage the different material flows. Which appears to be the case throughout the entire supply chain. As a base principle of SMM is to use less materials and use materials in the most productive way, a clear contract policy with sustainable guidelines, a product owner of the policy, and a suitable data infrastructure are essential in order to incorporate SMM properly.

Operational phase

Respondents reported that most of the material flows are unregistered during the operational phase. Which results in a business process which was based upon routines and not upon using materials and resources in the most productive way. It starts at the arrival of products at the expedition area all the way up to the waste production. For example, when suppliers deliver their products at the expedition area, in most cases with additional packaging, there is an absence of appropriate registration of the materials. Another example is at the moment a product turns into waste and ends up in trash bins. Respondents mention that trash bins are often half-empty when collected due to pre-fixed schedules. With a lack of control on the fill level and content of the trash bins, it is difficult to deviate from the current work routine and start using materials more productively, whilst at the same time, taking in account the different needs of the occupants, in line with the principles of SFM and SMM. By implementing a proper data infrastructure to monitor the different material flows, this can be by monitoring filling levels of trash bins or by registering additional packaging at the expedition area, the business process can be optimized to use less materials and eventually reduce the negative impact on the environment.

End phase

During the end phase we investigated the data which is currently used as a basis for making management decisions with regards to material management, waste creation, and disposal. In the

operational phase we established that there are no proper data registrations during the operational phase. By interviewing respondents, we established that facility professionals use data of their waste collector company to monitor the different (raw) material flows which run through their business operations. Waste collector companies hand over monthly specified overviews of the amount of collected waste. FM receives overviews of the different waste flows, which are sub-divided into, among others: i) plastic, metal, and drink-cartons (PMD), ii) paper, iii) organic waste, iv) coffee cups, and v) residual waste. This division is used by facility professionals to monitor their current sustainable objectives and to adjust, if deemed necessary.

We conducted control separation experiments to validate this data stream. By doing so , we found discrepancy between the overview provided by the waste collector company and the actual situation. By manually separating the different waste fractions, we found that all waste fractions were polluted. None of them fully contained the materials that belonged to that particular waste stream. For example, during the first period of ex-post separating waste, we established that only 60 percent of the PMD could be classified as PMD. With SFM and SMM it's important to have a validated data infrastructure to gain the most optimal result. As facility professionals use this data flow as primary source to monitor their (raw) material flows, it's important to assure the accuracy of the data stream.

CONCLUSIONS

With this study we have investigated how facility operations, and SFM and SMM in particular, can contribute to the sustainability goals set by the Dutch government for 2030. As it is the Dutch strategy to realize a reduction of 50% of the use of raw materials in 2030, SFM and SMM are an organizational solution in meeting these goals. SFM focusses on reducing the use of materials and its impact on the environment via waste reduction and the use of more sustainable materials. Whereas SMM focusses on using materials in the most productive way and reducing the use of materials in general. SMM is highly needed in order the meet the goals set by the Dutch government. Furthermore, with SFM and SMM we assure that the focus isn't merely on reducing the usage of materials. But that we also ensure that we have sufficient materials to meet today's needs and those of the future. By doing so, and by investigating all phases of the supply chain, procurement phase, operation phase, and end phase, we can give the following suggestions to (re)assure a proper implementation of a SFM and SMM policy: i) in the procurement phase it is important to establish a clear contract policy focused on sustainability including a policy owner. ii) In the operations phase, and the entire supply chain in general, is important to have a proper data infrastructure in which one can register and monitor the materials. By doing so, the business process can be optimized to use less materials. And iii) finally from the end phase we can conclude that it is important to work with validated data. Especially in a situation where the data registration is limited. To summarize, for SFM and SMM to assist organizations in meeting the goals of the Dutch government, it is important to have a clear contract policy focused on sustainability embedded throughout the entire business operations and to have a proper data infrastructure for managing and validating materials flows.

DISCUSSION AND LIMITATIONS

In this current case study, most of the data is gathered via semi-structured interviews with experts and stakeholders. However, this case study is part of a larger study into SMM in order to develop a guideline for SFM. The emergent question is how SMM and SFM should be incorporated in ISO 41001 and NEN 15221. We believe that a standardized focus via norms will accelerate SMM and SFM to achieve the highly needed cut of raw materials for 2030 and a full circular business operation by 2050. This question can be addressed in further research via inter alia surveys with professionals and cross referencing with other similar knowledge institutes and studies. Time is running out!

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Digital trends in FM - Awareness gap between end users and service providers

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ABSTRACT

Background and aim – Emerging digital technologies are defining the future of FM. In this process of transformation, stakeholders involved must ensure balanced development. This paper presents the results of an extensive survey on the perception of digital trends in FM. Purpose of the survey was to identify possible awareness gaps between end users and service providers regarding the significance of different emerging digital technologies.
Methods / Methodology – The nature of the research is explorative. Departing from an intensive literature review and investigation about key digital trends for FM, an online survey was designed and conducted, to collect qualitative and quantitative data from practice and academia. The survey drew nearly 4.000 responses from 104 countries. Industry data is segmented between service providers and end users. Based on an extensive database and selected indicators/indexes, a systematic analysis of individual technologies and stakeholder profiles was conducted.
Results – Results provide data to illustrate differences in perception between end users and service providers for 25 selected technologies, identified on literature review. Representative indicators have been developed and applied to analyse the level of digital awareness, digital interest, use of technologies, and level of maturity of these technologies.
Originality – The paper offers a comprehensive international analysis on digital trends in FM and gaps in awareness, usage, and interest between end users and service providers.
Practical or social implications – Digitalisation in Facility Management industry has a very important development potential for business, and knowledge and awareness about digitalization trends is needed to foster its implementation and improve business opportunities.
Type of paper – Research paper

KEYWORDS
Facility Management, Digital Transformation, Digital Technologies, Service Providers, End Users.

INTRODUCTION
Digital transformation (DT) refers to "*the profound changes that are taking place in the economy and society as a result of the uptake and integration of digital technologies in every aspect of human life*" (Desruelle, 2019). Digital technologies have become the foundation of all modern innovative economic and social systems. Digital technologies are affecting all sectors of the economy and society. Among these are the outsourced Facility Services industry, which is the third-biggest industry regarding of employment in the EU (Stopajnik/Redlein, 2017). The consequences of DT will therefore affect almost

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all European sectors and is expected to be a key driver for successful European economy for several years to come. Digital transformation is furthermore happening at increasing speed and there is an urgent need to be able to identify and address the current and future challenges for the economy and society, evaluating the impact and providing the required training and education.

The "PropTech Global Trends 2020 Annual Barometer" (Luque, 2021) defines 12 sub-sector categories relating to facility management, real estate, property management etc., identifying 1724 technology companies in the sector from 64 countries. Around 60% of them are located in the US (990), followed by Europe with 153 companies. 128 of these 1724 technology companies and 386 investors are focused on Facility Management (services) from 20 different countries. Total investment between 2000 and 2019 for the Facility Management sub-sector amounted to 0.32 billion US $, just 0.38% of the 84.4 $ billion invested in the property technology sector. In this sub-sector, the Swedish company LANDIS+GYR leads the investment in this period with $0.27 billion, followed by the Californian companies C3 and Trilliant.

Beyond the economic potential that these figures represent, there is a general recognition in the Facility Management sector that digitized facility service provision is largely able to generate added value as it supports the recipient to implement optimized processes as well (Lünendonk, 2018; Redlein and Grasl, 2018).There is a unanimous consensus in academia and a very broad consensus in the FM industry that the future necessarily lies in incorporating the process of digitalisation into the FM sector, and to this end, professional training and education must become a key driver for the successful implementation of these technologies in the medium term.

However, the current discussion in practice, as well as in academia, seems to narrow digitalisation in FM to one specific Technology – Building Information Modelling. Literature is full of various BIM definitions and focussing on its potentials for the Life Cycle Data Management for buildings and the evidence for productivity improvements through BIM (Ashworth, 2020; Dixit et al., 2019; Matarneh et. al., 2019; Ozorhon and Karadag, 2017; Tezel and Gritli, 2021; Tezel, Alatli and Gritli, 2021).

This paper reports on the results of an international study, conducted during an EU funded Erasmus+ strategic partnership project, called FMgoesDIGI. The purpose of the project is to identify the emerging digital trends that may have the greatest impact for the FM industry and to study the knowledge and perception of digital technologies among market actors. The study not only revealed the most important digital technologies in FM per target group, but also awareness gaps between the target groups.

LITERATURE STUDY

Digitalisation has been identified as one of the most important trends changing society and business. Digitalisation causes changes for businesses through the introduction of digital technologies in the organisation or operating (Paraviainen et al., 2017). Norton, Shroff and Edwards (2020) determined that organisations, which run digital services through their enterprise system, could achieve significant and long-term benefits, as optimising their customer-facing digital services is enhanced as FM-activities have a high significance for process optimisation (Chotipanich, 2004).

Therefore, the application of new technologies, like IoT, AI and ML becomes an important factor (Selinger et al., 2013). Recent studies have shown that digitalised facility services are highly capable of generating added value as they support the recipient in implementing optimised processes as well (Lünendonk, 2018; Redlein and Grasl, 2018). Ehrenberg (2018) noted that advances in mobile devices, the Internet of Things (IoT), artificial intelligence (AI) and smart building technologies are creating new opportunities for managing FM processes and workplaces. About technological progress in machine

learning, mobile robotics, they determined the probability of computerisation for over 700 occupations. Furthermore, the study of Stopajnik et al. 2017 shows the impact of digitalisation on the Facility Service Industry. They estimated that typical FS activities (Österreichisches Norminstitut 2007) are at very high risk, e.g., installation, maintenance, repair work has a 50 % probability to be automatised, janitors and cleaners have a probability of 66 %, and first-line supervisors of housekeeping and janitorial workers show a probability of 94 % to be automatised (Peneder, 2016).

Hüttenmeyer and Born (2019) concluded that efficiency in the use of real estate can be raised, as digital facility services processes, can be managed more flexibly and real estate can be developed more strategically. They also determined employees´ preparedness to change is an essential prerequisite for a successful transformation. Crawford (2017) and Lünendonk (2020) come to a similar conclusion. Before a digital transformation can take place, a company must be ready to change. The focus for a successful digital transformation is on the team and the workforce. They need to change their work habits and communication patterns with the support of the whole organisation if they want to exploit the potential power of digital transformation completely.

Uhl (2019) recommends that training and further education should be adapted to the current state of the art in the shortest possible time. Stanley (2020) also notes that the time for 'wait and see' is over for new technologies such as AI, machine learning and distributed digital ledgers.

RESEARCH METHODOLOGY

The nature of the research of the Erasmus+ FMgoesDigi project is explorative and follows a three-phase design (Figure 1). First phase, based on an intensive literature review, investigation of digital trends and existing technologies, and market exploration, we developed a map of technologies needed to foster digital transformation in the Facility management Industry. To explore the awareness and usage of these technologies, a worldwide online survey was designed, to collect qualitative and quantitative data from different target groups in the industry and in the Academia. In the second phase, the survey was disseminated internationally via social networks and through international and national FM association to their memberships. In the third phase, critical analysis, expert workshops discussions about technologies selection, knowledge and skills needed by professors, and to be implemented in students' curricula, innovative teaching methods and key drivers for successful students' learning, and conclusions gathered in different reports and guides will be performed.

Figure 1 Main approach in FMgoesDigi research.

The specific methodology for the purpose of this paper derives from the analysis of the survey designed for the FMgoesDigi project, which is much more ambitious in scope, and from which we draw the analysis for this paper.

The survey was designed to be widely disseminated among practitioners, addressing different profiles to be found in practice as well as in academia. Although it was intended to be answered in 3 minutes,

the qualitative information collected had to enable a quantitative analysis that would allow for the desired scope for cross-analysis data.

From extensive literature review, **25 different technologies** were selected for the survey. For the **End Users-Client Company** profiles, three sub-profiles have been considered, as we wanted to observe whether there were differences in perception between them: Director/Head of FM; Area Specialist/Coordinator; and Support/Assistant. For the **Service providers** the three sub-profiles considered are Director/Area Manager, Implant/In-house in client, and Operational Personnel. For the **Academia**, four different profiles have been selected: Dean/Program Director; Lecturer; Researcher; Student.

Technology	Comments
3D Scanning	Interior, spaces, buildings, etc.
3D Printing	Parts, consumables, etc.
5G Network	Smart Cities, etc.
Advance Metering Infrastructure	Real-time data acquisition
Artificial Reality	Augmented, virtual and mixed reality
Building Information modelling	Networking 3D-software
Biometrics Systems	Security, access, location, etc.
Blockchain based tools	Contracts, helpdesk, etc.
Building Automatization Systems	IoT, sensors, actuators, etc.
Building Management Systems	Monitoring, performance, etc.
Business Intelligence tools	To process large/different data
Computer Aided tools	IWMS, CAM, EMIS, etc.
Digital Twins models	Replicating physical assets
Drones & microdrones	For exterior and interior use
Generative Design	Iterative exploration process
Geographic Information systems	Geo localization
Holograms	Virtual display or assistance
Human Augmentation	Exo Skeletons, wearables, etc.
Indoor Navigation Systems	Beacons for GPS inside buildings, etc.
Laser Imaging Detection and Ranging	Mapping, measuring, etc.
Applications for Mobile Devices	Support, reporting, etc.
Remote Maintenance Services	Tele maintenance, etc.
Radio Frequency Identification	Tags or control systems
Robots	Cleaning, transport, security, etc.
Virtual Assistants	Reception, guidance, etc.

Table 1 Technologies covered in the survey

For each of the 25 selected technologies the key question was: "*What is your relationship with the following technologies in your day-to-day work*?" (This was for professionals. For Academia it was formulated as "*What is your position regarding the following technologies to become FM research themes?* "). Available answers were qualitative with similar response scales, adjusted to each profile. For professionals they were *I am using it; Sporadic use; Exploring to use; Heard but not relevant; Would like to know more;* and *Never Heard.*

The survey was launched worldwide through professional associations in different countries and through social networks with a very selective target of professionals and members of academia working in the Facility Management discipline. The survey was answered by 3934 respondents, of which 2925 were European. The distribution of the responses is shown in the following graphs, summarising both the overall responses and the responses from European respondents:

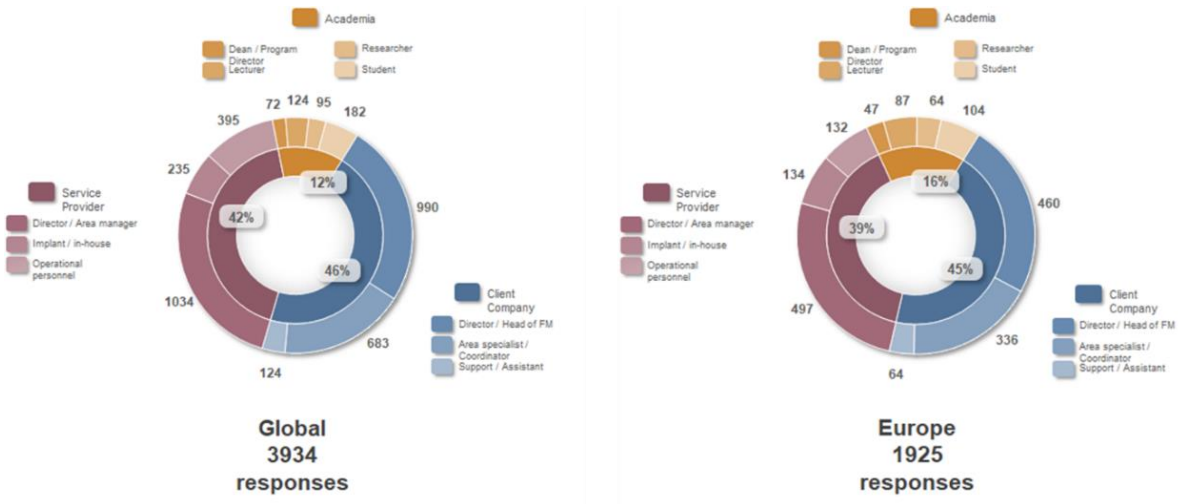

Figure 2 Responses distribution per profiles.

We have gathered answers from 104 countries worldwide, 34 of them from Europe. Only Africa is under-represented. The distribution of respondents per countries and continents has been as follows:

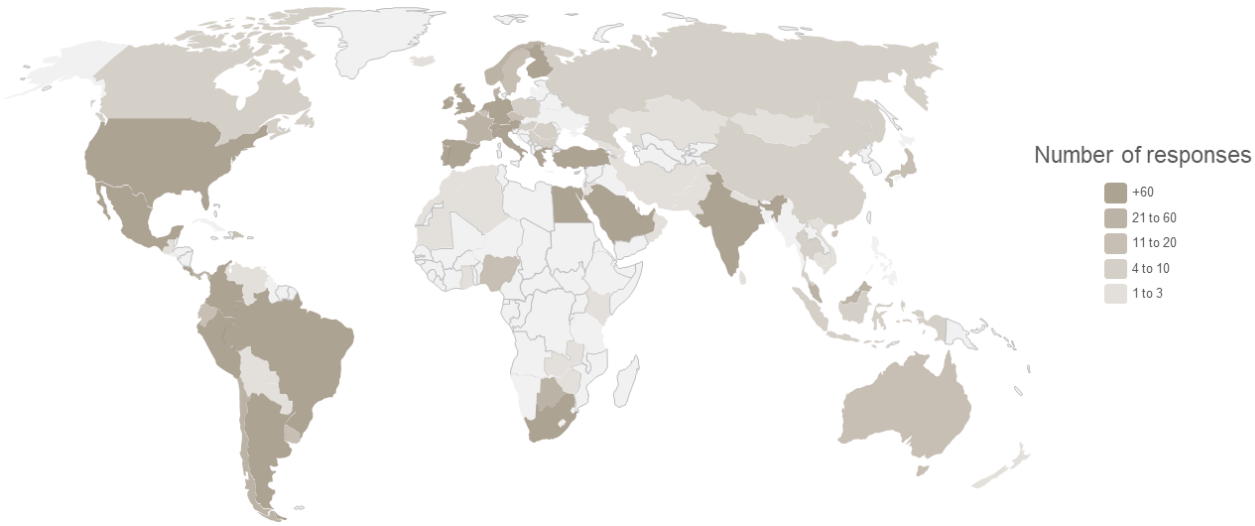

Figure 3 Responses distribution per countries

Although there are no major differences in the conclusions, to stick to the assessment of the European experience, data from respondents in Europe have been analysed with the following 4-step methodology.

STEPS 1&2 RESULTS AND DISCUSSIONS

Step 1 with the analysis of raw data, extensive and varied information were extracted, allowing not only the characterization of each of the 25 technologies for every profile, but also the comparative analysis between technologies. Thus, enabling the identification of the most implemented/applied technologies, or those that are considered to have the greatest potential. It will also enable a better understanding of which technologies and trends are worth "investing in" from a professional point of view (Figure 5).

By analysing all the technologies as a whole, not only do you have the 25 technologies at a glance, but it is also possible to discover with this representation system the profile of awareness and use of the technologies for each one of the 10 stakeholder profiles considered.

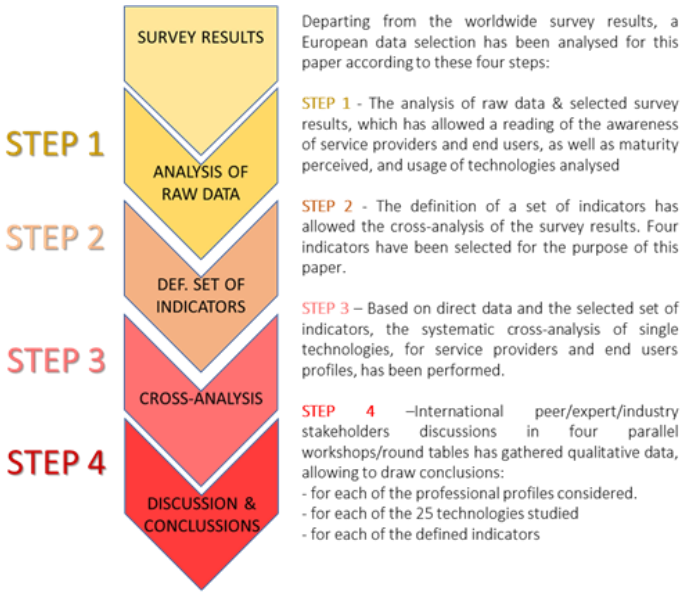

Figure 4 The four steps in the analysis

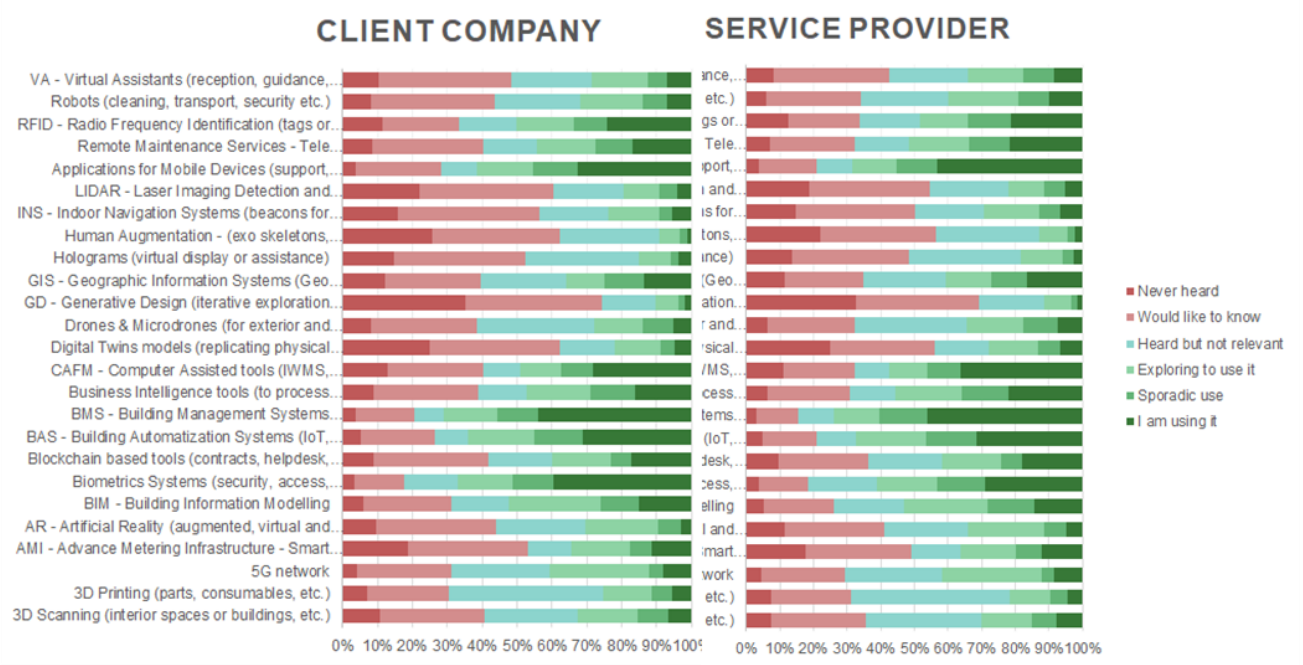

Figure 5 Digital technologies perception for professionals.

Some of the conclusions discussed from raw data analysis are:

- More mature technologies for professionals are Building Management Systems, Biometrics Systems, Building Automatization Systems, CAFM, applications for mobile devices, and Radio Frequency identification. Most promising technologies for FM professionals are the most mature plus 3D printing, 5G, GIS, Drones, Business intelligence tools.
- The Academia 's perception varies slightly when including among the more mature technologies such as BIM, GIS, and Biometrics systems. Most promising technologies also include 3D scanning, Drones, Business intelligence tools, Indoor navigation systems, remote maintenance systems, robots, virtual assistance, artificial reality.
- In general, a reasonable proportionality is observed between all professionals' profiles and technologies, although if we compare them with the perception of the Academia (professors and researchers), we observe a greater knowledge and awareness of usefulness among them, somewhat less among professionals, and even less among students.
- In addition to the differences observed between practitioners and academia in the perception of technologies such as BIM (figure 6), important differences are observed in the potential perception of technologies such as 3D Printing among professors and researchers (98%), compared to professionals (70%) and students (52%). 3D scanning among professors and researchers (97%), compared to professionals (63%) and students (56%). Or robots among professors and researchers (97%), compared to professionals (56%) and students (68%).

In Step 2 the design of a set of 14 indicators for a cross-analysis of the survey results, going further than the simple raw data analysis. In a first approach, two kinds of indicators have been defined:

Indicators to characterise each of the professional profiles and stakeholders in a way that allows a detailed understanding of the singularities of each one of the profiles, assessing aspects such as the level of awareness, interest in digital technologies, degree of use, level of anticipation, or the degree of proactivity in the face of new challenges.

Indicators to characterise more precisely the potential of each one of the technologies and enabling their comparison and ranking as well. Indicators will measure the interest in each of the technologies, their practical use, the level of anticipation they provoke, the level of maturity for

the market, or the perception of maturity of researchers or academia, etc., as well as the level of educational coverage.

For the purpose of this study, the four indicators that fit best for the comparative analysis of the profiles under study have been selected. They are: the level of digital awareness (Rate of Digital Unawareness – RDU/Rate of Digital Awareness - RDA); digital interest (FM-Industry Digital Interest - IDI); use of technologies (FM-Digital Usage of Technology - DUT); and perceived maturity level of these technologies (Technology Maturity for FM Industry - TMI).

STEPS 3&4 RESULTS AND DISCUSSIONS

In step 3 a systematic cross-analysis of single technologies (for each one of the 25 selected), stakeholder profiles (for each of the 10 professional profiles considered), and per countries or geographical areas, is performed, generating summary graphs to be analysed.

In Step 4 we have performed the cross-analysis and indicators results through **four international workshops and round tables** with peer/expert/industry/stakeholder discussions of processed information to draw conclusions. For the purposes of this paper, it was originally planned two international face-to-face workshops, one for the analysis of raw data and indicators selection, and the other for the results of the data and indicators cross-analysis. Due to the COVID scenario in which it has been developed, each of them was articulated in four local virtual workshops (Madrid-Academy, Madrid-Professionals, Helsinki, and Stuttgart) and a final joint session of conclusions. A total of 25-30 participants with very complementary profiles helped us in each of the two workshops held.

The following is a brief description of the indicators analysed to assess the European FM market and the differences in perception between end users (client company) and service providers, as well as some of the conclusions discussed with respect to some of the graphs generated in this paper.

RDA/RDU - Rate of FM digital awareness / unawareness per stakeholder

It is an indicator to measure the percentage of responders that do /or do not know the technology for each stakeholder. It is calculated with a weighted average according to the following formula:
*∑ (80% * sample Never heard +20% *sample would like to know/it's not relevant/Not valid for FM)/(25*sample).*

It has been calculated for each of the 10 stakeholder profiles, and for each of the 25 technologies studied. For obvious reasons of space, we only reproduce in this paper the global results for end users and client companies.

The European results (Figure 6) show a slightly higher awareness of directors to intermediate managers and assistants, and a higher average digital recognition for service providers (89,11%) than for client companies (86,01%). The lowest digital awareness ratio is for students with an RDA of 85.34%, and the highest is for Academics with 93.38%.

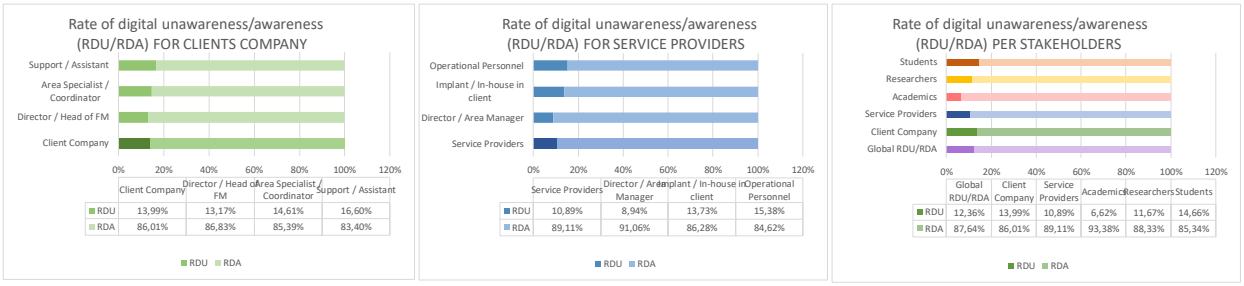

Figure 6 - European RDA/RDU - Rate of FM digital awareness / unawareness.

IDI - FM-Industry Digital Interest

It is an indicator to measure the interest/potential that is attributed to the technology within the industry representatives. It is calculated with a weighted average according to the following formula:

*∑ (50% using + 30% sporadic + 20% exploring) /25*sample*

As always, it has been calculated for each of the stakeholder profiles, and for each of the 25 technologies studied. We only reproduce in this paper the global results for end users and client companies.

The European results (Figure 7) show a higher digital interest for Directors than intermediate managers and assistants, and a higher digital interest for service providers (15,72%) than for end users-client companies (13,13%).

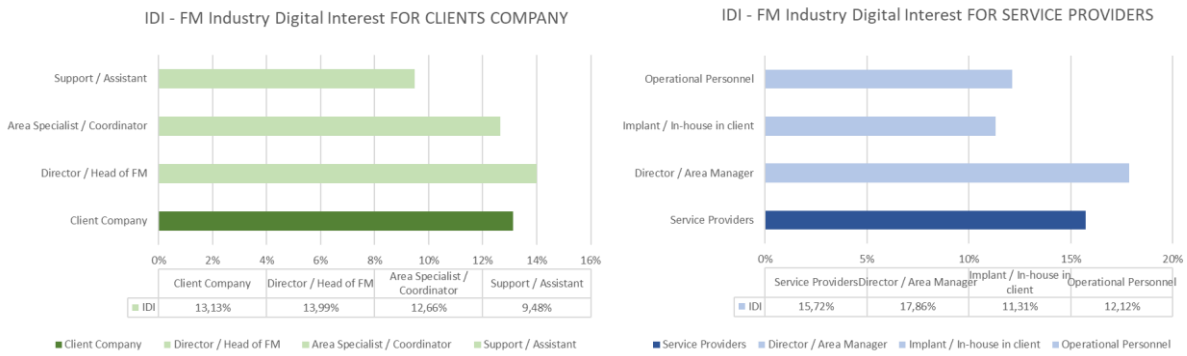

Figure 7 - European IDI - FM-Industry Digital Interest.

DUT – FM Digital Usage of Technology

It is an indicator to measure the technologies that are already in use within the industry representatives. It is calculated with a weighted average according to the following formula:

∑ % (100% using + 20% sporadic) or ∑ % working on or ∑ % included / (technology sample)

It has been calculated for each of the stakeholder profiles, and for each of the 25 technologies studied, just including the last one in this paper.

Many conclusions can be drawn from the analysis of this indicator DUT for Europe (Figure 8), both, in its comparison between the two professional profiles, and the results for all technologies and different stakeholders. To point out some of the most significant ones discussed in the workshops:

- From the analysis of DU indicator (FM digital usage per profile) (not included in this paper but linked to DUT analysis), once again, service providers (DU 19.46%) are more likely to use digital technologies than end users (client company 15.74%). There is also greater digital use among directors and heads of FM than among middle management and operational staff.
- In the comparison of digital use among the different stakeholders analysed, the case of academics stands out, who report a use of digital technologies in FM of 27.50%, significantly higher than end users (DU 15,74%).
- The most used digital technologies for the FM industry, both service providers and end users are BMS, APPs, CAFM, and BAS, observing in any case significant differences between the perceptions of use of service providers, usually with a significantly higher DUT indicator than end users. This gap is especially more significant in technologies such as APPs, CAFM, BAS, Remote Maintenance Services, Business intelligence tools, AMI, VA, or LIDAR.
- It is very significant in addition to the higher overall perception of digital use in FM among professors and heads of FM programs, which in some of the technologies is twice as high as the

industry indicator. For example, BIM is perceived by academics with a DUT of 56.82% compared to 31.7% for researchers, 20.55% for service providers, or 20.07% for end users.

– Significant gaps (up to threefold) in the perceived higher use of FM technologies among academics and professionals are also observed in technologies such as GIS, Robots, 3D Scanning, Drones & Microdrones, INS, Digital Twins, VA, AR, LIDAR, 3D Printing, Generative Design, Holograms, or Human Augmentation. Only BMS, APPs, CAFM, Remote Maintenance Services, Business Intelligent tools, and AMIs reverse the trend with a slightly higher DUT index from professionals.

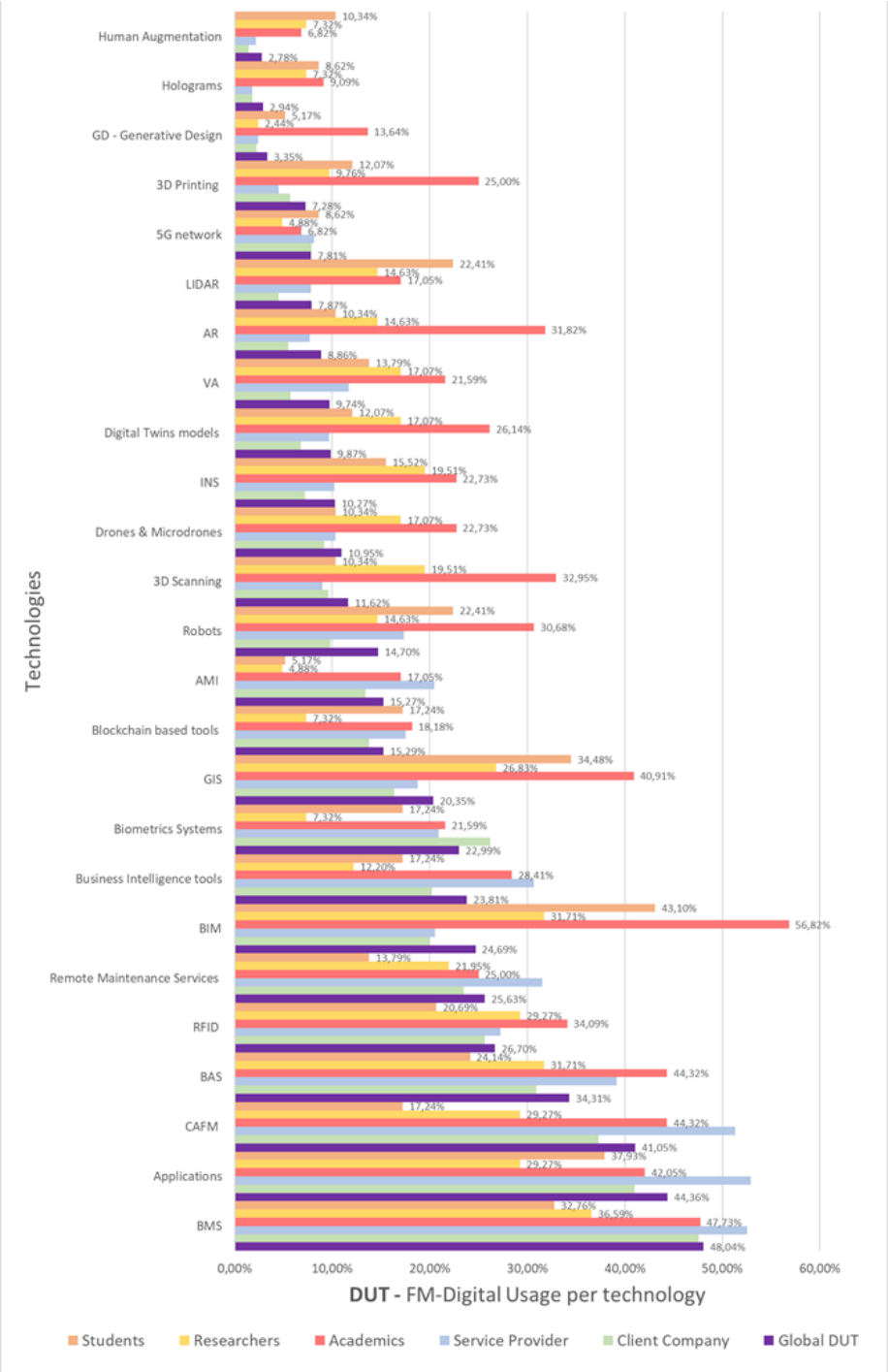

Figure 8- European DUT - FM- Digital Usage of Technology

TMI - Technology Maturity for FM Industry

It is an indicator to measure the maturity of the technology in FM Industry, linked to the usage perception from companies & providers. It is calculated with a weighted average according to the following formula:

50% using it + 30% sporadic use + 20% exploring to use)/(technology sample)

It has been calculated for each of the professional profiles, and for each of the 25 technologies studied. In this paper we are going just to compare this TMI index with similar indexes as TMA - Technology maturity for Academia, TMR - Technology maturity for Researchers, and TRI - Technology Readiness Index that is an indicator to measure the readiness of the technology for the market, and it is calculated as a weighted average according to the following formula:

TRI = 70% TMI+10% TMR+ 20% TMA

The results obtained in Europe (Figure 9) show a perception of maturity of digital technologies for FM that is higher among managers than among employees, and higher among service providers than among end users, as with the IDI indicator. The TMI indicator of maturity of the technology in FM Industry is 14.14%, lower than the Technology Readiness Index (TRI of 17.60%), or the maturity perceptions of researchers (TMR of 22.38%), or academics (TMA of 27.32%).

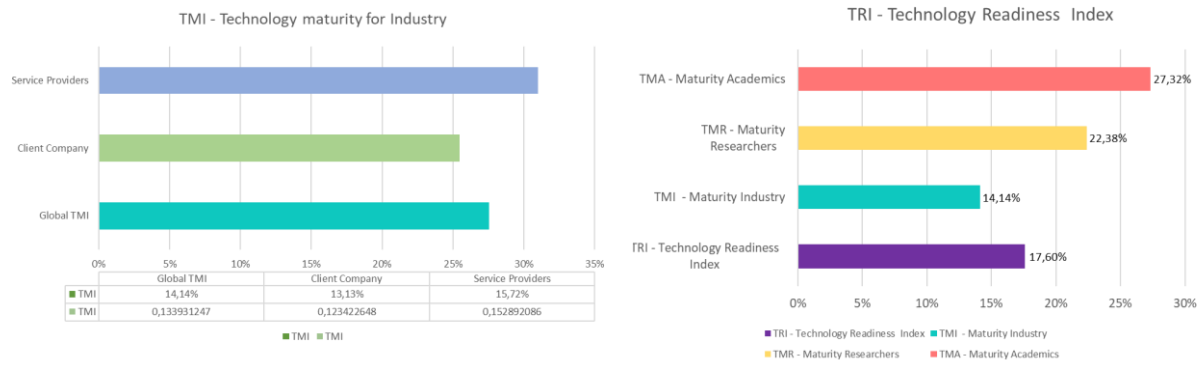

Figure 9 - European RDA/RDU - Rate of FM digital awareness / unawareness.

The perception of all these indicators for each one of the selected technologies are similar (with nuances) to those obtained with the DUT indicator, so we can extend main discussions and conclusions.

FINAL CONCLUSIONS

From the literature and from our own personal experience, we are convinced that digitalisation in the Facility Management industry, as in most professional sectors, has a very important development potential for business. It is necessary to make any effort to disseminate its potential, to generate and to spread knowledge of the technologies so that they can be applied in a way that improves business opportunities. The role of universities is critical for a wide awareness and technologies.

With the help of the experts who have participated in the successive workshops, we have discussed figures and graphs from the survey raw data and indicators cross-analysis Many new findings not reported till now in the scientific literature have emerged regarding the perception of the different stakeholders and profiles, as well as the different technologies. To outline some general conclusions of the data analysed in this paper, it is worth highlighting the following findings:

1. The methodology followed by literature review, study of the market, analysis of the global survey, and the two international workshops held (each one with 4 locals+1 common shared session), has allowed us to identify in which technologies we must train our students. They are Digital Twins&Building

Information Modelling, Business intelligence tools, Building Automation Systems&Building Management Systems, and Reality capture tools (3D scanners, drones, IoT). Some of these coincide with those identified in the literature review (BIM or BMS for instance). Others less so.

Two other later workshops with a similar structure held in recent months have enabled us to identify what knowledge and skills they should acquire, deepening into the top innovative teaching methodologies that are best suited for successful professional training on these technologies.

2. From the comparison of perception and awareness between end users and service providers, it is worth highlighting the greater use and maturity perception of FM digital technologies by service providers, as well as the greater awareness of Directors and heads of FM departments regarding employees.

3. Finally, it is worth noting that the main "gap" among stakeholders is observed between academics and professionals, with differences in the perception of maturity and use of technologies in general. Technologies such as BIM, GIS, Robots, 3D Scanning, Drones&Microdrones, INS, Digital Twins, VA, AR, LIDAR, 3D Printing, Generative Design, Holograms, or Human Augmentation, are perceived to be more mature double or even triple in some cases. This perception of higher technology maturity in academia is probably due to the university's own DNA, more inclined to innovation. Industry is more conservative and takes fewer risks. Companies are interested in short-term (economic) results and leave the exploration of new technologies to academia and researchers. They only enter into innovation when the technology is sufficiently mature, with less risk to the business. In this sense, their assessment is much more objective and realistic.

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Beyond Satisfaction – Internal Service Barometer for measuring customer satisfaction

Torben Bernhold[1], Niklas Wiesweg[2], Thomas Löhmer[3], and Susanne Lill[4]

ABSTRACT

Background and aim – The objective and research question is to measure the satisfaction of internal customers with various real estate services in the context of the operational utilization phase.
Methods / Methodology – Methodologically, the study is based on the context-related application and use of the structural equation model for measuring internal customer satisfaction. In this context, a questionnaire-based study was carried out at KPMG Germany with over 2,800 respondents and the respective satisfaction levels along various service lines were measured and evaluated.
Results –The results suggest a significant and clear causal relationship between internal service quality and internal customer satisfaction. The service quality - regardless of the service line considered in the real estate service area - is also significantly responsible for the internal recommendation rate. The results are thus able to measure the internal customer satisfaction of CREM services in all companies and internal organizational units and to include it as an integral component in the description and measurement of added value. The potential uses in the future are complex and range from the creation of a benchmark to the use within the framework of service level agreements and the linking of internal and external customer satisfaction.
Practical or social implications – The "internal" customer satisfaction is mostly a direct part of the target system of a CREM organization. Against this background, every CREM can use the basic structure of the model to measure, evaluate and optimize satisfaction - as a component of the CREM added value.
Type of paper – Full research paper.

KEYWORDS
Structural equation, internal service barometer, customer satisfaction, facility services.

INTRODUCTION
Within the past few years, corporate real estate management has made an increasingly clear development and is evolving more and more towards a potential system for companies to support their future competitive position and corporate success (Bernhold & Wiesweg, 2020; Cooke, Appel-Meulenbroek, & Arentze, 2019; Pfnür, Seger, & Appel-Meulenbroek, 2021). Especially the last years marked by the Corona pandemic revealed substantial changes in the field of collaboration and interaction but also in the shaping and expression of spaces and related services. Moreover, it remains the constitutive task of CREM to record and analyze the internal, core business requirements (e.g., for space and services) and to implement them coordinatively and institutionally under economic conditions (see Glatte, 2014; Kämpf-Dern & Pfnür, 2014). Without now going into various item-based ways of measuring CREM (Bernhold & Wiesweg, 2021b; Lindholm & Leväinen, 2006; Pfnür et al., 2021; van der Voordt & Jensen, 2021), a basic link between core business activities and employee satisfaction

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can be established (Appel-Meulenbroek, Clippard, & Pfnür, 2018; Budie, Appel-Meulenbroek, Kemperman, & Weijs-Perree, 2018).

THE INTERNAL SATISFACTION PERSPECTIVE AND ITS IMPORTANCE

This study takes up the basic idea of causality, but extends it to include facility services in and on buildings. It is assumed that this type of service is an integral part of office workspaces and that part of the satisfaction of (office) workspaces is thus also determined by the (dis)satisfaction of the services provided and perceived there. If the empirical results of internal customer-supplier relationships are integrated into these considerations (Bruhn, 2003, 2010), the following chain of success can be formulated for CREM, following BRUHN (Bruhn, 2010; Bruhn & Grund, 2000):

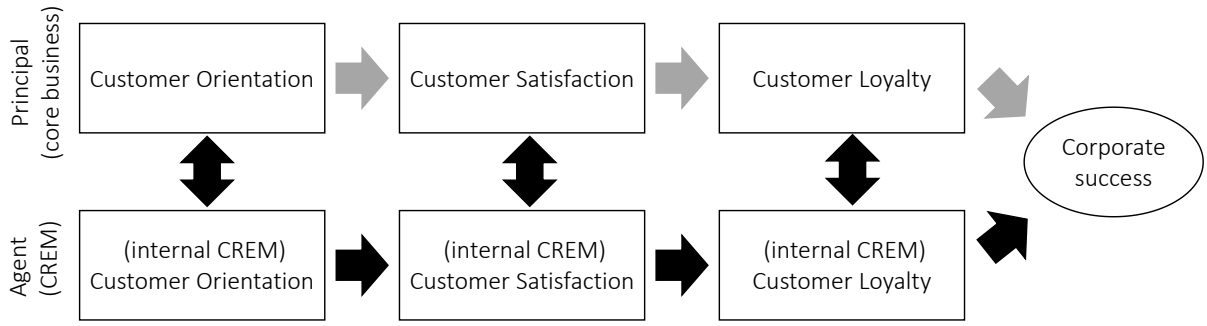


Figure 1 Internal and external success chain of customer orientation.

As an internal, supporting service function in the secondary area (Porter, 1999), CREM can thus make a contribution to employee satisfaction, which then in turn passes over to the external perspective; thus, both the internal and the external perspective make a contribution to the company's success to varying degrees. The authors assume different target contributions for individual facility services; this can be explained by the different characteristic of facility services. Although these can be summarized under certain descriptions and framework conditions (e.g., the term "facility services"), they are not completely homogeneous when viewed as a whole. Some services (Schmenner, 1986; Silvestro, Fitzgerald, Johnston, & Voss, 1992) can be characterized more as professional services (e.g. asset and property management), while other services will have more the character of service shops (e.g. maintenance) or mass services (e.g. cleaning, gardening, landscaping) (Bernhold, 2010). These services will differ, for example, in terms of the degree of interaction, customer orientation or perspective (front or back office services). Against this background, facility services will differ in terms of their "value contribution" from an internal customer perspective. In connection with the measurement of customer satisfaction, however, some differences between the internal perspective (internal customer-supplier relationship) and the external, market-oriented perspective (external customer-supplier relationship; company to customer) must be noted:

1. In the context of an internal contracting obligation, it must be assumed that CREM is a monopoly service provider vis-à-vis internal customers within the scope of the service offering (Bernhold & Wiesweg, 2021a; Bruhn, 2003, 2010).
2. Internal customers will not be able to independently, actively and/or freely use or form other market partners for a benchmark.
3. The contractual relationship arises from formally formed, organizational-hierarchical considerations and not from market (supply-demand) structures (Reichert, 2005).
4. It can be assumed that the business unit, and thus any internal customer, is interested in maximizing the cost-benefit ratio and that the CREM unit is interested in maximizing its own value contribution (in the understanding of supporting the corporate strategy) (Bernhold & Wiesweg, 2021a). If CREM services are not charged internally under market conditions, it can

be assumed that each internal customer will demand the maximum quantity and, in terms of service, always the highest service level.

In the external customer-supplier understanding, increased customer loyalty leads to higher repurchase rates, higher cross-selling purchases, higher willingness to pay prices and, above all, a positive reputation for the company and its products (Bruhn & Grund, 2000). If these aspects are transferred to the field of CREM (and in this case to facility services), increased customer satisfaction, loyalty and retention can support employee satisfaction with their jobs and thus make a positive contribution to overall employee productivity. Thus, supporting employee satisfaction can make a general contribution to business success as well as to ensuring a value contribution (added value) of CREM (Bernhold, Lellek, & Schlicht, 2019; Jensen & van der Voordt, 2017, 2021; van der Voordt & Jensen, 2021). Conversely, poor service quality can negatively influence service quality towards external customers (Bruhn, 2003; Bruhn & Georgi, 2008; Davis, 1991). Comparable interpretation, meanwhile, can be derived and supported via the service-profit chain (Heskett, Jones, Loveman, Sasser Jr., & Schlesinger, 1994).

RESEARCH METHODOLOGY

Methodologically and conceptually, the present study uses BRUHN's descriptions of the internal service barometer (Bruhn, 2003, 2010; Bruhn & Georgi, 2008; Bruhn & Grund, 2000), which are closely aligned with the fundamental work on building national customer satisfaction indices (Fornell, 1992). Related work, moreover, has already been taken up and addressed in the healthcare FM context by COENEN et al. (Coenen, Waldburger, & Felten, 2013). Internal service barometers can be defined as follows:

"Internal service barometers are measurements of customer satisfaction, its determinants as well as its effects at internal departments, which is carried out regularly in a company by a neutral institution." (Bruhn, 2010)

The hypotheses already assumed in BRUHN's model were also adapted for the study conducted, resulting in the following three hypotheses for the investigation:

(1) The higher the service quality, the higher the customer satisfaction.
(2) The higher the service quality, the higher the customer retention.
(3) The higher the customer satisfaction, the higher the customer retention.

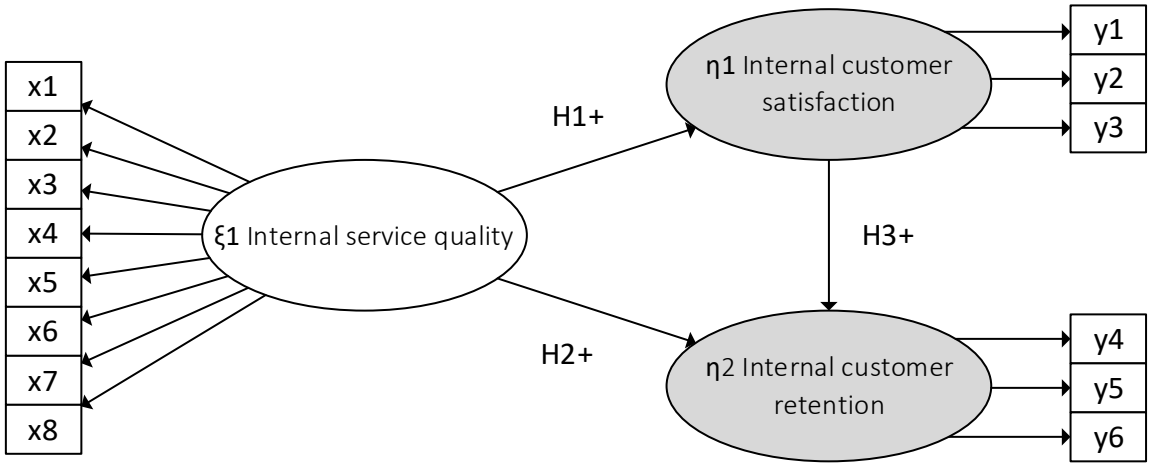


Figure 2 Measurement model.

In consultation with the research partner (KPMG Germany), the research design envisaged that the three facility services *cleaning*, *conference room service* and *reception service* would be investigated in more detail, as these services have a high personnel intensity and (partial) interaction between internal customers and service personnel, and are also frequently formulated in the direct perception of internal customers. An investigation of all facility services, on the other hand, would have exceeded the time required to answer the questions from internal customers, so that an appropriate selection had to be made.

In analogy to BRUHN's model, the service barometer used is composed of the latent exogenous factor of internal service quality (ξ1) and the two latent endogenous factors of internal customer satisfaction (η1) and internal customer retention (η2). Observable indicators are necessary to measure latent factors (Bagozzi & Phillips, 1982; Kline, 2011). The operationalization of the individual factors was very close to the items used as a basis by BRUHN. Table 1 shows the indicators used for the cleaning service line. For the other service lines, only the names of the respective service were exchanged. Also analogous to BRUHN, a 10-point Likert scale was used (1 "I don't agree at all"; 10 "I completely agree" and ["does not concern me"]), which allows the calculation of a satisfaction score based on the results of the study (Bruhn, 2003). Figure 1 shows the measurement model.

Table 1 Indicators.

Factors	Indicators	
ξ1 Internal service quality	x1	I find the cleaning service competent
	x2	I find the cleaning service reliable
	x3	I find the cleaners friendly
	x4	I am satisfied with the speed of response to complaints from the cleaning service
	x5	I feel the cleaning service is responsive and helpful when I have complaints
	x6	The cleaning service reacts flexibly to changing requirements
	x7	I feel the cleaning service is customer oriented with satisfactory solutions
	x8	I know exactly who to contact if I have a problem
η1 Internal customer satisfaction	y1	I am generally satisfied with the cleaning service
	y2	The cleaning service meets my expectations
	y3	The cleaning service meets my ideal expectations
η2 Internal customer retention	y4	I would hire this cleaning service again
	y5	I would recommend the cleaning service in principle
	y6	If I could decide independently, I would hire the cleaning service again

In addition to these questions relating to the structural model (questionnaire part 2), KPMG also integrated general aspects relating to various facets of day-to-day operations (e.g., use of the restaurant and coffee bar, use of a hairdresser, questions on mobility, etc.) (questionnaire part 1). The evaluation of these questions was carried out purely descriptively and detached from the measurement model presented here.

Data collection, sample and method

In the present investigation framework, a related investigation was carried out by students of Münster University of Applied Sciences as a neutral institution in the winter semester 21/22 as a snapshot, whereby the corresponding questionnaire expression can be used permanently and regularly. KPMG is an internationally active auditing and consulting company with > 13,000 employees in Germany. These are active at 28 locations in the areas of Audit, Central Services, Consulting, Deal Advisory, Financial Services, Law and Tax. Within the conception, the internal client was considered as any individual (employee) of the company who uses or makes use of related services (Bruhn, 2003).

The questionnaire was made available online via an internal platform of KPMG for its employees to answer for two weeks in November 2021. In total, the questionnaire was answered by 2,894 participants (in questionnaire parts 1 and 2). Due to the high number of responses, only fully completed data sets for the respective service line were used for the model evaluation. A separate data sample was formed for each service line (Table 2). In addition to the criterion of completeness, the different sizes result, among other things, from the fact that not every service is offered at the locations of KPMG.

Table 2 Data samples.

Serviceline	Sample size
Cleaning services	760
Reception services	1122
Conference room services	605

In contrast to the study of BRUHN, which follows a variance-based approach via the partial least squares (PLS) estimator, here we relied on the covariance-based approach with the diagonally weighted least squares (DWLS) estimator. The variance of the estimator has to be justified exclusively in teaching: Variance-based models focus on prediction, whereas covariance-based models are used especially for hypothesis testing (Chin & Newsted, 1999; Fornell & Bookstein, 1982; Lohmöller, 2013). Students at FH Münster are primarily expected to learn how to work with and understand reflective measurement models, and thus hypothesis testing and covariance-based models are the main focus of teaching. For completeness, the individual service lines were also calculated with the PLS estimator. The differences between the two approaches were not relevant with respect to the further key statements and were true for both the covariance-based and variance-based approaches. Calculations were performed using the Latent Variable Analysis (lavaan) package for R (Rosseel, 2012). The DWLS estimator was used due to the ordinal Likert scale (Kline, 2011).

RESULTS

Table 3 shows the evaluation criteria for the individual service line models, analogous to Bruhn (2003). With the exception of the RMSEA (Root Mean Square Error of Approximation; model fit indicator) for the Cleaning model, all set limits are met. Adjustments to the Cleaning model to achieve the set RMSEA cut-off criteria were not made because the models would then no longer be comparable with each other. The basic design of the model has already been successfully applied and statistically proven

several times, so that the reason for the increased RMSEA value can be attributed more to the underlying data material and less to inconsistencies in the model.

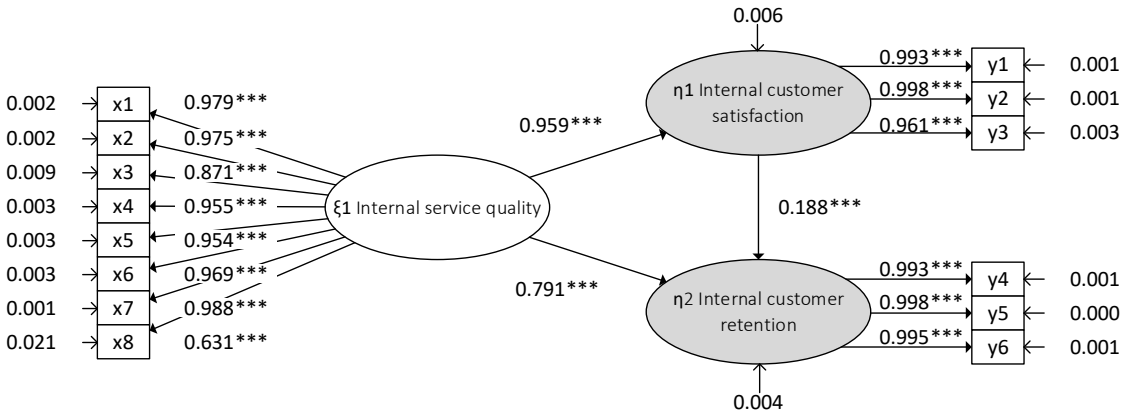
Table 3 Model fit.

Evaluation criteria		Cleaning	Reception	Conference	Cut-Off
Cronbach's Alpha	Internal service quality	0.963	0.971	0.968	≥ 0.7[a]
	Internal customer satisfaction	0.974	0.971	0.966	≥ 0.7[a]
	Internal customer retention	0.993	0.992	0.990	≥ 0.7[a]
CFI		1.000	1.000	1.000	≥ 0.95[b]
TLI		1.000	1.000	1.000	≥ 0.95[c]
RMSEA		0.136	0.059	0.098	≤ 0.1[d]
SRMR		0.028	0.008	0.016	≤ 0.08[e]

[a] (Nunnally & Bernstein, 1994); [b] (Bentler, 1990);[c] (L. R. Tucker & Lewis, 1973);[d] for moderate fit (Browne & Cudeck, 1993);[e] (Hu & Bentler, 1999)

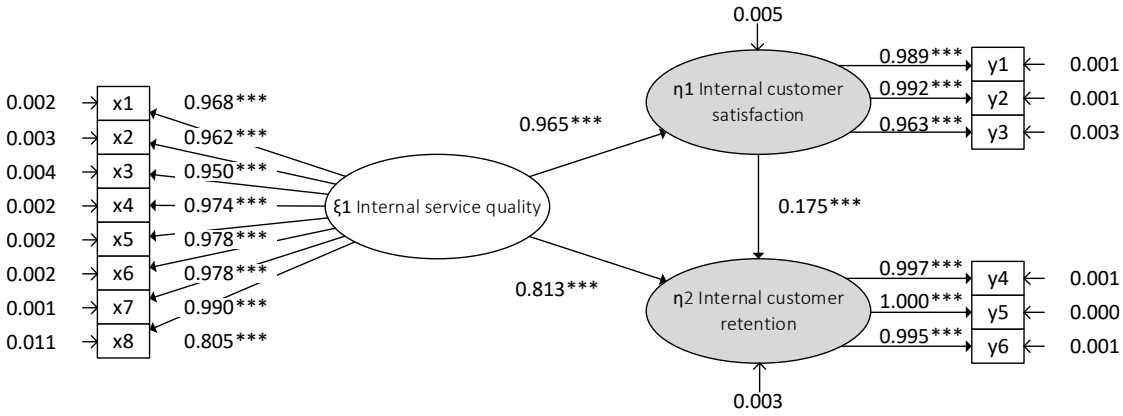
In addition to the model fit, the corresponding item loadings (> 0.5) are also relevant for the analysis (Straub, 1989). The following figures 2 to 4 show these for the three models. All item loadings are clearly above the set limit and very significant with P values < 0.001. Due to the very homogeneous results of all three samples, the following can be concluded against the background of the hypotheses stated above:

(1) Internal service quality influences internal customer satisfaction to a very high degree across all service lines at a significance level of <0.001.
(2) Internal service quality influences internal customer retention to a high degree across all service lines at a significance level of <0.001.
(3) Across all service lines, internal customer satisfaction influences internal customer retention only to a very small extent at a significance level of <0.001.
(4)



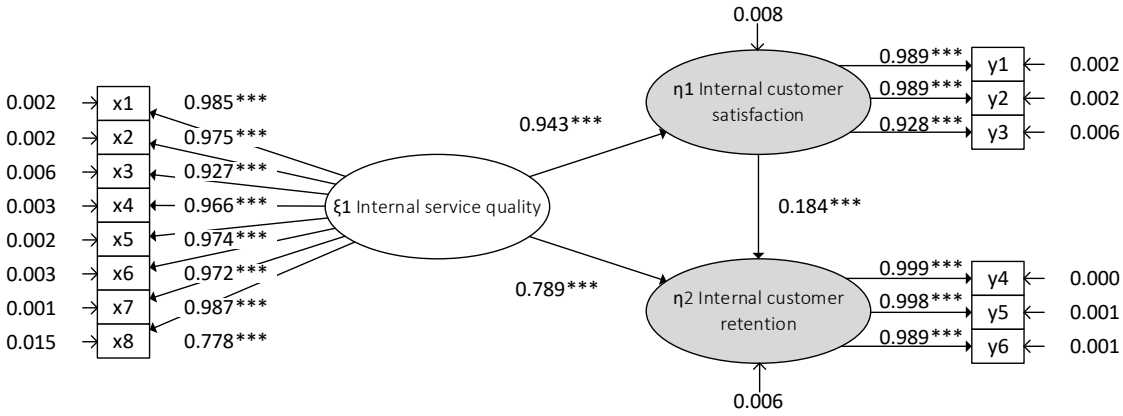
p-value < 0.001 = ***; p-value < 0.01 = **; p-value < 0.05 = *. Standardized coefficients are shown.

Figure 1 Results Cleaning services.



p-value < 0.001 = ***; p-value < 0.01 = **; p-value < 0.05 = *. Standardized coefficients are shown.

Figure 2 Results Reception services.



p-value < 0.001 = ***; p-value < 0.01 = **; p-value < 0.05 = *. Standardized coefficients are shown.

Figure 3 Results Conference room services

Customer Satisfaction of CREM Services (CSI CREM)

For the calculation of the customer satisfaction (CSI CREM) the well-known approaches of BRUHN (Bruhn, 2003) were used. Here, the arithmetic mean of the indicators of the items y1-y3 of the factor of internal customer satisfaction (η1) is multiplied/weighted by the item loading and divided by the idealized value. See Equation 1 for further details.

$$Customer\ Satisfaction\ Index\ (CREM) = \frac{\overline{y1} * y1\eta1 + \overline{y2} * y2\eta1 + \overline{y3} * y3\eta1}{\overline{y1} * 10 + \overline{y2} * 10 + \overline{y3} * 10}$$

Equation 1 Calculation CSI (CREM)

The satisfaction levels for the three service lines surveyed are as follows:

(1) Cleaning services = 77.71 %
(2) Reception services = 86.26 %

(3) Conference room services = 82.10 %

In this context, satisfaction with the Property Operations department itself was also queried within the study, which in the present case can be stated as 82.51%. Due to the already extensive questionnaire, however, these questions were limited to one question per factor (ξ1, η1 and η2) and not analyzed within the structural equation model, so that a direct comparability is not fully given at this point.

Further implications in the application

With regard to the applicability of a CSI CREM, the following implications can be derived and described:

1. Regular application

According to BRUHN, the intention behind the creation of a service barometer would be to conduct this study regularly (e.g., annually) (Bruhn & Georgi, 2008) and to compare the respective satisfaction values and analyze any deviations. In this way, anomalies and deviations can be analyzed and directly related to the value contribution of CREM and external customer satisfaction.

2. Holism

In addition to the service areas partially surveyed here, a holistic CREM view with regard to the services provided internally is appropriate. It is precisely at this point that resources can be developed and, above all, adapted in a more targeted manner with regard to the value contribution and also the perception by the customer. If, for example, services are assessed as less important from the internal customer perspective, ceteris paribus (prerequisite: no direct significance for external customers), service levels could be reduced at this point; freed-up financial and personnel resources could be used in other service lines. In the understanding of added value (Bernhold et al., 2019) as well as under general productivity considerations, this situation would result in an increase in productivity (increase in output [higher satisfaction] with the same input [in the form of the resources used]). Internal customer satisfaction surveys should therefore be understood not only as a snapshot but as an instrument of resource allocation in itself.

3. Utilization in the understanding of a pre-economic factor

In addition to the statistical investigation and analysis, individual relationships within the services can be examined and mapped in more detail. For all service lines, the importance/significance of the individual services was recorded from the internal customer perspective. This enables the company to optimize resource allocation in the direction of the services perceived by the customer as having priority and specific characteristics. However, service barometers do not actually serve an end in themselves, but rather the shaping and creation of a specific value contribution to be achieved by CREM. It is precisely against this background that regularity on an annual basis and holism are induced. If the CSI CREM is also interpreted as a pre-economic performance factor (Bruhn, 2003), its importance for the success of the company as a whole becomes visible. In this context, it is important to survey external and internal customer satisfaction in equal measure and to link corresponding correlations (Bruhn, 2003). The further analysis of the service lines was carried out with the help of Tableau and enables KPMG to gain deeper insights. For example, service adjustments can be made at the site level and the effects can be analyzed in more detail in the next panel and evaluated in terms of success (before and after); an analysis based on socio-demographic criteria is also possible.

4. Integration in the supply chain

The majority of CREM services in the operational area are performed by external service providers, whereby the agreed service levels are laid down in service specifications or service level agreements. Regular application of the methodology described here would also make it possible to integrate internal

customer satisfaction (in relation to the respective service line) into the contracts and the incentive system with the service provider, which would result in a clear alignment of interests (Bernhold, 2010). In currently existing contractual relationships, there is usually a pure penalty for services not performed (if not performed on Monday ... then deduction). The service provider, on the other hand, is not usually integrated into the added value metrics system. However, this would allow the service provider to be much more closely integrated into the value chain and the success of a CREM, so that strategic and operational partnerships would be significantly strengthened.

5. Internal communication

The primacy of action and thus of performance in CREM is often and erroneously seen in the pure reduction of costs. However, these internal service barometers can contribute to a better understanding within the company and make the value contribution of a CREM visible and, above all, communicable - for example, by establishing the connection between internal and external customer satisfaction. This could create a willingness to further develop and professionalize the CREM.

LIMITATIONS

Within the scope of the study, the items specified by BRUHN had to be adapted - especially in view of the scope of the questionnaire - so that there is no complete structural comparability with other study results. Particularly against the background of the questionnaire scope, the survey of internal satisfaction with the superordinate organizational unit (Property Operations) was also conducted on a general and not on an item-based level.

The study was conducted as a case study at KPMG in Germany. Notwithstanding this, it can be assumed that the model can be transferred to all CREM organizations. Furthermore, the development of a national service barometer for internal CREM services would be useful to further specify and benchmark the results (e.g., by region, industry, company size, etc.). As with the application of statistical models in general, a good and solid observation size (answered questionnaires) should be available (> 100).

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The value of FM for a healthy urban environment; application of the FM Value Map to Urban FM

Jaap Wijnja[1] and Jeannette Nijkamp[2]

ABSTRACT

Background and aim - Facility management is the art of facilitating the core process of a company, providing an inspiring and healthy environment for both employees and clients. When the perspective would be broadened from healthy buildings to healthy cities, what value could be added by an "Urban FM" approach, facilitating living in a city, striving to offer a healthy and inspiring urban environment? In 2010 the FM Value Map was introduced, offering a conceptual framework that can be used in general, to provide a better understanding of the value and contributions of FM to a business and its surroundings. The aim of this paper is to discuss if the FM Value Map can also be used as a conceptual framework to understand and explain how Urban FM can contribute to a healthy and inspiring urban environment.
Methods - The FM Value Map was applied to the Molukkenpark, an urban park in a Groningen neighbourhood. To fill in the model, desk research was combined with the findings from interviews and attentive observations of phenomena related to facility management and management of the urban environment.
Results - Insight into the applicability of the FM Value Map from an Urban FM perspective.
Originality - This is the first time that the FM Value Map is tested concerning Urban FM.
Practical or social implications - The results are relevant for the development of the (Urban) FM profession and the curricula of education in the fields of FM and the built environment.
Type of paper - Research paper (short).

KEYWORDS
Facility management, Urban facility management, Healthy cities, City Parks, Added value, FM Value Map, Urban management.

INTRODUCTION
In 2018, 55% of the world's population resided in urban areas and this is expected to increase to 68% by 2050 (UN, 2018). Urban living is associated with several environmental and social issues, such as noise, pollution, traffic density and a lack of green spaces, which negatively influence health and well-being and discourage an active lifestyle (WHO, 2017). Michell (2013) emphasises that ensuring long-term sustainability is a permanent challenge in all cities and urban precincts. She stresses that in order to make the urban environment more sustainable, a better understanding of the relationship between buildings, people and the urban precinct is needed.

Contributing to sustainability is also an important objective of Facility Management (FM), as well as increasing health and wellbeing. So far, FM is mostly considered the art of facilitating the core process of a company, providing sustainable, inspiring and healthy buildings and services for both employees and clients. When that perspective would be broadened to healthy and sustainable cities, what value

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could be added by an "Urban FM" approach, facilitating living in a city, striving to offer a sustainable, healthy and inspiring urban environment? Tammo and Nelson (2012) distinguish five domains in which FM can contribute to community development, namely:

1. service management: providing facilities that enable effective delivery of services in response to local needs;
2. social inclusion: including social objectives and involving community members;
3. environmental performance: offering an eco-friendly and sustainable environment, raising awareness of environmental issues within the community;
4. economic sustainability: offering economically viable and sustainable services, affordable by the community;
5. strategic development: analysing the urban context, and applying principles of engagement with public space, such as the ones formulated by Gehl (1980), including striving for integration instead of segregation, inviting instead of repelling, and opening up instead of closing in.

The following definition of Urban FM is provided by Temeljotov Salaj and Lindkvist (2020):

> "Urban FM aims to provide integrated deliveries such as flexible solutions, well maintained and adaptable buildings, and activities/services in the space between buildings oriented towards the customer's satisfaction and needs."

Kuijlenburg (2020) points out that the tangibility of the FM manager is an issue, asking what the added value of FM could be.

The FM Value Map (figure 1), which was introduced by Jensen (2010) to clarify the added value of FM to the core process of a company, might help to also shed light to the added value of FM for an urban environment. The FM Value Map offers a conceptual framework that can be used as a generic model, to provide a better understanding of the value and contributions of FM to a core business as well as its surroundings. The main structure of the FM Value Map corresponds to the following general process model (Jensen & van der Voordt, 2017):

Input → Throughput → Output → Outcome = Impact = Added Value

This paper aims to discuss if the FM Value Map can also be used as a conceptual framework to understand and explain how Urban FM can add value to an urban environment. This will be done by applying the FM Value Map to practice, to the Molukkenpark, an urban park facilitating the residents of Groningen, a city in the North of the Netherlands.

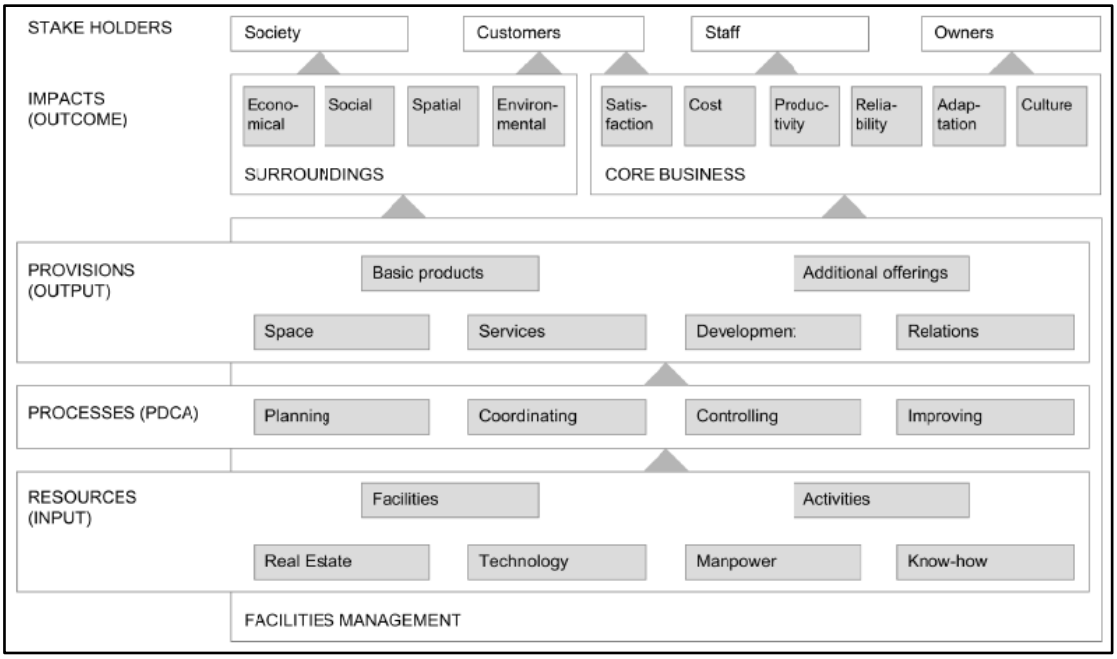

Figure 1 Generic FM Value Map (Jensen, 2010).

METHOD

The Molukkenpark was chosen as our research object by means of a mix of purposeful sampling and convenience sampling (Patton, 1990), because relevant data concerning this park had already been collected in a previous research project of Hanze University of Applied Sciences Groningen. During the autumn of 2021, three groups of students from Hanze University investigated the current situation in the Molukkenpark and advised on how to improve its attractiveness (Gruppen et al., 2021; Jongstra et al., 2021; WCG, 2021). They gathered data by desk research, by observation of the park and by interviewing different stakeholders involved.

For this paper, desk research concerning Urban FM and concerning the FM Value Map was combined with the results from students' research. Furthermore, the project manager who is responsible for improving the Molukkenpark was interviewed about possibilities to apply urban FM in relation to the park. These results were used to fill in the fields of the FM Value Map with regard to the Molukkenpark, considering this park as an urban facility.

RESULTS

Based on the main structure of the FM Value Map, the results of filling in this model in relation to the Molukkenpark are presented. The bottom part of the model, containing "Input", "Processes" and "Provisions" (figure 2) is presented first, followed by the top part, containing "Impacts" and "Stakeholders" (figure 3).

Resources, Processes and Provisions

The *Resource* Molukkenpark is located in the north-eastern part of the city of Groningen, in a neighbourhood called "Indische buurt". It has a size of approximately 6.5 ha. The park is part of the green belt around three northern and eastern pre-war districts. The Molukkenpark has an English landscape appearance, with asymmetrical lines and flowing paths. Special trees have been planted here, such as weeping willows, special evergreen oaks, stately ash trees, a double row of lime trees and alternating shrubbery patches. The edges of the various ponds are largely ecologically designed. The

park contains over 200 different species of plants and animals (Gemeente Groningen, 2015). In the middle of the park there is an elementary school; this part of the park has been given a more movement-oriented character aimed at schoolchildren.

The *Processes* part contains the Plan-Do-Check-Act circle (in this model addressed with the terms Planning, Coordinating, Controlling and Improving). "Planning" is where Strategy finds its place in the Added Value Model. In facility management, strategy is usually aiming at supporting the core business in the best way possible. As the owner of the park, the City of Groningen is responsible for the relevant Processes. In its policy plan for green infrastructure, the City of Groningen states:

> "Within the robust green network, the parks and larger green spaces are the most important links. They are destinations for residents to take a short walk, enjoy a barbecue, go jogging or just relax in a quiet spot. As the city grows and becomes busier, so does the pressure on the parks. Sufficiently attractive and diverse parks help to disperse the pressure. (…) the neighbourhood parks are actually important for daily contact with greenery. They therefore deserve our special attention" (Gemeente Groningen, 2020).

However, as nowadays far from all residents perceive the Molukkenpark as a pleasant environment, improvement is required. For example, there are residents who find the park unsafe because of poor sightlines, steep banks of the ponds (danger of drowning), poor maintenance or loitering youths. In 2021 a project has been launched, aiming to improve the park's attractiveness.

Hence the Molukkenpark is intended to be an attractive *Provision* for all neighbourhood residents, both children and adults. It already contains facilities aiming at different target groups, especially a playground for children, a fitness park for adults including elderly as well as places where you can just relax. In addition, there are plans to create an experience garden for people with early onset dementia near the Odensehuis, a meeting place for people who are dealing with dementia.

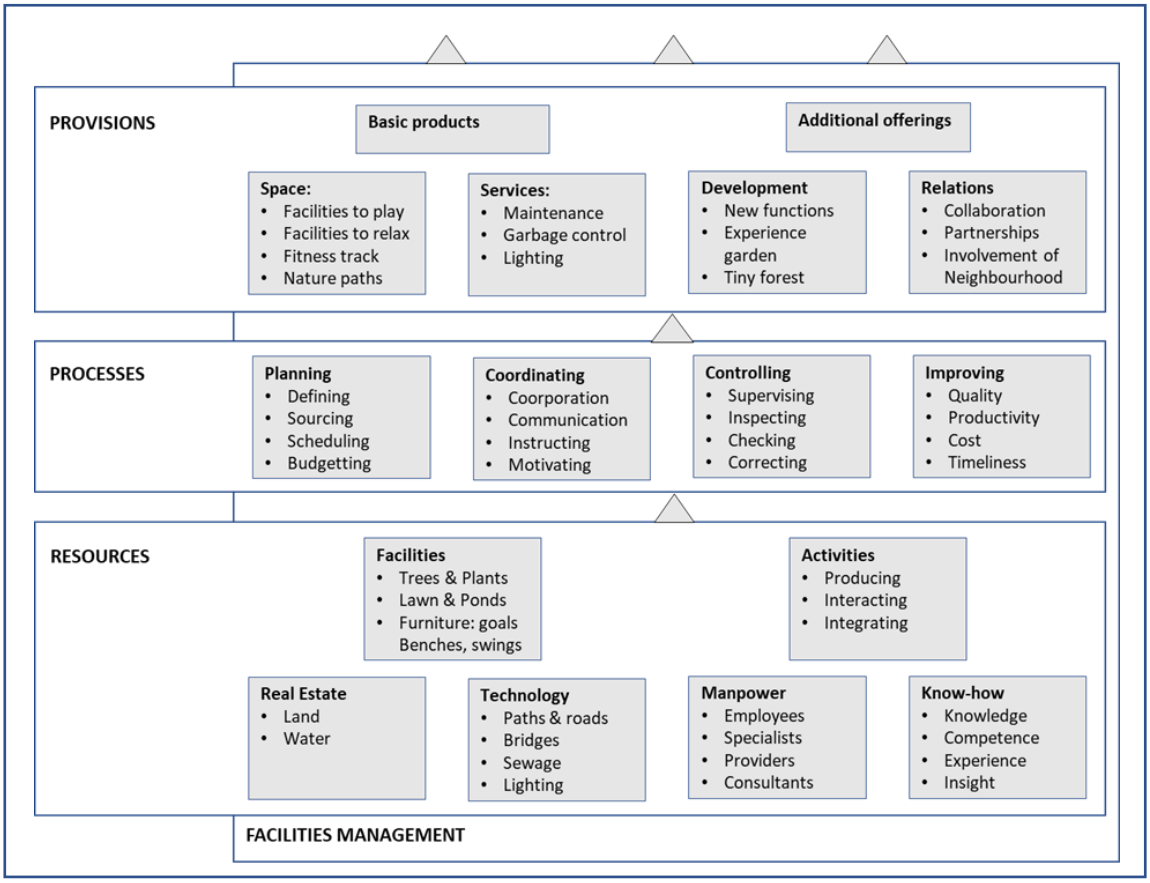

Figure 2 The Molukkenpark Value Map - bottom part.

Impacts & Stakeholders

The four aspects of the Added Value model concerning impact on the surroundings of the Molukkenpark can be concretised as shown in figure 3. Parks contribute to a rise of the local tax base and increased property values and also provide significant indirect revenues to local and regional *Economies* by being a place for sports tournaments and special events. A park also provides places to *Socialise*, to meet, to walk, sport and play together with other people, while available for everyone no matter age or income. Access to parks may lead to reduction of crime and of juvenile delinquency (NRPA, 2010). However, at the Molukkenpark loitering youths and poor maintenance give the residents an unsafe feeling. Important possible positive *Environmental* effects of parks are noise buffering combined with the production of natural sounds, less exposure to air pollution and reduction of the urban heat island effect (WHO, 2016). Parks function as a water-buffer in case of severe rainfall, improve the air that we breathe and offer room for wildlife and plants (200 different species in the Molukkenpark!). In the Added Value model *spatial* is linked with landscaping and townscaping, meaning that a well-designed park contributes to a perception of aesthetic space, not only of the park, but also of the adjacent neighbourhood.

From the urban FM perspective, the core business of the Molukkenpark is not immediately clear. In order to be able to describe the impacts the Molukkenpark has on that core business, it is necessary for it to be determined. According to the project manager who is responsible for the improvement of the Molukkenpark, the challenge for the park is “to ensure that it is a safe, attractive, pleasant park for the entire neighbourhood”. Both this challenge and the policy as expressed by the City of Groningen suggest that “facilitating the life of everyone in the neighbourhood” can in this case be assumed to be the core business. Based on that assumption, the six impacts on the core business have been filled in in the

Added Value model. By offering inspiration and by contributing to regeneration, the park helps to boost the *Productivity* of its visitors and therefore of the neighbourhood. *Costs* are being made by the city government, covering operational costs, costs of staff and investments needed.

Looking at *Stakeholders*, since the Molukkenpark is open for everybody, every neighbourhood resident can be considered a potential customer and the same holds for animals. Under *Society* the different stakeholders involved in the park are mentioned.

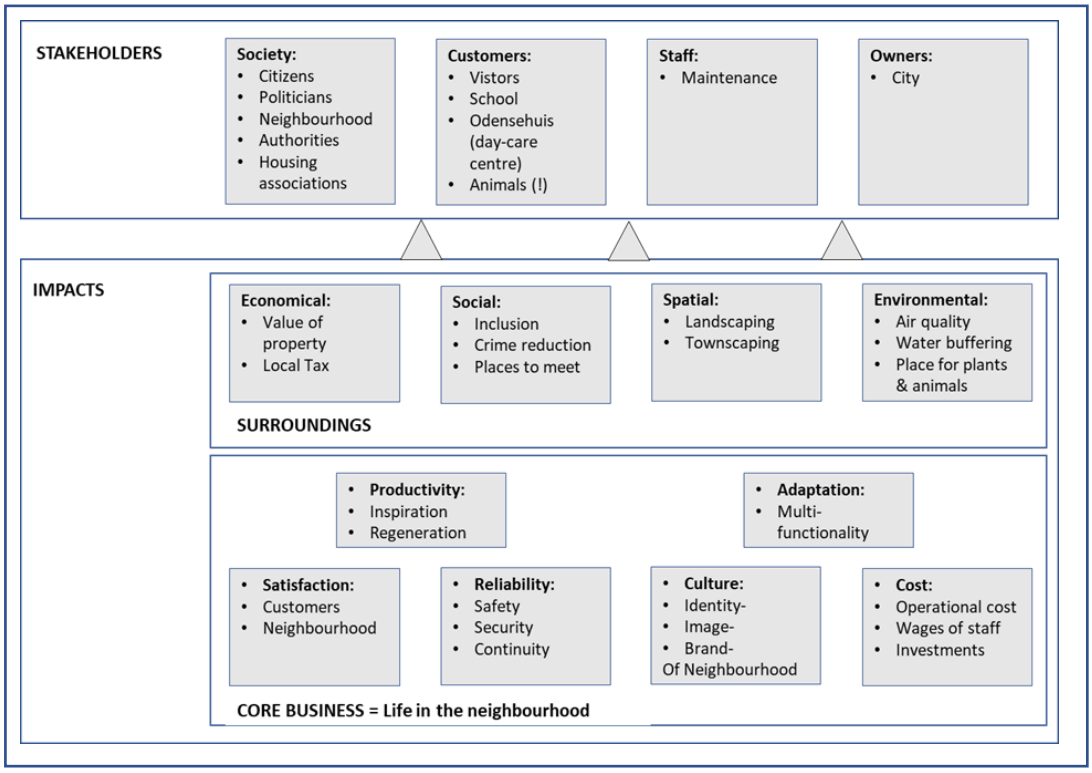

Figure 3 The Molukkenpark Value Map - top part.

CONCLUSION AND DISCUSSION

From our exercise of filling in the FM Value Model concerning the Molukkenpark it can be concluded that this model might be applicable in an Urban FM context in order to shed light on its value. However, before it can really be used, there are still some challenges to overcome.

First of all, to provide a strategy with an aim in order to determine how to put the Molukkenpark to best use, a prioritisation of impacts is needed, which can only be realised when it is clear what the core business is. In the case of the Molukkenpark, the assumption that "facilitating life in the neighbourhood" is the core business, might work out well. But important questions remain, like: what to define as the productivity of this life in the neighbourhood? And also: if this counts for the Molukkenpark, will it also be applicable to Urban FM in general?
Secondly, to measure the effectiveness of a chosen strategy, it is essential to be able to measure the impacts the strategy is aiming at. Some measuring has already been done by means of a yearly survey in the neighbourhood of the park, but that is not covering all the aspects of the impacts.

Thirdly, some obvious impacts, like for example a positive influence on the health of residents and especially of visitors of the park, as well as stimulation of social cohesion and of environmental awareness by the park, were hard to place in the Added Value Map.

The assumed strength of applying the FM Value Map to an urban environment will lie in the fact that it supports a holistic approach of facilitating its core business by delivering support with the right choice of impacts, based on the ability to measure those impacts and to steer on them.

To be able to do so, it is important to agree upon a clear definition of the core business of a city or a neighbourhood. After having established this definition, the impacts that play an important role when facilitating this core business can be derived. New knowledge is also needed on how to measure these impacts. Facility management, with its holistic approach, has proved to be able to support complex organisations in steering on the right choice of impacts. In the future, Urban FM should be able to do so in the same way when facilitating complex cities. In order for this to become reality, our research efforts will have to focus on finding a clear definition of Urban FM, on defining the relevant impacts and on describing how to measure these impacts. This will lead to an Urban FM Value Map, offering a framework that can be used as a generic model, to provide a better understanding of the value and contributions of Urban FM to the core business of a city. Education in the fields of FM and the built environment will need to develop curricula to educate the Urban facility managers of the future. This model will help to bring structure in the holistic knowledge and vision that they need.

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The role of FM post pandemic: Delivering employee experience and meeting business needs

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ABSTRACT

Background and aim – This paper reviews the engagement in a case study organisation adapting to hybrid working to determine the post pandemic role of FM and to understand how FM can drive and be a key stakeholder in the cocreation of the human-centric workplace.
Methods / Methodology – The study was carried out using an action research strategy with a mixed methods approach, which included use of observations, semi-structured interviews, workshops and employee pulse surveys at regular intervals over 11 months. The study engaged a range of employees, from junior leadership to board level executives who were part of the roll-out of a new way of working project.
Results – The research data suggests there is not a 'one size fits all' approach to ways of working for an organisation. The research highlights the importance of FM becoming the strategic leader for employee-led change to create a human-centric experience in the workplace; underpinned by engagement with employees, HR, IT, and senior management teams.
Originality – A focus on the use of human-centric leadership and the role FM can play in terms of the employee experience. This study is grounded within both academic theory and practical experience.
Practical or social implications – The implication of the research is highlighting the importance of the 'workplace' approach to change, encapsulating people, space, technology, and process with FM as a key stakeholder offering 'the voice of the people' and the operational underpinning required for the human-centric workplace to be achievable.
Type of paper – Research paper (full).

KEYWORDS
Employee experience, FM leadership, hybrid working, human-centric, workplace.

INTRODUCTION
The world of work is changing as we move through the pandemic. There are acknowledgements that the new ways of working have brought some benefits to business and their people, but some continue to find a path through their challenges. *"The shift to homeworking has been a positive experience for some whilst it continues to be a struggle for others. In the future, employers will need to offer flexibility and choice for employees about how and where they work, whilst re-thinking the function of offices as places to foster collaboration, build networks and facilitate in person knowledge transfer" (Claire Tunley, CEO, Financial Services Skills Commission* cited in KPMG, 2020, p.10). New ways of working or 'hybrid working' are being considered by organisations giving an opportunity to reduce property portfolio, deliver to the environmental agenda and to embrace the benefits this can offer in terms of staff motivation and the human-centric workplace (Fenton-Jarvis, 2021; Babapour Chafi et al, 2022). Even prior to the pandemic a changed way of working was being mooted, for example, in 2001, Vos and van der Voordt discussed the changes in modern society and the changes in technology which meant that

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people could work *"just as well at home, at the client's or under way"* (2001, p.49) with recognition of the appropriate workspace/workplace for the need at the time. There was also recognition from Vos and van der Voordt that whilst working from home offers benefits there needs to be clear boundaries and delineation between work and home. Through the pandemic this has not always been easy to achieve, as for some people the workplace may have been their bedroom in a shared house, or the dining table and the impact of stress on individuals varies dependent on living arrangements (Royal Society for Public Health, 2021). Therefore, this research sought to understand the concept of hybrid working/remote working alongside the skills that organisations need to address in terms of their leadership and culture to enable them to maintain an engaged and collaborative workforce and the role that FM Leadership needs to play.

The research was focused in one organisation, ProfServicesCo (a global financial services company – anonymised for the purpose of the paper), which employs 100,000 people globally, with 3,000 within the UK. This strategic project was driven by the Head of the Property Services team to focus on new ways of working based on previous occupancy data and a timely opportunity to reduce the property portfolio but also to drive wellbeing and work/life balance through the reduction of commuting time and to meet the sustainability targets for the organisation. The study took place from February 2021 to January 2022 with the 3,000 UK employees split across five locations. The overarching research question was for FM to better understand the employee experience to meet business strategic objectives in a post pandemic world. The project KPIs included:

- Employee Feedback: focused on collaboration, satisfaction, wellbeing, connectedness, belonging, technology, space, relationships, and leadership.
- Management Feedback: focused on collaboration, satisfaction, wellbeing, connectedness, communication, effectiveness and efficiency, technology, and space.
- Sustainability: Measuring the impact of the project on corporate travel miles and personal travel miles and methods.
- Space: Utilisation and optimisation, effectiveness, design, and experience.
- Employee Experience: Space, technology, culture, engagement, job satisfaction, wellbeing, leadership, and culture.

This article will focus on the employee and manager feedback and overall employee experience surrounding new ways of working and how it impacts FM leadership.

LITERATURE STUDY

The concept of a more flexible workplace is not new (Vos and van der Voordt, 2001) however due to the pandemic it has been forced on organisations to start to rethink their approaches. "Both the pandemic and Brexit uncertainties have opened financial services leaders' eyes to new possibilities regarding working locations, not least working from. Wherever we land, there is little doubt that the ability to lead teams virtually, using digital solutions rather than in-person contact, will be the defining leadership characteristic of the next five years" (Tim Payne, Partner, People Consulting, cited in KPMG, 2020, p10). Bennet et al. (2009) discussed the need to ensure there is some form of social interaction which reinforces the need for contact to prevent isolation of workers and to create a shared sense of culture and values, but organisations need to revisit the forms this takes in terms of how they engage their staff with the office environment post pandemic.

The main considerations for organisations and the workplace as we move forward in 2022 are the organisational leadership, culture, technology, and space. In terms of leadership there needs to be a better understanding of the human-centric workplace, Fenton-Jarvis (2021) discussed the need for the leaders of the 21st Century to not be just "good at the job" but to have the ability and the will to listen

to their staff, to have empathy and to be human in terms of bringing their full self to work, and recognising this as a way to empower their followers and embed a sense of trust and psychological safety (Edmondson, 2014). Working in a hybrid way has trust at its heart and leaders need to focus on how they can create the collaborative working environment in diverse ways rather than just having people "sat" in the office (Edmondson, 2020). The concept of collaboration and connection needs to be a focus for organisations; allowing people to still feel connected and engaged in the organisation and to not feel excluded through hybrid/remote working (Fenton-Jarvis, 2021; Babapour Chafi et al., 2022); and to encourage leaders to be open and honest and courageous enough to embrace their vulnerability and to be imperfect (Brown, 2012); and to epitomise the concept of authentic leadership (Kernis and Goldman, 2006; Gardner et al., 2021). Authentic leaders are defined by George and Sims (2007, p.xxxi) as *"genuine people who are true to themselves and to what they believe in. They engender trust and develop genuine connections with others. Because people trust them, they are able to motivate others to high levels of performance".* Authentic leadership links closely with the concept of a coaching culture (Clutterbuck and Megginson, 2005; Hawkins, 2012). Bull and Stokes (2020) referred to the use of embedded reflective practice in an organisation to encourage the coaching culture approach and reduction of blame, to be able to be psychologically safe to share and learn from mistakes (Brown, 2012) and to embed a concept of learning through the organisation (Cunliffe, 2009).

Couch, O'Sullivan and Malatzky (2021) discuss the benefits of working from home for working mothers through the pandemic and the impact this had on managing conflicting demands as a mother and academic. The paper drew on personal reflections but identified some key areas of consideration of the practicalities that working from home can offer, including flexibility and productivity. However, they also recognised the blurring of boundaries and also the potential damage of not being seen to be present in the workplace which could have an impact on potential career progression. Presenteeism is a damaging concept and there needs to be a focus on outputs not input from organisations as we move forward in a tech-savvy world. *"It's a new reality that we're settling into, with employees finally feeling valued for their work and not for irrelevant metrics that simply quantify their working day, without any real link to the contribution they make to the business"* (Gegg, 2022: para 22). Why would it matter if people are not "sat at a desk" if the work is being delivered? There is also a need to understand why people would come into the office to sit in "online meetings" (Fenton-Jarvis, 2021), there needs to be greater consideration of what offices are for now. Again, Vos and van der Voordt (2001) challenged the focus of office space as a place for collaboration as opposed to individual work. Bell et al (2008) recognised the importance of the workplace being a place to engage and participate in the organisation, but not focused on a place to "come to work". The Leesman report (Oldman, 2021) Why Workplace: A leader's guide to rebuilding the post-pandemic workplace has continued the challenge on the role of real estate and FM, but also the need to ensure we have a strategic approach for organisations as we find the new normal in a post pandemic world.

As we move forward to working in a hybrid way, we need to be careful about the wistful comments being made to the "old ways"! The Leesman report (Oldman, 2021) refers to the overhyped discussion of the "water cooler moments" that appear to focus on only the positive conversations whereas in reality these can also be "toxic". There is however a need to consider how the informal social interactions and informal unplanned meetings will occur and how spaces can support this. More concerning is the lack of strategy for our workplaces and our people, the Leesman report offers an insight from their poll with real estate and workplace leaders "*70% said that they have a plan for the post-pandemic workplace, so the reset is underway. Yet only 36% had communicated this to employees, and a worrying 29% were still "at the early stages of formulating a plan"." (Oldman, 2021:39).* As Abisuga et al. (2021) discuss, in terms of post occupancy evaluation, there is a need to address the FM relationship with end users; however more generally if there was improved communication this would

ensure FM are not only feeding into the strategy but drawing on the thoughts of these end users to help formulate it. Abisuga et al.'s (2021, p16) research also found that the view of the end users was that "*facility managers' neglect of users' participation, poor communication, and facility managers' reactive nature."* As we move forward, we need to ensure there is a clear communication channel between the leadership team, employees, HR, and FM. As the Leesman report (Oldman, 2021, p72) suggests *"employees are developing strong opinions"*. The space that FM creates to encourage participation in the "office" needs to be carefully considered with a clear organisational strategy in place. The FM and Property teams will need new skills, to include soft skills such as 'psychology and communication' and also hard skills such as data analytics with greater understanding of the "workplace why"? (Oldman, 2021). Bull and Brown's (2012) research on change communication found that end users needed to be consulted, and ensure that their feedback is listened and responded to, with an explicit explanation of the "why" when changes are being made to ways of working by Estates and Facilities within a large organisation; without this approach it increases the dissatisfaction of working for the organisation.

In terms of the practicalities, with only 1 in 2 employees agreeing their workplace enables them to be productive (Leesman Index, 2016), the Stoddart Review concluded that the office environment being key to productivity with just a 1% increase in productivity across the UK macroeconomy adding £20 billion to the national output. "...the more tailored the infrastructure (hard, soft, and virtual) to the needs of those it accommodates, the better employees perform" (2016, p.6). The Stoddart Review (2016) also concluded that technology is bringing people together to facilitate greater levels of collaboration and innovation, with a workforce who have access to good technology having the choice between going to the office or not, with the office playing a vital role in facilitating community and cohesion. "...the tech-enabled workplace…is also the most humane workplace delivered to date. It provides a level of individual customisation and data previously unimaginable" (p. 6). The brief literature review has highlighted the need for FM to engage with their leadership, culture, and people skills alongside technology/hard skills as we enter a period of change in working practices and workplaces.

RESEARCH METHODS

The research was developed using an action research methodology (Eden and Huxham, 1996) over a period of 11 months. The chief investigator developed a 12-step journey (figure 1) for the organisation, which resulted in the use of a mixed method approach (Ivankova and Wingo, 2018) and delivery of a set of recommendations for improvement and review (Robson, 2002). As part of the case study the mixed methods used included three surveys, pre-project (February 2021), during the pilot (June 2021) and December 2021 (after the project six-month pilot had been completed), onsite observation, workshops, and semi-structured interviews (Coghlan and Brannick, 2005).

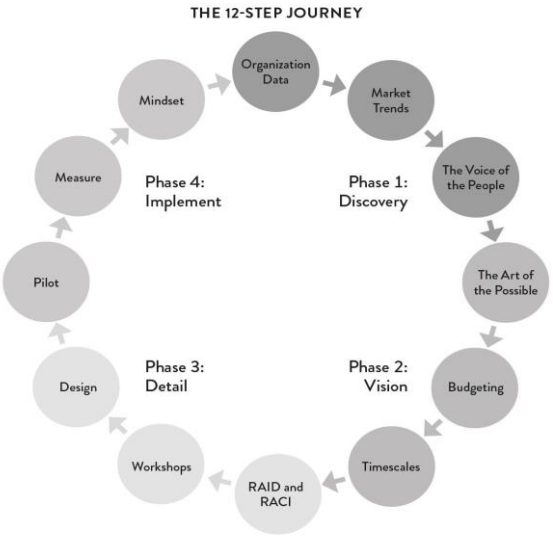

Figure 1 The 12-Step Journey (Fenton-Jarvis, 2021).

A new way of working 3:2 was the first pilot, whereby people worked 3 days within the office and 2 days from home. The iteration following data collection was then 2 days within the office and 3 days from home. The status quo is 2 days within the office and 3 days from home, however, that is now flexible for leaders to define in line with individual and departmental needs. A summary of the phases and the activities undertaken can be found below:

Figure 2 The steps in the research.

Phase 1 Discovery: During this phase, the project focused on understanding the voice of the people and experiences of working throughout the pandemic (Schein, 1999), the survey was designed based on initial discussions with the organisations' leadership to determine the current ways of working, the desired future state and the challenges and steps needed to be overcome to achieve such a future state (Saunders et al, 2009). The survey was sent to all 3,000 employees and consisted of three sections: Part 1: Understanding the current experiences towards space/technology/culture; Part 2: Capturing feelings in relation to future desires; Part 3: (Managers only) The effectiveness and efficiency of teams. Following the survey, which had a 65% response rate, and subsequent thematic analysis, using the action research approach, onsite observations took place at each of the five sites over a 10-day period (two days at each location), with two workplace consultants observing a cross-section of teams and departments (Gobo & Marciniak, 2011). The observations were conducted, with minimal interaction, so as to minimise

changes to people's behaviours (Robson, 2002). During the observations, the following was being observed: 1. The physical location of the teams on the floors. 2. The movement of people throughout the spaces, in particular observing if all work was completed at a single desk location. 3. The technology being used. 4. The number of meetings taking place. 5. The 'watercooler' serendipitous conversations taking place.

Semi-Structured workshops were also undertaken at the sites with a purpose of listening to the voice of the people and diving deeper into key themes from the survey and on-site observations (Ørngreen & Levinsen, 2017). The workshop participants were self-nominated, with a question being asked within the phase 1 survey whether they would like to take part in future workshops and/or interviews. There were 20 workshops, ranging from 5-8 people within each one, with a semi-structured nature the following themes were structured for discussion: the impact of remote working on team connectedness; the impact of remote working on wellbeing; the impact of remote working on team communications; the types of spaces required for teams to work effectively; and the technology required to support a hybrid world.

Semi structured, explorative interviews (Longhurst, 2010) were undertaken in February and March 2021 with ten employees (knowledge workers) with the focus being on what their desired experiences were and how new ways of working would achieve such experience for them to be effective in their roles and thrive as people. Interviews were conducted virtually with participants taking part from across the five workplace locations. The interview transcripts were analysed for thematic trends to discover patterns, visualise, and share findings (Braun & Clarke, 2012). The coding process required the reading and re-reading to develop an in-depth understanding, the themes process was reviewed three times to ensure accuracy of the data buckets and to realign the buckets where similarities existed (Braun & Clarke, 2019).

Phase 2 Vision: the findings from Phase 1 were taken into phase 2 to create the vision. Within this phase the findings were discussed at a strategic level to create a business case for change, discuss the art of the possible and carry out a cost x benefit analysis. Eight one-to-one interviews were carried out with leadership and c-suite to capture qualitative feedback of their experiences and thoughts for the future (Chevalier & Buckles, 2019).

Phase 3 Detail: utilising the survey and one to one knowledge worker interviews into five workshops with management in order to map out the future working practice and align it with the business culture and strategy. Risks, assumptions, issues, and dependencies were analysed alongside identifying the key stakeholders who are responsible, accountable, consulted, and informed. Data was shared with the architects and designs were mocked up which were then discussed with key stakeholders in a further set of five workshops with a cross section of knowledge workers and team leaders/managers (Luck, 2018).

Phase 4 Implementation: the roll-out of new ways of working pilot commenced with people working in an office for 3 days and at home 2 days (Lahti & Nenonen, 2021). Feedback was collected on a daily basis via a virtual 'post-box' and after 3-months a survey was launched to capture further feedback regarding people's experiences throughout the 3-month period of new ways of working which focused on the experience and adoption of:

- Smart Technologies: Space Booking / AV / A new video conferencing solution / Interactive whiteboards.
- Activity Based Working: Spaces and furniture to aid collaboration, communication, concentration, contemplation, and curiosity.

- Increased flexibility: From 9-5pm Monday to Friday in an office to 3 days in the office with only set core hours of 11-2pm for everybody, providing flexibility of the working day.
- A new leadership approach: From traditional time driven performance management practises to output driven management, focusing on changing the parent-child dynamic to an adult-adult dynamic.

Following thematic analysis, twelve interviews were conducted with departmental managers to explore leadership and management perspectives of guiding principles for the team. This then led to amendments to the proposed new ways of working, to people working in the office 2 days and at home 3 days (Zuber-Skerritt, 2021). Feedback was once again collected on a daily basis via a virtual 'post-box' and again after 3-months a survey was launched to capture further feedback regarding people's experiences throughout the 3-month period of new ways of working which focused on the experience and adoption of smart technologies and activity-based working as before but also included:

- Increased flexibility: From the 3 days in the office with set core hours of 11-2pm for everybody to 2 days in the office with the continued set core hours of 11-2pm.
- Leadership: With a focus on leadership providing regular feedback and ensuring non-transactional conversations to build relationships and trust.
- Continued professional development: Structured courses / in-house training and mentoring.

RESULTS

Throughout the research project which included: surveys, on-site observations, one-to-one interviews and workshops, engagement was high from the knowledge workers, however the senior management were sceptical about changing working practices, evidencing a sense of nervousness and a reluctance to engage a levelling up of working practices. The author noted a sense of 'loss of control and power' for the senior executives and a sense of mistrust for flexible working. There was also concern about cellular offices being removed and therefore a loss of status. The key themes running through the surveys/workshops/interviews before, during and after the project from the cross section of respondents is summarised below:

Table 1 Phase of the project and the feedback trends across each organisational subset (reference 1).

Project Phase	Knowledge Workers	Leadership	C-Suite
Before (0 days working at home)	Flexibility, trust, technology, community, gratitude, and experience.	Presenteeism, productivity, teamwork, and data reporting	Productivity, churn and retention, teamwork, process, experience, presenteeism and trust.
Pilot (3 days office, 2 days home)	Flexibility, trust, communication, learning, mentoring, community, team, technology, and wellbeing	Childcare, onboarding of new recruits, communication, working patterns and times, being contactable, cameras on during VC calls.	Trust, productivity, performance, team effectiveness, communication, uncertainty, culture, and wellbeing.
Pilot (2 days office, 3 days home)	Flexibility, trust, culture, learning, processes, team, and cross-departmental communications	Presenteeism, productivity, being contactable, technology, culture, visibility, and wellbeing.	Productivity, culture change re: hierarchy, visibility, communication, and data reporting.

Before the project commenced, the normal operating model for the organisation was 9-5pm Monday to Friday in an office. Internal employee engagement surveys captured that people were wanting increased flexibility and trust, better technology and an office which offered community and experience. Leadership had concerns about presenteeism, productivity and a lack of transparency of data reporting. The C-Suite were concerned about productivity, churn and retention, inefficient processes, and trust (Edmondson & Mortensen, 2021). When people worked within the office for 3 days and at home for 2 days, the feedback from knowledge workers was themed around flexibility, trust, communication, learning and mentoring, technology, and wellbeing. The standout positives focused on: reduced commuting and the time gained back (90%), increased concentration and productivity (29%), a better work life balance (22%). Comments included:

- *"Our team has worked very well, made us communicate better with each other and less travel time and wear and tear on my vehicle. spending more time at home, I've now become used to this new way of working, although do miss the office also"*
- *"A better work life balance as I don't have 2 hrs commute every day, getting out for more exercise and more time for myself"*
- *"Better flexibility, better interactions with my team who are located over 2 sites, more relaxed atmosphere, not having to struggle through traffic in rush hour"*

When the pilot changed to 2 days in the office and 3 days working at home, people felt their wellbeing increased (51%) they had more time with family (49%) and people felt more productive (40%). Experiences varied throughout the first part of the pilot (3 days in the office, 2 days at home). Many challenges were experienced, ranging from childcare (70%), loneliness (34%), a lack of dedicated space at home (39%), too much screen time (24%) and wellbeing (72%). Comments included:

- *"Workload has expanded and inefficiencies of WFH mean that working time has expanded to take up time that used to be used for active commute so now much less active and unable to switch off from work properly"*
- *"The lack of informal communication with team members and having to ask all questions over Teams/phone call and not being able to quickly pop to a colleague's desk to ask a question/show them something"*
- *"As I live on my own, I sometimes don't see anybody else all day, that can be a bit of a downer. Back-to-back meetings on teams all morning is also a killer as one usually begins before the previous one finishes."*

When the pilot changed to 2 days working in the office and 3 days working at home, people found childcare easier, wellbeing improved, and people reported they had more time to exercise. The November 2021 survey data found that 50% of people had a dedicated room to work from, 35% had a dedicated area but not a separate room, and 15% of people were working from wherever they could i.e., kitchen table or sofa. 89% of people had a desk (an increase from 67% in February 2021), 79% had an ergonomic chair (an increase from 41% in February 2021), 62% had a second monitor (an increase from 50% in February 2021), 97% had Wi-Fi (an increase from 78% in February 2021) and 92% had an audio headset (an increase from 64% in February 2021).

The challenges highlighted how FM can transform their leadership to overcome such challenges. The future office should act as a hub for community, collaboration and connection and adding variety into the working week. The role of FM isn't just within the workplace, the working from home environments also need to be catered for, from providing equipment, such as second monitors and ergonomic chairs, to supporting wellbeing education through training and communications. Communication was a challenge, with nine accepted platforms for communication used within the organisation. MS teams was the most adopted with 80% of respondents utilising it. Throughout the project, the communication

platforms were reduced down to 4 key platforms, with 100% of people utilising MS teams to aid collaboration and streamlined communications.

The data showed people wanted flexibility between working in the office and working from home. The data highlighted that 92% missed people when not working in the office, 46% said they found face to face meetings to be more effective, 67% stated they wanted the work life balance / routines and structure that the office gave them. 60% said they missed the atmosphere of the office and the banter, with other responses including missing the on-site catering, the physical office set-ups, and printing facilities. When asked about ideal working patterns in the future, 30% wanted to work in the office 1 day, 27% wanted to work in the office 2 days, 13% wanted to work in the office 3 days, 26% wanted to work in the office depending on the tasks they were carrying out and only 2% of people wanted to work in an office 4 days, and 2% 5 days. This data highlighted the need for change away from the 5-day working week in an office, and also highlighted that each individual had their own individual needs and wants for their future working patterns.

The main concerns about working in the office in the future provide an opportunity for FM leadership to adapt and transform. Catching covid-19 (95%) provides an opportunity for FM to communicate how they promote and manage a safe working environment for all. Commuting was a key concern (60%) which may provide FM with an opportunity to adopt a new location strategy for their real estate, potentially signalling the need for a hub and spoke model. People were also concerned about returning to the office and not having an assigned desk (50%) signalling a strong attachment to their individual spaces. This provides FM with an opportunity to untether people from their territorial thinking related to the assigned desk and instead create the sense of belonging within the wider building to the organisation, their colleagues and the community feel. When asked what people would go to an office for, meetings (25%), socialising and connecting (28%) and 1-2-1's with line management (21%) were the most popular answers. Other responses included innovating (10%), printing and admin (10%) and concentration work (5%). This data provides FM with the opportunity to ensure the physical spaces meet the requirements of the users which focus on connection, community, and communication (Nanayakkara et al, 2021).

CONCLUSIONS

The research has found that the FM role is to deliver a workplace experience which meets individual preferences, through a human-centric approach (Fenton-Jarvis, 2021), to deliver strategic business objectives; there is not a 'one size fits all' approach to ways of working for an organisation. Employees have complex and individual needs, alongside team working, cross pollination of departments and expectations around structured learning and mentoring. To achieve this FM need to act as the super connector between the employees, HR and IT; through regular communication and feedback loops, with a mindset of continuous improvement. Key themes from the project are highlighted below:

Table 2 Themes and Key Findings.

Theme	Key Findings	References
The Physical Location	Individuals have a range of working from home experiences from dedicated rooms, dedicated areas, to working wherever they can find a space which impacts upon wellbeing, productivity, and experience	Oldman, 2021
Equipment	Individuals have a range of working from home physical set-ups which need to be assessed on an individual basis and in line with job function. Not everybody requires an audio headset and two monitors, but a desk and an ergonomic chair should be considered as hygiene factors	Hertzberg, 1959; Samani, 2015; Carter et al, 2020
Communication	Individuals have different communication needs, preferences, and desires. 20% of people choose to communicate via WhatsApp, 10% of people want	Quirke, 2008; McAlpine,

	to communicate via email and 44% of people miss face to face meetings. Organisations must communicate in a range of methods and empower individual choice	2018; Hayes et al, 2021
Homelife	Individual experiences when working from home are affected by many factors. Whether they live alone, the length of commute, whether they have childcare responsibilities, their physical set-up and wellbeing. FM has an opportunity to cocreate the human-centric workplace through listening, empathy, agility, and human experience	Royal Society for Public Health, 2021; Oldman, 2021
Office needs	Individuals needs and desires of the office, from social interaction to the on-site facilities, and the physical set-up and concerns relating to covid-19, childcare, family life and wellbeing all affect the employee experience and how an office is optimally designed for productivity, experience, and wellbeing (Haynes, 2008). FM is well positioned to transform and drive a human-centric approach to enable all people, no matter where they are located.	Haynes, 2008; Babapour Chafi et al, 2022
Individual Preference	Individual's preferences for future ways of working vary, 30% wanted to work in the office 1 day, 27% wanted to work in the office 2 days, 13% wanted to work in the office 3 days, 26% wanted to work in the office depending on the tasks they were carrying out and only 2% of people wanted to work in an office 4 days, and 2% 5 days. People want choice!	Fenton-Jarvis, 2021; Oldman, 2021
Role of FM	To avoid knee jerk reactions, decision making must be data driven, and collaborative amongst HR, FM, and IT. These teams must take time to reflect, analyse, pilot, and iterate and always remain curious. FM has an opportunity to transform their leadership to drive the human-centric workplace	Nanayakkara et al, 2021; Fenton-Jarvis, 2021; Abisuga et al, 2021

As per Fig 1, this is an evolving process, the workplace is a living breathing dynamic "thing" and therefore will never be finished (Usher, 2018). This case study is ongoing as it moves into the next phase of transformation.

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Hybrid profiles for knowledge workers – flexible workplace and time

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ABSTRACT

Background and aim – As a result of Covid-19 pandemic many organizations have adopted more flexible and mobile working arrangements. Knowledge workers have been able to choose significantly more freely than before when and where they work, hybrid work has generalized. As organizations move into the post-pandemic period, they will re-evaluate what workplace solution serves their needs in the future. This paper aims to construct a framework for hybrid knowledge worker profiles.
Methods / Methodology – The exploratory research process was conducted in two steps. Step one was a framework proposition about hybrid work profiles based on literature and step two included framework testing in eight workshops for 185 persons.
Results – The identified eight hybrid work profiles are based on space and time used in fixed or flexible manner. The context of space and time varies from home-based to office-based network of places. The descriptive framework provides insights to the new user needs of hybrid work.
Originality – The proposed framework builds on previous workplace user profiles related research and practice. It complements previous knowledge, particularly by focusing on understanding the different hybrid workplace user preferences.
Practical or social implications –Hybrid knowledge work profile -classification can be used to identify the types and quantities of hybrid workers' organizations must support the design and updating of the workplaces.
Type of paper – Research paper (full).

KEYWORDS
Workplace development, user profiles, user preferences, hybrid work, higher education.

INTRODUCTION
Covid-19 pandemic has changed the way we do knowledge work. Many organizations have adopted more flexible and mobile working arrangements. On a global scale, knowledge workers have been able to choose significantly more freely than before when and where they work. Flexible way of working has been commonly called hybrid work. Hybrid workspaces are an important feature of the post-pandemic world (Gratton, 2021) and they are understood as 'multiply located' (Halford, 2005, p. 22), with people working more 'flexibly' thanks to information and communication technology (ICT), splitting their time across different places (e.g. home, corporate offices, coworking spaces). Flexible Work Arrangements (FWA) can be implemented through various types of workspaces. The new type of workspaces emerged from FWA include Flex Office (FO), Co-Working (CO), Total Home Office (HOT) and Partial Home Office (HOP). The combination of these new workspace type and flexible working time are the new features of the job satisfaction and high performance (Davidescu et al., 2020).

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The question that arises is what workplace strategies are most effective - how much flexibility around where and when people do their job is best (Gratton, 2020). Employers are expected to check and if necessary, re-design their physical and digital workplaces to offer solutions that support flexible working and hybrid collaboration in an optimal way. (Bababour *et al.,* 2021). In this paper, we focus on hybrid knowledge workers and their profiles on the multi-locational workspaces. This study also tests these profiles in the context of academic workplace development in higher education.

THE FLEXIBLE WORK ARRANGEMENTS

Organizations must evaluate what workplace solution serves their needs in the future. These solutions can range from work from any location to a full return to office-based work, with a whole range of fixed and flexible working arrangements in between (Gratton, 2020). Traditional work practices are transforming towards Flexible work arrangement (FWA) concerning work environment and schedule. FWA offers time and location flexibility for employees to engage in work-related tasks. FWA includes flexitime, contractual working, work shifts (Gill & Siddiqui, 2020), job sharing, telecommuting or remote working and a compressed workweek, while the most common one is work from home (WFH), where employees work full-time from their home (Kossek et al., 2014) The future challenge is to manage inconsistent occupancy rates and impact of the FWA approach. The hybrid and flexible working style and culture is set towards the added value of the companies. Chua et al., (2022) adds on the significance of FWA approach in synchrony with the Global Agenda 2030: Sustainable Development Goals by United Nations.

The possibility to work remotely from home is typically offered in connection with activity-based office (ABO) concept (van den Berg *et al*., 2020.) Once the pandemic has subsided, organizations are updating their considerations about what kind of workplace solution and (ABO) will best support their goals. Falkman (2020) states that ABO concepts will be even more popular from now on, since they are designed to be flexible depending how many choose to come into work, and the work these spaces most encourage is work done together. The fixed location in the office in comparison with a multi-locational work environment is now more common to a larger group of knowledge workers. Many of them will clearly prefer for continuing with at least some working from home in post-pandemic period, indicating high levels of satisfaction for many who have been working from home (Sailer *et al.*, 2021).

Amid the pandemic, the mindset of activity-based working (ABW) seems to be already adopted and implemented although many organizations and workers do not know it by this name. Many of the negative aspects related to the human and physical environment in the current body of literature in relation to ABW concept might diminish as ABW evolves into its new shape. Having control over the work environment, satisfaction with IEQ, privacy, being able to complete focused work and higher productivity rates have already been reported in recent studies on work from home arrangements (Marzan et al., 2022).

The interest to make some pandemic period mobile workplace practices permanent requires from the organizations adaptive and flexible workplace management regarding employees´ individual needs and work/life strategies. The hybrid work environments require changes in the HR-policies but also often in the level of physical work environments, available ICT tools and their use. There is a need to redefine user profiles. Organisations will have to consider remote policies and practices in the post-pandemic future to gain many consequential benefits and to address increasing remote work expectations. This will require a review of organisational practices, and cultural and physical support for work-from-home arrangements based on the diversity in work tasks, individual possibilities to work from home as well as both individual and social productivity and wellbeing. (de Klerk et al., 2021).

The traditional user profiles consider e.g., mobility of employees (Lilschkis, 2003; Greene and Myerson, 2011), digital competencies (Rantala, 2016) and the motivation of workers to implement new ways of work practices (Dau, 2017). The four knowledge worker user profiles by Greene and Myerson (2011) have been widely applied both in the research and practice: office-based (1) *anchor* and (2) *connector*, and widely afield working (3) *gatherer* and (4) *navigator* have helped to understand the variety of spaces and tools that knowledge workers can adjust based on their individual preferences and the tasks in hand. The digital profiling of Rantala (2016) focused on different demands, attitudes and goals related to technology use of knowledge workers. Profiling helps the designers to target digital services to certain user groups and be assured about the real demands and effective use. (Petrulaitiene *et al*. 2018.) Dau (2017) investigated what drives individuals towards mobile work elsewhere than office. Her research concentrated on the workplace in social, physical, and virtual contexts where autonomy, relatedness and competence can be supported. (Petrulaitiene *et al.*2018.) The traditional user profiles do not build on the fact that the work from home can be option more knowledge workers than ever, see e.g. Sailer et al, 2021).

Gratton (2021) states that organisations must put more attention to the shift made along the time axis, from being time-constrained (working synchronously with others) to being time-unconstrained (working asynchronously whenever they choose). Pandemic period made the shift from being place-constrained (working in the office) to being place-unconstrained (working anywhere). These space and time dimensions are presented in the Figure 1.

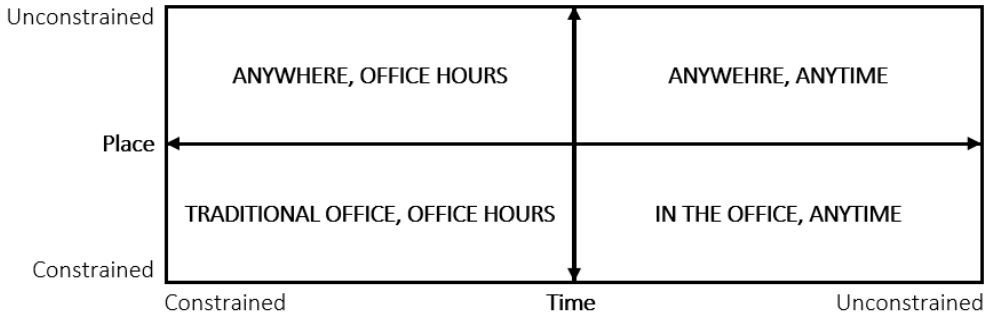

Figure 1 Work arrangements in space and time (applied from Gratton, 2021).

Before Covid-19, most companies offered minimal flexibility along both dimensions. The traditional user profiles are also articulated in this limited context. This put them in the lower-left quadrant, with workers in the office during prescribed hours. Some firms had begun to venture into the lower-right quadrant, by allowing more-flexible hours. The traditional user profiles are also articulated in this limited context. Some companies were experimenting in the upper-left quadrant, by offering workers more flexibility in where they work, most often from home. Very few firms, however, were moving directly into the upper-right quadrant, which represents an anywhere, anytime model of working—the hybrid model. (Gratton, 2021.) Flexible Work Arrangements connect both time and place, which has been described in individual level by Falkman (2020). She proposes four different core strategies for dealing with individual work and life in the digitally set work-life. They are (1) total integrator, (2) place separator, (3) time separator and (4) total separator and illustrated in the Picture 1.

TOTAL INTEGRATOR Integrating work and space: working anywhere, anytime	PLACE SEPARATOR Integrating time, separating space: working anytime, but only in the office
TIME SEPARATOR Separating time, integrating space: working anywhere, but only during office hours	TOTAL SEPARATOR Separating time and space: working office hours at office

Figure 2 Four strategies for dealing with digitally set work-life (applied from Falkman, 2020).

A time separator works only during office hours, while a total integrator can work anytime such as weekends, evenings and vacations. A place separator only works at dedicated spots such as a desk at home. A total integrator works wherever; for instance, in the bedroom, the kitchen, living room and bathroom. Most people combine or switch strategies due to workload, family life or personal taste. This might be the way to understand how organizations can develop the office of the future. By customizing the configurations to the specific workplace, we will see a renewed interest in workplace design and health (Falkman, 2020).

To construct a framework of different hybrid work profiles of workplace users, four strategies for dealing with digitally set work-life (Figure 1) and four work arrangements in space and time (Figure 2) were integrated. As Baygi et al. (2021) state that the task of researchers is to locate bounded actors spatially in space and time to get hold on fluid and dynamic life and work. The integration provides a compass with eight compass points – this is a framework for hybrid work profiles.

The basic elements are space and time. They can be fixed or flexible. Eight different employee preferences can be identified (Table 1).

Table 1 Framework of space and time to hybrid profiles.

Basic element	Basic quality	Employee preference	Clarification	Justification examples
Space	Fixed	Home	Home as a prior workplace	Many of knowledge workers will clearly prefer for continuing with at least some working from home in post-pandemic period, indicating high levels of satisfaction for many who have been working from home (Sailer *et al.*, 2021)
		Office	Office as a prior workplace	ABO concepts will be even more popular from now on, since they are designed to be flexible depending how many choose to come into work, and the work these spaces most encourage is work done together (Falkman 2020)
	Flexible	Home orientated	Using office while home is the prior workplace, integrates office to home	Flexible Work Arrangements (FWA) can be implemented through various types of workspaces. The new type of workspaces emerged from FWA include Flex Office (FO), Co-Working (CO), Total Home Office (HOT) and Partial Home Office (HOP). Davidescu et al., 2020).
		Office orientated	Using home while office is the prior workplace,	

			integrates home to office	
Time	Fixed	Home	Works only during office hours at home	Employees work full-time from their home (Kossek et al., 2014)
		Office	Works only during office hours	Work from any location to a full return to office-based work, with a whole range of fixed and flexible working arrangements in between (Gratton, 2020).
	Flexible	Home orientated	Integrates time in the office with the time worked at home	FWA includes flexi-time, contractual working, work shifts (Siddiqui, 2020),
		Office orientated	Integrates time at home to the time worked in the office	Job sharing, telecommuting or remote working and a compressed workweek (Kossek et al., 2014) People working more 'flexibly' thanks to information and communication technology (ICT), splitting their time across different places ((Halford, 2005)

The preferences of workplace vary from fixed home (1) or office (2) setting to twofold flexibility: (3) using office while home is the prior workplace, integrates office to home or (4) using home while office is the prior workplace, integrates home to office. The preferences of worktime vary from fixed office hours at office (5) to fixed office hours at home (6). Preferences about flexible time use are also twofold: employee integrates time at the office with the time worked at home (7) or employee integrates time at home with the time worked at office (8). The office use from the perspective of new member in the organisations is considered in the profiles as a notable profile.

METHOD

This paper aims to construct a framework for hybrid knowledge work profiles by two steps and follows the exploratory case study method in the empirical step two. The method aims to prove tested propositions by investigating distinct phenomena characterized by a lack of detailed preliminary research, in this case the hybrid profiles of knowledge workers (Seaton and Schwier, 2014). Exploratory case study attempts to answer questions typically framed by the pronoun what (Yin, 2014). It seeks to define research questions of a subsequent study or to determine the feasibility of research procedures. (Hancock & Algozzine, 2011)

Step 1 was a conceptual proposition of eight hybrid knowledge worker profiles based on the literature review. The latest research of flexible work arrangements was investigated. Two frameworks from 2020 and 2021 were integrated and the basic elements of space and time were categorised at first according to flexible and fixed work arrangements. Then eight different user preferences were identified. The method used was based on literature review, but the profiling is seeking also support from ethnographic techniques of creating personas. Such techniques help to identify patterns which differ between different users (Goodwin, 2008).

Step 2 was about framework testing. Eight workshops performed in university administration groups in Finland. Total number of participants was 185. The group size varied from 8 persons to 49 persons. The groups were existing administrational units, which wished to join to the workshops connected to returning to the office. So, the participants knew each other and discussed about the topics in the context of their own team. Data collection was conducted between November 2021 and April 2022 and

involved three types of workshops. Two of them was conducted as face-to-face workshops, 6 remotely, using MS Teams and a digital facilitation tool called Flinga and one in a hybrid way: part of the participants was present and part of them joined remotely, using Flinga. The structure of each workshop was similar: 1. Description on proposed profiles. 2. Individual silent task to choose and mark the own profile: everyone individually chose the profile, which was the most descriptive. They indicated it by setting a sticker (in face-to-face workshop to the paper and in digital workshops to Flinga board) under the chosen profile. 3.The group-discussions focused on identifying the diversity in the flexible ways of working and exploring the needs of different profiles.

The participants were from different administrational units from university administration with some jobs that are mainly onsite and some that can be performed remotely (planning, administration, meetings, etc.), both during and after the pandemic restrictions were in force. The organisations had devised a post-pandemic strategy for remote and on-site work at the time of data collection. In total, workshops involved 196 participants, who worked part- or full-time from home due to the pandemic. The topic of the workshops was about the return to office and identification of new workstyles and hybrid work profiles. One workshop was connected to identification of the new workstyles and hybrid work profiles in relocation of the office and one in refurbishment of the office. Workshops are summarised in Table 2.

Table 2 Workshop details.

Number	Date	Duration (h)	Participants	Workshop topic
1	Oct 2021	3	13	Return to office
2	Nov 2021	1	16	Return to office
3	Dec 2021	2	16	Return to office
4	Dec 2021	1,5	12	Return to office
5	Jan 2022	1,5	7	Return to office
6	March 2022	3	40	Return to office
7	March 2022	2	32	Relocation
8	April 2022	1,5	49	Refurbishment
Total			185	

The workshop notes about discussions were transcribed and anonymized. The content from the Flinga boards was analyzed together with the transcriptions. The content analysis was based on a bottom-up coding strategy. The collected data from eight workshops were analyzed and discussed in a framework development group. Summaries of the workshops were provided for the participants. The workshop outcomes were analyzed from two angles. Firstly, they were analyzed from the viewpoint of what kind of fit for hybrid knowledge work profiles were found among participants. Secondly, they were examined to see what kind of topics emerged in terms of physical, digital, and social work environment as well as work time. To increase the reliability of the results the analysis was conducted simultaneously by two researchers. One has joined the workshops and the other was analysing the data without participation in the workshops aligning the transcript material more to the proposed framework.

RESULTS

Proposed hybrid work profiles

Combining space and times categories systematically different employee preferences conceptually provided eight different hybrid knowledge work profiles (Table 3).

Table 3 The hybrid work profiles.

Space				Time				
Fixed		Flexible		Fixed		Flexible		
Home	Office	Home orientated	Office orientated	Home	Office	Home orientated	Office orientated	
o				o				8 Mostly at home all week
o						o		7 Flexible use of multiple places, flexible time
		o		o				6 Dropping in the office unfrequently
		o				o		5 When needed in the office by agreement
			o				o	4 Flexible times in the office during the week
			o		o			3 Frequently in the office part of the week
	o						o	2 Constantly in the office as a beginner in the organization*
	o							1 Mostly in the office all week

The short profile descriptions are the following emphasizing the mindset of time and place in different profiles.

(1) *Mostly in the office all week*

Office is the primary workplace and the fixed office hours are setting the rhythm to the workday and week.

(2) *Constantly in the office as a new face in the* organization

Office is the primary workplace because the person is new in the organization and the physical workplace is one way to get to know the culture of the organization. Later the person can be reset based on the work task requirements and the life situation of the person.

(3) *Frequently in the office part of the week*

Office is the primary workplace, but the time used in the office is organized externally e.g. in shifts. This person tends to spend a defined period in the office and the periods might be fixed. The rest of time is working at home.

(4) *Flexible times in the office during the week*.

Office is the primary workplace, but also home is used for working. This person tends to spend a few days a week in the office and the days are chosen in a flexible manner.

(5) *When needed - in the office by agreement*

Home is the primary workplace, but the person is coming to the office when needed for meetings or other tasks.

(6) *Dropping in the office unfrequently*

Home is the primary workplace, but the person is visiting the office occasionally e.g., in organised social events for the team, unit etc.

(7) *Flexible use of multiple places with flexible time*

Home is the primary workplace, but also the other locations, such places can be cottage, satellite office, library nearby and, which are determined by the individually.
(8) *Mostly at home all week*.
Home is the primary workplace and time is fixed to office hours.

The profile testing in the workshops

The most popular profile was the profile "Flexible times in the office during the week". The second profile "When needed - in the office by agreement". Table 4 is summarizing the choices.

Table 4 Frequency of the profiles in the data.

	Profile description		Choices
1	Mostly in the office all week		18
2	Constantly in the office as a new face in the organization		3
3	Frequently in the office		4
4	Flexible times in the office during the week		75
5	When needed - in the office by agreement		47
6	Dropping into the office unfrequently		19
7	Flexible use of multiple places, flexible time		13
8	Mostly at home all week		6
		In total	185

When comparing the office as a primary workplace -orientated profiles (1-4) to home as the primary workplace -orientated profiles (5-8), the former group includes 100 choices while the latter one includes 85 choices. The dissemination of the profiles indicate that all profiles were recognizable from the sample. The network of places in multilocational work can be home-based or office based.

These eight profiles provide a tool to discuss the working from home -preferences in balance with the working from office-preferences. The choice of the profile was mentioned to be challenging because the organization is still in the transition of hybrid working culture and the limited experience of the hybrid work mode effect to the choice. The descriptions were clear enough and the role of working from home aspect was appreciated. The academic year and its requirement might change the weight in some profiles as well as the circumstances at home e.g., the surrounding noise due to infrastructure renovation can affect occasionally the user preferences of multilocational work.

The outcome of discussion about the diversity in the flexible ways of working and the needs of different profiles are summarized to the Table 5.

Table 5 The different needs of different profiles.

	Profile	Work environment		
		Physical	Social	Digital
1	**Mostly in the office all week**	Alternatives to choose e.g., in the furniture: individual and social work processes and spaces for them	Joy of meeting people Separating the work from leisure time	Amount and size of screens Digital meetings and space for them
2	**Constantly in the office as a new face in the organization**		Meeting people – learning the culture	Learning the digital culture

3	**Flexible times in the office during the week**	Using meeting facilities	Informal social time important New ways of planning the time use with the team	Digital meetings and space for them
4	**Frequently in the office**	Sharing workstations	Easy to agree meetings to the office	
5	**When needed - in the office by agreement**	More emphasis on social work processes and spaces for them	Using booking systems for collaborative spaces New ways of planning the time use with the team	
6	**Dropping into the office unfrequently**		Informal social time important	Carrying the essentials with
7	**Flexible use of multiple places, flexible time**	Diverse places with diversity in ergonomics	Working along together with the people outside the work community	Easy to move around technology
8	**Mostly at home all week**	Homestudio	Socially depending on digital community	Importance of hybrid meeting practices

Common themes for all the hybrid work profile were:

- The inclusiveness: the hybrid work profiles in one organisation causes situations for hybrid events: some are physically present and some on-line. One need to pay attention to inclusiveness so that everyone can feel the sense of belonging to the community.
- The workplace with add-on´s: The office environment is not only about meeting and working facilities but also about little issues along the workplace user journey: storage for different purposes during the day is important, the needs are diverse for different hybrid profiles.
- The unity: It is important to ensure that the house rules of physical place in the office but also in digital behaviour e.g., in Teams-meetings are aligned in large scale while the work will be more multilocational.

Summary of the results

The value of eight hybrid work profile is in enhancing the discussion about the different orientations to time and place as part of the hybrid work. It is not only one individual working in hybrid way with own choices – the individual choices effect to the team and work community. The hybrid work requires the dialogue with fixed and flexible orientation to time and physical, social and digital place and its use.

PRACTICAL IMPLICATIONS

The hybrid workplace development is driven much more than before by the workplace users' individual preferences especially in terms of flexible use of time and home. This is related to organizations´ interpretations and decisions of the most effective way to organize the work, time, and place. The proposed framework provides a tool for discussions about the diversity of requirements for the hybrid workplace, which is multi-locational.

Hybrid knowledge work profile -classification can be used to identify the types and quantities of hybrid employees in the organization. The profiles are outlines rather than accurately distinctive definitions. The profiles may to some extent overlap with each other. The profile is also context dependent and can

change e.g., according to the changes in the work tasks. The profiles may evolve over time. In this study, the eight hybrid work profiles were tested with staff of university administration, while the hybrid working culture was just about to start to develop. However, this framework can be also applied to investigate the user profiles of other knowledge work environments such as students in academic context or user of coworking space in the context of multi-tenant office environments.

In practise, the profile investigation could be conducted as a survey, or as in the empirical data gathering by using digital collaboration platform (e.g. Miro or Mural). The framework can be especially useful in the needs assessment phase of a project - it is a tool to gather initial information when updating current activity-based offices and developing new ones. This information can also be useful when discussing and agreeing in the organization, unit, or team level about how the workplace is used and should be used.

CONCLUSIONS

The hybrid and flexible work arrangements increase the dimensions of work time and workplace. The traditional office hours can now be conducted at home. The fixed use of time has traditionally set the requirements for the office and its services. The flexibility in time and place transforms our work practices, our mindset, and our physical, digital and social work environment.

This research aimed to understand the balance between different hybrid knowledge work profiles. The sample of this research was limited to a single university and group of its administration employees in a single country. This directly influences the generalizability and reliability of the results. However, this research can be seen as a starting point for future research. Future research is needed to verify and refine the framework and its profiles. Following studies could focus for instance on applying the framework in workplace workshops for different user groups. In the context of higher education these could be students or academic personnel. The hybrid workscape with physical, digital, and social flow is the entity for hybrid individuals, teams and organisations to develop further.

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BIM-based information model for the provision of the demand-oriented facility management services janitorial cleaning

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ABSTRACT

Background and aim – Facility management (FM) refers to multidisciplinary activities pertaining to performance-based or results-based delivery. Although results-based delivery provides economic benefits, missing definitions of the demands on executing facility services (FS) present a challenge to contractors. Existing sensor-based systems for identifying the demand of FS require building-relevant information. Building information modeling (BIM) offers the possibility of creating FM-relevant information as early as the building planning phase. While not all data from the planning phase are relevant for executing FS, we aim to present a BIM-based information model for the sensor-based determination of executing FS.
Methods / Methodology – This research focuses on the FS of janitorial cleaning. First, an analysis of contract specifications is conducted to identify demand orientation in tendering and awarding processes. Next, the information required for the execution of FS is defined, structured, and constituted as an information model. The model includes interfaces for implementing a sensor-based determination of executing FS.
Results – The result is an information model containing all the required information to provide effective FS. The linking of the individual information structures of the model forms the basis of using sensor-based methods to determine the demands of FS demand-based-delivery.
Practical or social implications – Information on the demand and location of a service provision is necessary to determine the requirements of FS as well as to commission, perform, and document activities. Different stakeholders can use the developed information model. By the model, the required information is already defined in the planning phase of a building, which minimizes the risk of information loss.
Type of paper – Research paper (full).

KEYWORDS
BIM, demand-oriented FM, soft facility service delivery, janitorial cleaning.

INTRODUCTION
At 44%, occupancy costs are the most significant cost component in the life cycle of a building (Bogenstätter, 2008; Litau, 2015). Infrastructural facility management (FM) encompasses multidisciplinary soft and hard facility services (FS). Hard facility services relate to technical aspects such as building services or plant and machinery. Soft facility services (SFS) pertain to the management of human needs in the use of a building, such as janitorial cleaning or space management. Infrastructural FM accounts for the second-largest revenue share of SFS. In 2020, the FM industry generated revenues of €44.7 billion, of which 59% (€26.37 billion) was attributable to infrastructural FM (Lünendonk &

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Hossenfelder GmbH, 2021). However, infrastructural FM is also the most significant cost driver in the management of buildings; depending on the type of building, 50% to 73% of costs in infrastructural FM are attributable to cleaning (Rotermund, 2016). In FM, SFS can be delivered in a performance-based or output-based manner, which is also known as demand-oriented FS delivery. In performance-based delivery, the main concern is the actual activity process and the quality of service delivery. Service delivery is based on defined process specifications, whereby the need for service delivery is assessed at particular intervals of service delivery, such as weekly or daily. Service descriptions include the performance and functional requirements stipulated in service level agreements (SLA) (Hirschner et al., 2018). While delivering demand-oriented SFS, the focus is not on the performance process but on the achieved result that was previously agreed upon between the contracting parties (Gondring et al., 2018). The performance of SFS requires building-relevant information that occurs at different phases of a building life cycle. Collaboration amongst project stakeholders in FM for exchanging required information is one of the biggest challenges in the architecture, engineering, and construction (AEC) industry. By supporting this collaboration, building information modeling (BIM) can advance FM activities handled by different stakeholders (Wills et al., 2018).

The successive digitalization of the AEC industry in Germany, particularly in BIM and sensor technologies, represents opportunities for delivering SFS in a more efficient way. BIM is a rapidly evolving method in the AEC industry (Fauth et al., 2019) and has been gradually implemented in infrastructure projects in Germany since 2020 (BMVI, 2015). Through BIM, information is theoretically utilizable from the planning phase to the use phase of buildings. In addition to BIM, sensor technologies and the Internet of Things (IoT) are recognizable trends in the FM industry (Al Dakheel et al., 2020; Fialho et al., 2020). In practice, IoT and sensor technologies are used in sub-areas of FM, such as energy management, occupancy management, or janitorial cleaning (Jaspers et al., 2018). Sensor technologies offer the possibility to record condition parameters. The monitoring, interpretation, and associated information generation of building environments form the basis for FS delivery (Dibley et al., 2011). The most significant drawback to FM-based sensor technologies is their realization via niche products programmed and installed by software manufacturers for specific customer needs (Pärn et al., 2017; Zhang et al., 2015). Software manufacturers neglect to provide scientific elaborations concerning the determination of needs for demand-oriented SFS delivery. While recent research endeavors focus on sensor-based FM, the integration of BIM for demand-oriented FS is lacking. Moreover, the focus of using sensor technologies in FM is energy management and maintenance management, which considers individual sub-areas of FM, but not service-oriented activities of IFM (Atta et al., 2020; Edirisinghe et al., 2020). We seek to demonstrate and link the information required for demand-oriented SFS delivery which must be known at the planning phase of buildings. First, we quantitatively analyze FM contract specifications of janitorial cleaning with regard to the status of demand orientation. Next, the information required for the demand-oriented FS delivery is defined, categorized, structured, and constituted as an information model. Simulations are conducted to test whether the information model comprises the correct values of information for determining demands and delivering SFS. We conclude with a discussion of the results and with an outlook on potential future research directions.

LITERATURE STUDY

BIM in FM

To date, BIM is primarily used in the planning phase and construction phase of buildings (Succar, 2009), whereas the usage of BIM in FM is rare, despite known advantages (Bartels, 2020; Bender et al., 2018). BIM in FM is applicable to SFS, such as space management support (occupancy planning), contract management (transfer of tenant data into the BIM model), realizing FM sustainability targets according to “German Facility Management Association” (GEFMA) guideline 160 "Sustainability in Facility

Management" (Wills et al., 2018), occupational health and safety for FM staff (Wetzel et al., 2018), hard facility services such as maintenance and repair (GEFMA, 2019b; Hu et al., 2018), the planning of remodeling and new construction measures, and simulations for energy optimization (GEFMA, 2019b). To use BIM in FM, requirements for FS delivery must be considered as early as the planning phase of buildings (GEFMA, 2019b). Therefore, the requirements must be integrated into the Employers Information Requirements (EIR). The EIR aim to ensure that the correct quality and quantity of information is available in the correct place simultaneously (GEFMA, 2019b; VDI Verein Deutscher Ingenieure, 2020). Defining detailed requirements of FM in the EIR avoids conflicts between stakeholders (Becerik-Gerber et al., 2012; Kassem et al., 2015).

Contributing to the problems cited by Teicholz (2013) for the low level of BIM in FM are a lack of information required for FS delivery as well as the poor quality and quantity of information (Bartels, 2020; Giel et al., 2016). However, internationally, BIM in FM is limited to less than 1% of all new and as-built buildings (GEFMA 926). Reasons for the limited use are a lack of standards and the unrecognized benefits of a life-cycle approach in companies (CAFM Ring e.V., 2017). Moreover, data relevant for demand-oriented FS delivery are not known in the planning phase of buildings but must be provided by the client. Paradoxically, the client to perform FS is not assigned until the use phase of buildings. In practice, FM receives a large amount of irrelevant information for the actual FS delivery (Kassem et al., 2015). As an example, the cleaning of floor surfaces is mentioned: in addition to the relevant information of the surface material, in practice, other attributes are supplied, such as the thickness of the covering and the fabric of the underlying structure, e.g., screed, and the ceiling. Unnecessary information leads to extra work in terms of management and structuring (Dias et al., 2020). The inconsistency between information supply and information demand represents another barrier in integrating BIM in FM. Although BIM enables greater information for FM, this information is not necessarily represented in FM-compliant semantic formats (GEFMA, 2019b). According to the recommendation of GEFMA, the concepts for the provision of services should be prepared within the construction phase in the life cycle phase (LCP) 3 of a building and commissioned in LCP 6, which is the maintenance and usage phase of a building (GEFMA, 2013b). However, the requirements of service providers known from practice cannot be integrated into the building planning process since the development of concepts, commissioning of service providers, and handover of documents occurs at a later stage. While BIM is primarily used for hard FS, research endeavors on BIM for SFS are rare.

Sensor technologies in FM

In FM, sensor technologies and the IoT represent a significant trend in further developments of digital building operations: A study of FM companies from 2019 shows that 36% of the participants name sensor technologies and IoT (34%) as a significant trend in digital building operations. Other trends are service robots (26%), e-commerce (24%), Augmented Reality (23%), machine learning (22%), and Artificial Intelligence (21%) (Hossenfelder et al., 2020). By IoT, building users, facilities, components, and FS can be (physically) connected by sensor technologies to communicate with each other (Jaspers et al., 2018). Furthermore, the IoT enables FM stakeholders to create knowledge-based sensor data to link and retrieve this data on demand via intelligent systems such as information platforms (Atta & Talamo, 2020; Jaspers et al., 2018). In FM, IoT describes the current behavior of building subsystems, building users, or user experience. Furthermore, IoT can be used to monitor the climate, energy and resource consumption, building condition (from a structural engineering point of view), or the demand for space (Jaspers et al., 2018). FM-based sensor technologies lead to improvements in FM, e.g., in the area of space management or maintenance and repair planning (Gomes-Jauregui et al., 2019; Parn et al., 2019). Energy management and maintenance management constitute the services mainly used in BIM- and FM-based sensor technologies (Al Dakheel et al., 2020; Atta & Talamo, 2020; Edirisinghe & Woo, 2020). The research field on the integrated approach of BIM and sensor technologies in FM considers individual

sub-areas of FM but not demand-oriented SFS delivery. Full-scale research and integration approaches for using BIM and sensor technologies in FM with all the associated task areas, especially in operational FM, are only available in rudimentary form.

RESEARCH METHODS

Before identifying and defining information required for SFS, demand orientation in current tendering and awarding processes has been investigated. Therefore, we have analyzed the specification of services, contract documents, and SLA of tendering processes (n=43) for janitorial cleaning. The analyzed documents of public and private clients cover a total area of 84,664.96 sqm cleaning area. The keywords, and any combination thereof, that were searched were "as needed," "if required," "as required," "as necessary," "as and when required," "if necessary," "according to requirements," "as the need arises," "demand-oriented," "just in time cleaning," "dependent on requirements," or "just in time delivery." Next, the required information for executing the SFS janitorial cleaning had to be identified and constituted as an information model. The constitution of a model for identifying the determinants of demands is a multi-stage process. To identify the general information required to deliver the SFS janitorial cleaning, a comprehensive literature review was conducted to gain an overview of the required information on demand-oriented FS delivery. To this end, the review included an in-depth survey of guidelines, standards, and best-practice approaches. Moreover, the previously analyzed documents of current tendering and awards processes have been investigated with regard to information required for fulfilling janitorial cleaning. In particular, the GEFMA guideline is applied in European countries such as Austria and Switzerland. While in Europe, the cleaning industry is subject to legal regulations, in the US, for example, no licenses or regulations are required exclusive to this industry. In the USA, various municipal guidelines and occupational health and safety regulations are required, including those relating to the use and safe storage of cleaning chemicals and compounds. (Lang, 2021). Table 1 shows the investigated guidelines and standards classified by institutions. Guidelines by the GEFMA and "German Social Accident Insurance" (DGUV) are only available in German. The authors have listed the original guideline titles and the translation in the table below. To ensure that the information identified is generally valid for different building types, analyzed documents were examined according to building and room use types per DIN 32835-2.

Table 1 Reviewed guidelines and standards.

Institution	Guidelines and standards
DIN	DIN 32736:200-08: Building Management – Definitions and scope of services. DIN 32736:200-08-Beiblatt 1: Building Management – Definitions and scope of services – Comparisons of services. DIN 32835-1:2007-01: Building Management – Definitions and scope of services – Comparisons of services. DIN 32835-2:2007-02: Technical product documentation – Facility management documentation – Part 2: Building occupancy documentation DIN EN 15221-5-5:2011: Facility Management – Part 5: Guidance on Facility Management processes; German version EN 15221-5:2011 DIN EN 13549: Cleaning services – Basic requirements and recommendations for quality measuring systems; German version EN 13549:2001 DIN EN 13549 (2001-08-00): Cleaning services – Basic requirements and recommendations for quality measuring systems; German version
GEFMA	GEFMA 100-1: Facility Management: Grundlagen (Facility Management: Basics) GEFMA 100-2: Facility Management: Leistungsspektrum (Facility Management: Range of services) GEFMA 198-1: Dokumentation im Facility Management (Documentation in Facility Management)

	GEFMA 198-2: Dokumentation im Facility Management – Einzeldokumente (Dokumentenliste) (Documentation in Facility Management) – Single documents GEFMA 922-01: Übersicht zu Daten und Dokumenten im Lebenszyklus einer Immobilie (Overview of data and documents in the life cycle of a building) GEFMA 470: Austausch digitaler Daten im FM (Digital data exchange in FM) GEFMA 924: Datenmodell, Kataloge und Ordnungsrahmen für das FM (Data model, catalogs, and regulatory framework for FM)
Other	DGUV-R 209, DGUV Regel 101-019: Regeln für den Umgang mit Reinigungs- und Pflegemitteln (Rules for handling cleaning and care products) DGUV-I 659: DGUV-Informationen – Gebäudereinigungsarbeiten (Information – Building cleaning services) (German Statutory Accident Insurance [GSAI])-Information: DGUV Regel 101-605: Branche Gebäudereinigung (Branch cleaning services) BGR 209 DGUV Regel 101-018 (2001-10-00): BG-Regel - Umgang mit Reinigungs- und Pflegemitteln (Handling cleaning and care products)

Once the required information had been identified, the results were categorized according to content context. Subsequently, the categorized information was structured by its content and divided into process information, building information, and sensor information. In order to determine demands based on information, the structuring of information is established on the modeling of a relational database. The applicability of the developed BIM model is tested virtually as a simulation which enables different scenarios of the utilization phase to be run through in a theoretical building. The building information represents a non-real office building in IFC format, edited in the BIM software Autodesk Revit 2021. The considered maintenance area is 408.48 sqm. The information structures were exported from the Autodesk software and imported into the CAFM software. In the simulation, 64 virtual sensors are used that count up measured values, e.g., people counters and garbage can levels. Fifteen sensors are used, counting down measured values, e.g., levels in soap and hygiene dispensers. The simulated factors are weather, number of people in the building, and dust content of indoor air.

RESULTS

Demand orientation in janitor cleaning

The analysis of current tendering and award process documents has shown that explicit definitions of the demands of service are missing. As shown in Figure 1, only 72% of the analyzed documents mention demand-based keywords. Further examination of these documents has revealed that only 6% of them include a description of demands. However, the mentioned definitions indicate that the recognition of a demand to execute FS is the contractor's responsibility. None of the examined documents contains objectively traceable and measurable metrics for when demand exists.

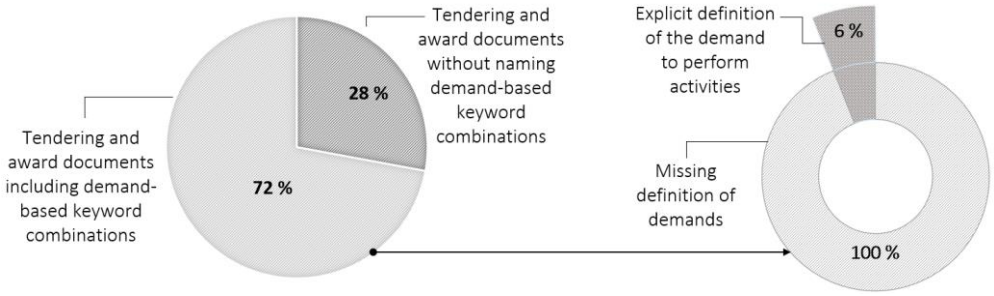

Figure 1 Demand-orientation within tendering and awards documents of janitorial cleaning.

Relevant information for providing the facility service of janitor cleaning

The literature reviewed in this paper shows that SFS are performed on elements, areas, and facilities. To provide a sufficient quantity of information for FM performance from the planning phase to the operational phase, particularly in regard to the SFS of janitorial cleaning, the following information is required: cleaning interval, surface material, elements to be cleaned, spatial placement of the elements, work method (e.g., sanitary module or wet area), quantity and size of elements, care instructions, job description, and building accessibility. Next, the defined information must be categorized. The categorization of information according to its context is based on the types of information defined by GEFMA, which result in such categories as “as-built,” “process,” and “other information” (GEFMA, 2013a). Table 2 shows the identified information categorized according to its content context.

Table 2 Categorization of required information for FS performances.

Type of information	Content	Justification
As-built information	Buildings and furnishing (surface material, spatial placement, elements, quantity, size)	In the use phase of buildings, the construction only changes due to external interventions, e.g., a planned refurbishment, modernization, or remodeling.
Order information (process information)	Service provider (contact, payment terms)	Information on SFS contract awarding, such as the service provider, only changes due to an intervention by the FM, e.g., the commissioning of a new contractor.
Status information (process information)	Demand / need	The current state of elements is subject to changes even without explicitly planned external influences. For example, the degree of soiling of floor surfaces is changed by foot traffic and weather influences.
Information on consumption (process information)	Demand / need	Media consumption and fill levels (e.g., soap) in buildings in use change continuously and are therefore categorized as dynamic.
Other information	Activity/task (care instruction, execution, cleaning area, cleaning interval/schedule)	Information relevant for the delivery of SFS that are agreed in SLA only changes due to an intervention by the FM, for instance.

In summary, three types of information are identified that are relevant for the delivery of SFS:

1. Information about the building, equipment, spatial allocation, surfaces, and materials, which do not change without external influence. In the following, this information is referred to as "building information."
2. Information describing the performance of services, such as, activities, method of performing the activity, times, contractor, and instructions for performing the activity. This information is referred to as "process information."
3. Information concerning the need for activity execution. Although the interval is static, it is classified as dynamic concerning the demand orientation. Since sensor technologies determine the demand for fulfilling FS delivery, this information is referred to in the following as "sensor information."

The information relevant for providing a service is now categorized but is not interconnected. Therefore, the categorized information is structured into meaningful entities with attributes. First, building information and process information are structured, followed by the structuring of sensor information.

Structuring of building information

First, we will structure the above identified and categorized building information for executing SFS. Categorizing a building demands a unique identification and location (GEFMA, 2019a). While an identification number (ID) enables a unique identification, the address of a building specifies its location. Since a building commonly consists of floors that include rooms, floors and rooms represent the required information for spatial placement. A unique number and name identify both. The execution of SFS demands an area, which is the size of a room. Rooms, in turn, contain elements where the execution of activities takes place. Elements include all objects located in a building, i.e., equipment and furnishings, components, and installations. All elements in a building have at least one surface. An example is a wall whose surface is wallpaper. However, some elements consist of multiple surfaces and surface materials, such as a chair with casters of plastic, a frame of metal, and a seat of linen fabric. In order to structure the content of the multitude of elements in a building, elements are typified in BIM. The assignment of an element type to each element, such as furniture, technology, sanitary equipment, or walls, is already used in applying open data exchange formats such as Industry Foundation Classes. The FS delivery is implemented via room groups or component groups. Therefore, grouping elements allows the delivery of FS to occur flexibly with regard to individual elements or several related elements, enabling demand-oriented service delivery. Moreover, janitorial cleaning contains care instructions with details on cleaning. Other FS also contain instructions that must be considered when performing activities, such as the safety warnings for the maintenance and operation of elevators and escalators (DIN, 2017). Since activities are performed on elements, the instructions also refer to these.

For realization in a database, the information defined above must be combined into meaningful entities and attributes. The authors choose primary keys in IDs for unique identification in a database to identify the entities.

Structuring of process information

Next, we will structure information concerning the SFS delivery performance, referred to as “process information.” An SFS delivery consists of a job, an order, and a client. Each job consists of various activities. For instance, the delivery of janitorial cleaning includes activities such as vacuuming, dusting, or mopping. Service delivery comprises the commissioning, the execution, and the documentation of activities. In practice, various activities, such as filling soap dispensers, emptying dust bins, and wiping floors, can be combined into one order. Therefore, an order includes a clear description of the activities required, the address of the client, and a textual description of the activity required. The execution time is a parameter for remuneration and control over the performance. For demand-oriented SFS delivery, the possibility of direct notification to the skilled worker instead of the company contact should exist. The type of notification can take various forms, such as SMS or e-mail. Analogous to the structuring of building information, separate entities and attributes of the process information are interconnected.

Structuring of sensor information

For delivering SFS on demand instead of in defined fixed intervals, sensor technologies conduct the recognition of demands. For this purpose, information that influences SFS delivery is to be derived from the activities of an SFS. Exemplarily, the demand of cleaning floors depends on the information “degree of soiling.” Sensors that are mounted on elements within rooms record the level of soiling. An IP address and a unique name identify the sensor. Sensors are integrated into a network and communicate via protocols. Moreover, the sensors for recognizing demands are located on and in elements that belong to rooms. To secure sensors against unauthorized access, the definition of usernames and passwords are possible. Therefore, we introduce entity sensors, whose attributes are ID sensor, sensor name, IP, username, password, room, and measured variable.

Total modeling

The defined information structures of building information, process information, and sensor information are to be placed in an overall taxonomy, as shown in Figure 2.

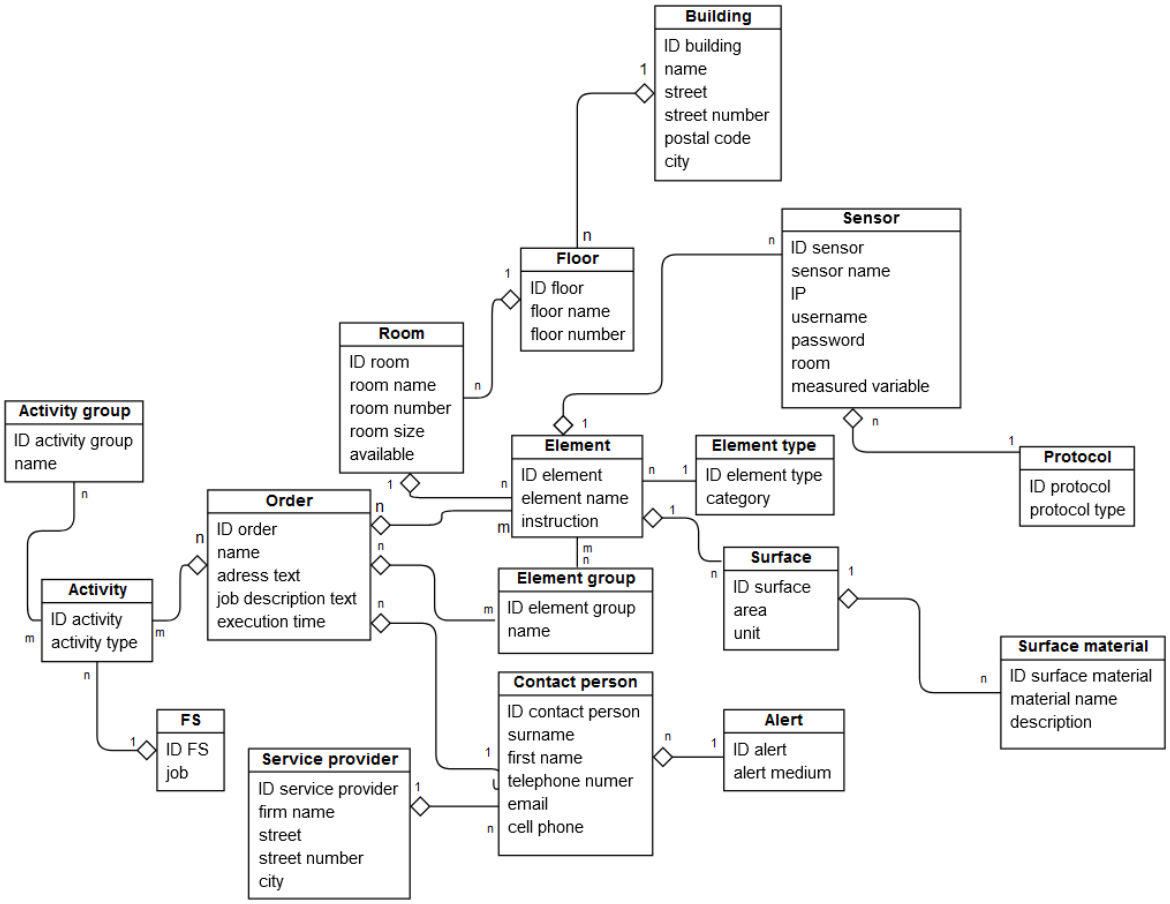

Figure 2 Total modeling.

As the analysis on standards, guidelines, and current tender documents indicates, activities are performed on elements. To deliver different activities with similar demands simultaneously, activity parameters, activity groups, and elements must be affiliated with each other. Therefore, these entity types are related to "job." Each of the relations is an m:n relation because many jobs can contain many elements, activities, and activity groups. The sensors used for recording demands are mounted on elements or integrated into ceilings, walls, exterior facades, or as pressure sensors in moving screens.

The developed information model is created analogously to the diagrams in a relational database, as they are mainly used in FM. All information has been exchanged from BIM software to FM databases.

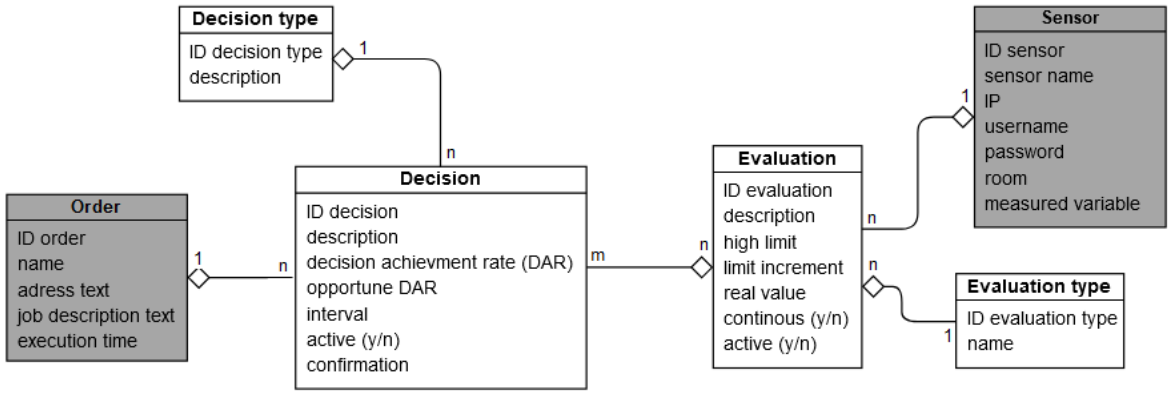

Figure 3 Information structures for demand determination.

The databases moreover consist of algorithms and rules. The algorithms access the measurement values of the sensors and recognize the demand of delivering SFS mathematically. The model user can chose between different types of decisions for carrying out activities within one job. The information structures for making a decision and awarding an order are shown in Figure 3. Grey-colored entities represent the interfaces to the above shown total BIM-based information model.

In order to demonstrate the potential of demand-driven SFS delivery, simulations were performed using the developed information model and algorithms for demand determination. In the simulation period under consideration, 306 orders of janitorial cleaning were triggered based on a daily fixture-based service provision at 6pm (performance-based cleaning) and 259 orders based on BIM-model-based service provision. Figure 4 compares a partially amount of orders for each type of service provision.

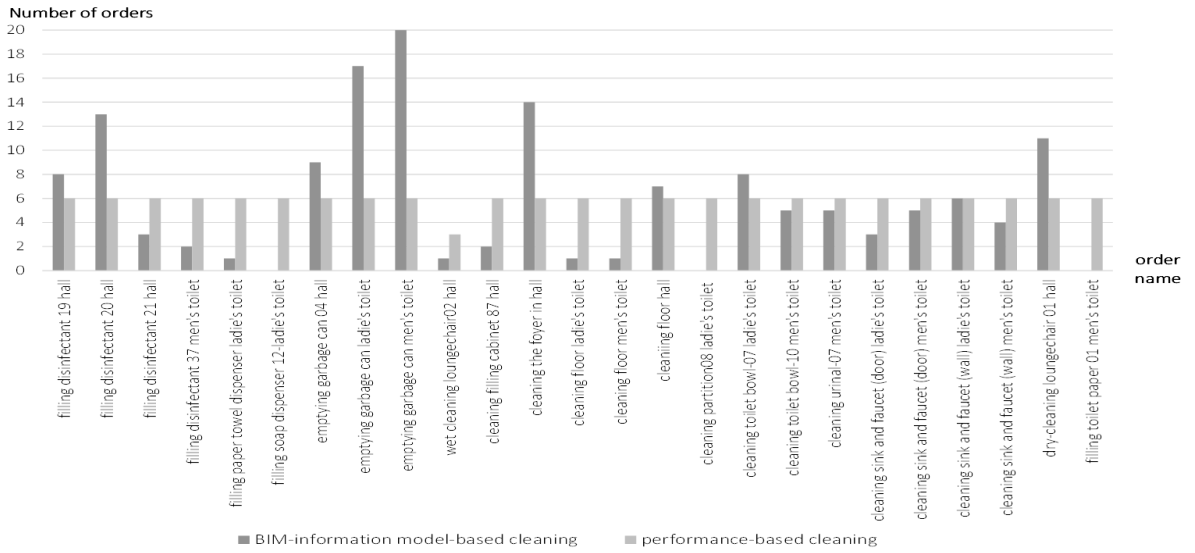

Figure 4 Comparison BIM-model-based and performance-based service provision.

If the pure processing time of the assigned activities is summed up on the basis of performance indicators of janitorial cleaning, 16.36 hours are provided for the BIM-information model-based cleaning and 20.58 hours for the performance-based cleaning, which results in a saving of 20.5%.

DISCUSSION AND CONCLUSION

The analysis of current tendering and award documents has revealed a lack of definitions concerning when SFS must be performed. Missing definitions of current demands for SFS execution lead to dissatisfaction on both parties to the contract. Demand-driven service delivery requires the service provider to identify demands to deliver contractually defined results. Manual needs assessments based on visual inspections are subjective and do not provide a fully quantifiable needs assessment. Furthermore, determining a demand for SFS delivery results in cost increases to the contractor when personnel is required to capture the need through visual inspections. BIM only proves advantageous if FM requirements are communicated between all project participants as early as the planning phase. Not all information that arises in the planning and construction phase is required for executing individual FS, such as janitorial cleaning. Therefore, only the required information must be communicated at the beginning of the project. Existing BIM use cases consider the outcome-oriented service delivery of SFS in FM. BIM use cases already represent sensor-based approaches for determining requirements of hard FS. However, the execution of demand-oriented SFS, which significantly influences the management costs, has not been considered in these use cases.

We have investigated information requirements for delivering SFS in a demand-oriented manner. A quantitative analysis of guidelines, standards, and current tendering documents has been conducted to define information required for delivering SFS. The identified information has been categorized, structured, and linked to a BIM-based information model. Simulations have demonstrated that using the model delivers the correct quantity of information for recognizing demands, ordering, and delivering facility services. As a result, the developed model that consists of FM-relevant attributes shall be presented as Asset Information Requirements and included in the BIM project documentation. The results of this paper relate to recent research on BIM use cases such as "Cleaning Management" of the University of Wuppertal (Helmus et al., 2020). However, the information model developed in this paper aims to create an information model of sensor-based demand-oriented SFS delivery.

Our research has several limitations. First, the SFS of janitorial cleaning represents only one of many infrastructural soft facility services. Therefore, it might be a valuable investment to create analogous BIM-based information models for several demand-oriented SFS. Second, the developed BIM-information model is based on Industry Foundation Classes and must be tested for functionality against other open data exchange formats. Next, the validation of the demand assessment for the delivery of FS based on simulations was carried out. A worthwhile task for future research is to verify the applicability of the BIM information model in actual buildings. Lastly, the scope of this paper did not permit a detailed description of the algorithms and rules used for recognizing the demand of SFS.

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Interior design features predicting satisfaction with office workspace privacy and noise

Susanne Colenberg[1], Natalia Romero Herrera[2], and David Keyson[2]

ABSTRACT

Background and aim – Lack of privacy is a prominent issue in contemporary offices. This study aimed to identify interior design features that jointly influence satisfaction with privacy and noise in the office workspace, and estimate their predictive power. This knowledge can inform strategic workplace design.
Methods – Eight design features were defined that were expected to influence visual, acoustic and physical privacy, noise from other people and acoustic quality, and which would be easy to report for users. Data were collected through an online survey among office workers in the Dutch public sector (*N* = 323). The joint impact of design features on the experienced privacy and noise was calculated through ordinal regression analysis.
Results – The data indicate that small, relatively isolated rooms predict privacy and noise satisfaction better than privacy screens, soft flooring, and visibility control. Workspace soundproofing increases satisfaction with sound privacy and acoustics, but it does not reduce noise annoyance.
Originality – This study operationalizes architectural privacy along several dimensions and from a user perspective, and hierarchically relates them to specific workspace satisfaction outcomes, generating actionable insights for workplace designers.
Practical and social implications – The study can serve as a source for evidence-based workplace design and management that aims to balance user needs for privacy and quiet against their need for social interaction. Currently, this balance is especially important because hybrid working may increase the need for informal interaction at the office while there still is a need for privacy and quiet spaces.
Type of paper – Research paper (full).

KEYWORDS
Office space, interior design, satisfaction, privacy, noise, acoustics.

INTRODUCTION
Workspace satisfaction has been observed to influence job satisfaction, which in turn is related to productivity and turnover (Davis et al., 2011; Van der Voordt, 2004; Wright & Bonett, 2007). It is therefore important for organisations to support user needs towards workspace privacy. The prolonged working from home during the covid-19 pandemic has once more underlined that many offices fail to adequately support individual user needs. For the average employee, the home office performs better than the office workplace (Leesman, 2021). It offers considerably more privacy and quiet, and a better ambience than their pre-Covid workspace at the office (Colenberg & Keyson, 2021).

In the past years, perceived lack of privacy and noise annoyance have been the most prominent issues in office environments, especially in open-plan offices and activity-based working environments (Bodin Danielsson & Bodin, 2009; Engelen et al., 2019; Kim & De Dear, 2020; Marzban et al., 2021; Vanhoutte,

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2015). Noise annoyance and perceived lack of privacy refer to unwanted social interactions. The tension between privacy and interaction may be especially salient if substantial working from home results in a higher need for social interaction at the office than before, while there still is a need for quiet workspaces at the office. Recent research showed that the expected crowdedness and the availability of private spaces for concentration and meetings determined employees' choice to return to the office (Appel-Meulenbroek et al., 2022).

However, without detailed knowledge about the sources of privacy dissatisfaction and their relationship with office workspace design, it is difficult to decide upon changes for improvement. Empirical studies that relate actual workspace characteristics to noise annoyance are scarce (Colenberg et al., 2021). Furthermore, in real-life settings, design features do not occur in isolation but are related to each other. Privacy is a complex concept with several dimensions which may impose different needs on the physical environment. Therefore, this study aims to explore to what extent specific workspace design features jointly predict satisfaction with specific dimensions of perceived privacy and noise in offices.

Experienced privacy at the office

A widely used conceptualisation of privacy is by Altman (1975), who defines privacy as the individual's ability to regulate and maintain an optimal level of social interaction. According to Gifford (2014, p. 171) current typologies of privacy are often based on the ideas of Alan Westin, who distinguished being alone (solitude), group privacy (intimacy), being among others without interaction and while not being identified (anonymity), and psychological barriers against intrusion (reserve). Solitude with no one else nearby is referred to as isolation. At the office, isolation from the sights and sounds of other people may be needed for concentration work and recovery from stress, intimacy for private conversations and bonding, and reserve to prevent feelings of crowding and reduce distractions.

In studies on satisfaction with office workspace privacy, there often is a distinction between visual privacy, which refers to not being seen, and sound, acoustical, or speech privacy, which refers to not being overheard (Kim & de Dear, 2013; Leder et al., 2016; Oldham, 1988). A recent application of Altman's theory to the work context distinguishes between input from others and output to others of general, social, visual, and acoustic stimuli (Weber et al., 2021). According to this perspective, perceived privacy at the office not only includes control over how much others can see or hear of you (disclosure), but also the absence of unwanted sound (noise) caused by other people. This means that the concepts of workspace privacy and noise from others are entwined. Since the intrusion of personal space could be considered a violation of physical privacy, this was added to the studied privacy dimensions.

Privacy by interior design

In this study, workspace design refers to the interior design of office space, which ranges from layout and arrangement of spaces to surface materials and furniture (Ching & Binggeli, 2018). In contrast to experienced privacy, *architectural* privacy (Sundstrom et al., 1980) at the office refers to the actual enclosure of the workspaces and whether a door can be closed. Architectural workspace privacy is importantly influenced by spatial arrangement (Gifford, 2014, p.350). Naturally, a smaller room or more partitions will provide more enclosure and restrict accessibility. The number of workstations impacts the density and proximity of people within the workspaces. Spatial and social density reduce the possibilities to achieve desired privacy and can induce feelings of crowding. Even the arrangement of furniture matters, for example, whether users face each other or not, and the distance to neighbours (Laurence et al., 2013). According to the theory of prospect and refuge (Appleton, 1984), people prefer having their back covered, while being able to overview the area in front of them.

Furthermore, layout and spatial organisation determine the travel routes of people and sound within the office building. Passers-by can violate the office workers' privacy by looking into the workspace or producing noise by walking and talking. According to space syntax theory, office workspaces having a central, integrated position on the floor will attract more users than those having a less central, more isolated position (Sailer & Koutsolampros, 2021). In large or open office workspaces, people passing by closely can infringe the worker's personal space, since the preferred interpersonal distance in business relations is 1.20 to 3.50 m (Hall, 1966). Apart from physical openness, the use of transparent building materials enables vision from one space into the other and thereby reduces visual privacy. Solid partitions obstruct vision and additionally reduce sound transmission, especially if they are covered with sound-absorbing material. Surface finishes, such as floor covering, may influence the reflection and distribution of sound.

Conceptual framework

Based on the above definition of privacy dimensions, and the theoretical and practical identification of possibly related workspace characteristics, eight design features were chosen that were expected to reflect the architectural privacy and acoustic quality of an office workspace (see Figure 1). They include spatial characteristics, finishes and furniture, which cover important components of interior design. Furthermore, these design features were assumed to be easy to identify and report by office users. Self-report measures are appropriate for individual experience and satisfaction. Noise, for instance, is a psychological interpretation that depends on sensitivity and situational aspects and not just on the sound level. Regarding design features, measurement of some might be more detailed or accurate when taken by independent observers, for example, the height of partitions, but we expect self-report measures reasonably accurate while much easier to obtain.

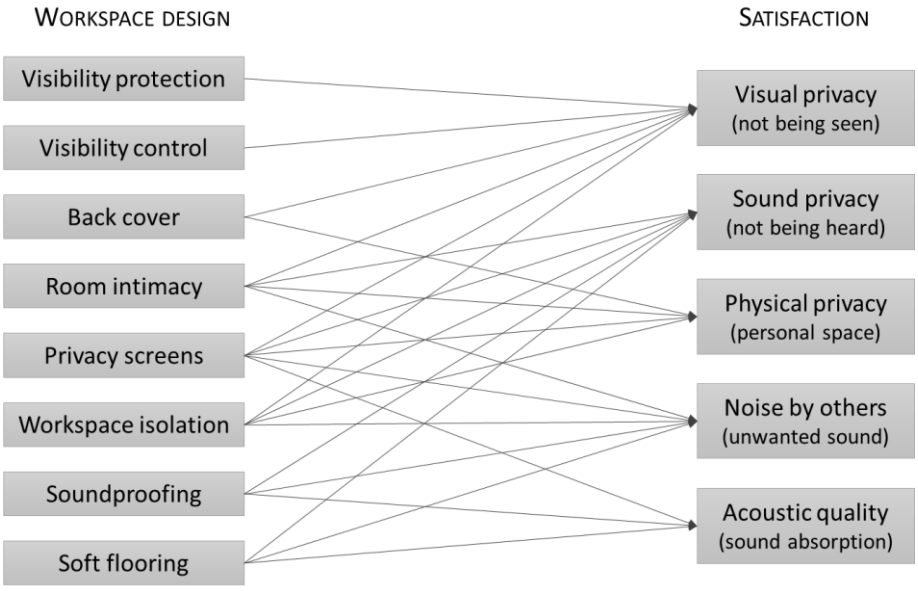

Figure 1 Hypothesized design predictors of satisfaction with privacy and noise.

It was expected that satisfaction with visual privacy (not being seen) would be predicted by the visibility of the user from outside the workspace, possibilities for the users to adapt their visibility, for instance through closing the door or closing curtains, and a back cover preventing others to approach them unseen or look at their computer screen. Furthermore, the number of roommates (room intimacy), the presence and height of privacy screens attached to the workstation, and the isolated location of the workspace were expected to affect visual privacy. Isolation of the workspace in the spatial layout was chosen to reflect the risk of privacy violence and noise from people passing by. Sound privacy (not being

heard by others) was expected to depend on room intimacy, screens, isolation and the degree of speech transmission (soundproofing). Physical privacy (personal space, distance to others) was expected to depend on the back cover, room intimacy, screens, and isolation. Annoyance with the noise of others was expected to be predicted by large workspaces, lack of (sound-absorbing) screens, regular traffic around the workspace, and lack of soundproofing and soft flooring. Acoustic quality was expected to depend on screens, soundproofing and flooring material.

METHOD

Variables and measurement

The aspects of architectural privacy and acoustic quality that were chosen to reflect the scope of interior design and the various dimensions of privacy, as explained above, were operationalized into eight ordinal variables (Table 1), which were to be measured by self-report rather than direct observation.

Table 1 Operationalization of the degree of architectural privacy and acoustic quality of the office workspace ranging from a low (1) to a medium (2) and high (3) level.

Design feature	Level 1 (low quality)	Level 2 (medium)	Level 3 (high)
a. Visibility protection	Look in at eye level from 2+ sides	Look in at eye level from 1 side	Worker not visible at eye-level
b. User visibility control	No possibilities for adjusting the visibility	Limited possibilities	Several possibilities
c. Back covered when seated	No cover (back towards open space)	Half-high or transparent cover	High & solid back cover
d. Room intimacy	Large/open (> 6 pers.)	Medium (4-6 persons)	Small (1-3 persons)
e. Privacy screens workstation	No screens attached/ next to the workstation	Low screens (can look over standing-up)	High screens (not able to look over)
f. Isolation of workspace	People pass by regularly/ continuously	People pass by now and then	Few passers-by due to isolation
g. Soundproofing of workspace	Any speech can be overheard	Only loud speech/ intonation passes	Workspace (almost) soundproof
h. Flooring material	Hard, reflecting sound	In between, walking makes sound	Soft & absorbing sound

Architectural privacy, or actual enclosure, was operationalized into six variables (Table 1, row a-f) that were measured by self-report. Visibility protection (a) within the workspace was indicated by the reported number of sides from which passers-by could look into the workspace from outside, the door (if present) closed, due to openness or transparency of the wall or door at eye level. The degree of visibility control (b) was measured by the perceived amount of possibilities for workers to prevent people to look into their workspace from outside. Room intimacy (d) measured the number of persons sharing the room, i.e. the number of workstations as reported. Open workspaces were included in the category of large rooms. Isolation of the workspace (f) from traffic was expressed by the usual amount of passers-by. Other aspects of workspace enclosure were measured by (e) the self-reported presence and height of non-transparent privacy screens attached or placed next to the workstations, and (c) to what extent the users feel their back covered by for example a wall or bookcase while seated at their workstation.

As self-report measures of acoustic quality, two acoustic design solutions were included that should be easy to identify by ordinary office users: (g) the degree of soundproofing, expressed by how well people

at one metre outside the workspace can overhear speech from within the workspace, and (f) sound absorption by type of workspace flooring, ranging from a surface that is perceived as hard and sound-reflecting to one that is soft and well absorbing the sound of walking. Privacy screens attached to the workstation may also support acoustic quality, but they will only absorb speech if they are sufficiently high (above 1.40m from the ground) and covered by sufficiently sound-absorbing material.

Satisfaction with privacy and noise in the workspace was measured through satisfaction with five workspace characteristics which were phrased and explained in the questionnaire as follows: visual privacy (yourself or your screen not being seen by others), sound privacy (not being heard by others), personal space (others sitting or passing by at a comfortable distance), the amount of noise by other people, and acoustics (echo and sound spreading). Respondents were asked to indicate their average satisfaction with these aspects of the workstation(s) they use at the office on a 5-point Likert scale ranging from 1 (very dissatisfied) to 5 (very satisfied).

Questionnaire and data collection procedure

Data were collected through an online survey among office workers in The Netherlands, which was developed for a larger study on workplace design and well-being. In this questionnaire, items with Likert scales were presented in a random order to prevent anchoring bias. The order of responses to ordinal variables alternated between low-high and high-low to prevent primacy bias. In the case of desk-sharing, participants were instructed to answer the questions with their usual or most used workstation in mind.

Four organisations in the Dutch public sector, recruited through the network of the first author, participated in the study. They occupied three different office buildings featuring a variety of workspaces, with an emphasis on traditional cellular offices but also featuring activity-based working environments. In each organisation, a key person distributed the anonymous link to the questionnaire among all employees, between November 2020 and February 2021. Of the approximately 1200 employees that were invited, 589 (± 49%) responded to the survey. Respondents who had joined the organisation after the first lockdown of March 13, 2020, were excluded from our analysis because they had not experienced the office at its normal occupancy. Between the lockdowns of Spring and Autumn 2020, working from home was still advised in these organisations and the Summer holidays further reduced occupancy. Additionally, respondents were excluded who did not indicate that they had been working at the office for at least several days since that first lockdown, because then memories of their office workspace experience might have faded or changed. In total, 323 valid questionnaires were used for this study.

Sample characteristics

Approximately half (48%) of the respondents in our sample were 40 to 59 years old, 18% were younger than 40 and 34% older than 59. The majority (68%) had been working in their current department for more than two years. At the office, most of the respondents either formally (47%) or practically (17%) owned a workstation, and an additional 24% nearly always resided in the same area; only 10% indicated using a wide range of workspaces in the office. Due to COVID-19 restrictions, 43% of the respondents were completely working from home when they completed the survey, although they had been working in the office regularly or incidentally in between lockdowns, a few months before.

Statistical analyses and modelling

We tested our expectation that privacy and noise would be related by calculating Spearman's rank correlations between the five satisfaction variables. The distributions of all variables were explored through descriptive analyses. To evaluate the predictive power of combined design features and forecast the effects of design changes, we performed ordinal (i.e. cumulative logistic) regression

analyses. Ordinal regression is a parametric statistical test to determine whether one or more predictor variables have a statistically significant effect on an ordinal outcome, such as Likert scale variables (Eiselen & Van Huyssteen, 2021). Each regression analysis took one aspect of satisfaction as the dependent variable and several design features as independent variables (see Fig.1). According to (Norusis, 2012), the complementary log-log link function is best for variables heavy in positive values, the negative log-log for positively skewed variables, and the logit for more or less evenly distributed variables. For our data, the logit link provided the best results.

The ordinal regression analyses were started by including all of the predictors that were expected to be important to the dependent variable (see Fig. 1). When predictors seemed not to be helpful in the model, they were removed and the model was re-estimated. To check if the data met the required assumptions, they were assessed for multicollinearity and proportional odds. Since odds ratios provide additional interpretations of the regression models in real-world contexts (Eiselen & Van Huyssteen, 2021), they were calculated through $e^{-\beta}$, β being the estimated coefficient (Norusis, 2012). All statistical analyses were performed using IBM SPSS Statistics 25.

RESULTS

Correlations

As expected, satisfaction with privacy and noise are entwined. Table 2 shows substantial and statistically significant correlations between all aspects of perceived privacy and noise annoyance, with the strongest relationship between visual and physical privacy (ρ = .600), and the least strong connection between visual privacy and acoustic quality (ρ =.479).

Table 2 Non-parametric correlations (Spearman's rho) between satisfaction variables.

	Visual	Sound	Physical	Noise	Acoustic
Visual privacy	1	.528**	.600**	.520**	.479**
Sound privacy		1	.542**	.585**	.529**
Physical privacy			1	.554**	.557**
Noise of others				1	.599**
Acoustic quality					1

** Correlation is significant at the 0.01 level (2-tailed).

The reported design features also correlate to each other, but coefficients are much lower (see Table 3) and do not indicate problematic multicollinearity (Field,2013, p.335).

Table 3 Non-parametric correlations (Spearman's rho) between design features.

	Room	Isolated	Visible	Control	Screen	Cover	Sound	Floor
Room intimacy	1	-.199**	.274**	.339**	-.404**	.556**	.376**	.136*
Isolation		1	.162**	.123*	.110	-.042	.012	-.048
Visibility protect			1	.264**	-.188**	.287**	.357**	.065
Visibility control				1	-.154**	.275**	.202**	.091
Screens					1	-.295**	-.254**	-.039
Back cover						1	.239**	.109
Soundproof							1	.150*
Soft flooring								1

** Correlation is significant at the .01 level (2-tailed); * significant at .05 level

Table 3 shows that in the studied sample, smaller, more intimate rooms more often have privacy-supporting design features such as a covered back, less visibility of the user in the workspace, more

control of visibility, and a more soundproof workspace, and more soft flooring which could reduce noise. Not surprisingly, privacy screens more often appear in larger rooms and open spaces than in smaller rooms. More remarkable is the centrality of smaller rooms: apparently, in this sample they are more often located within the office traffic flow (less isolated, more passers-by) than large workspaces. Extending the sample to other office buildings might lead to different correlations due to different design choices influenced by for example user preferences or budget.

Frequencies and distributions

Figure 2 illustrates that the majority of the respondents were satisfied with personal space and acoustics in their office workspace, but relatively many of them were dissatisfied with noise, sound privacy, and visual privacy. Note that this may have been influenced by the home working experience, which offered many office workers more quiet and privacy than working at the office.

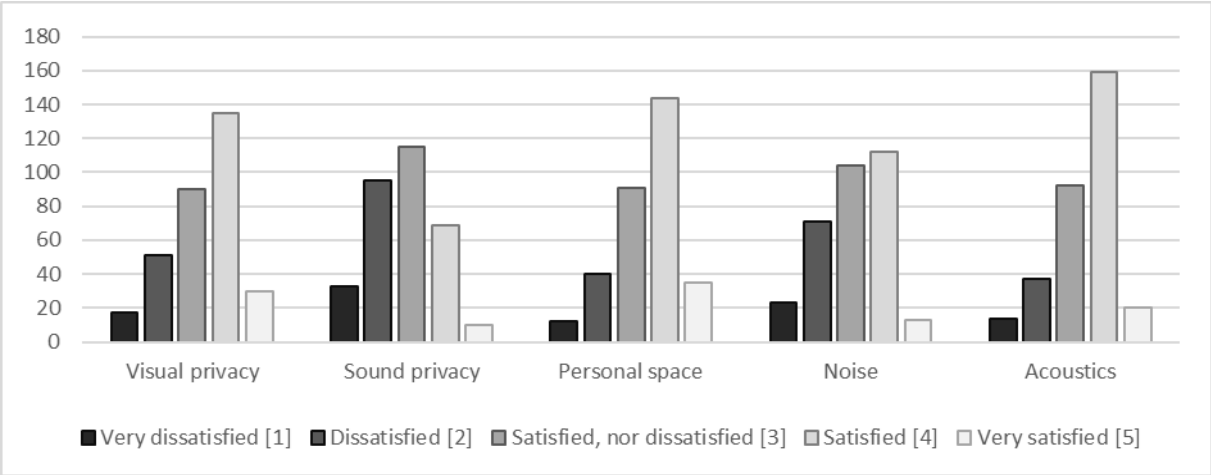

Figure 2 Frequencies (count) of the dependent variables.

Figure 3 reflects the differences in workspace design within the sample. In these offices, only a few workstations featured privacy screens around them, but many had a high and solid partition behind them. Soft flooring was more common than a hard floor surface, soundproofing is reasonable, and the majority of the workspaces were integrated rather than isolated.

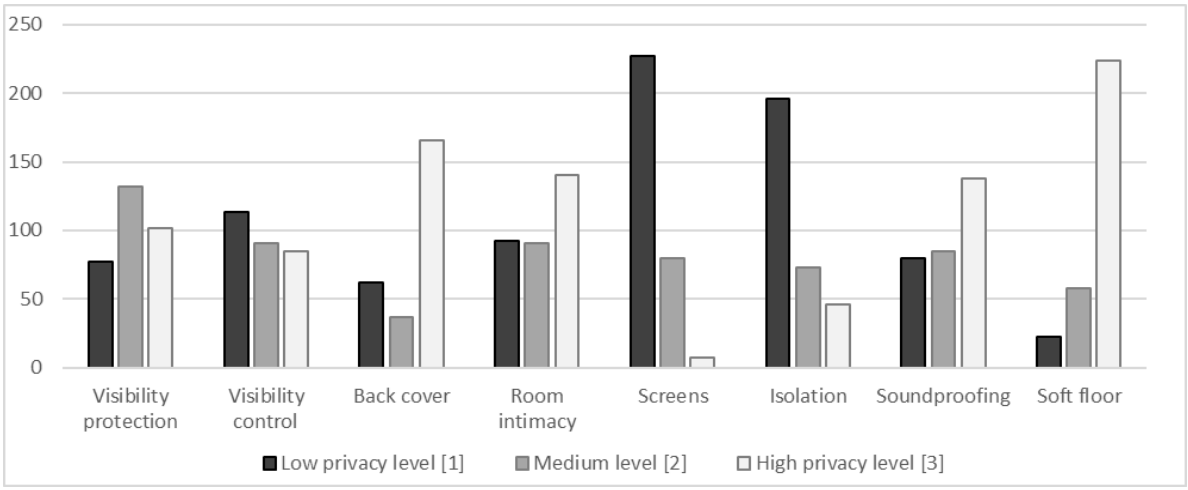

Figure 3 Frequencies (count) of the independent variables.

Figures 2 and 3 show that neither of the variables is normally distributed, hence a parametric test is a right choice to analyse relationships. They also show that several categories are filled with less than fifty cases. Sparse levels increase the risk of empty cells in the regression analysis, which undermine the reliability of the chi-square-based fit statistics and parallel lines test for proportional odds. To reduce this risk, the dependent variables were condensed into three categories: (1) dissatisfied, (2) neutral, and (3) satisfied. Furthermore, the two smallest categories of independent variables *Back cover*, *Screens, Isolation,* and *Flooring* (see Fig. 3) were collapsed into their adjacent categories to form dichotomous variables: *Back cover* either high and solid (2) or low/transparent/none (1), *Screens* present (2) vs. absent (1), *Isolation* scored as isolated with infrequent passers-by (2) vs. central (1) with frequent passers-by, and *Flooring* as soft (2) vs. medium/hard (1).

Regression analyses

The first regression analysis of *Visual privacy* with all six hypothesized predictors (Fig. 1) showed that three of them did not significantly contribute to the model according to Wald's test: *Visibility Control*, *Isolation* and *Screens.* These predictors were removed from the model. To solve the problem of empty cells, either *Back cover* or *Visual protection* had to be dropped, since dichotomizing *Visual protection* did not reduce the number of empty cells to zero. *Visual protection* was retained because the model fit was better (R^2 = .208) than for the model including *Back cover* (R^2 = .186).

Regarding satisfaction with *Sound privacy*, predictors of *Isolation*, *Screens* and *Flooring* appeared to not significantly contribute to the model. They were removed while keeping *Room intimacy* and *Soundproofing* (R^2 =.159). *Screens* and *Back cover* did not significantly contribute to satisfaction with physical privacy, and neither did *Screens* contribute to satisfaction with noise or acoustics. Excluding those variables resulted in a model including *Room intimacy* and *Isolation* for predicting satisfaction with physical privacy (R^2 = .098), and a model including *Soundproofing* and *Flooring* for predicting satisfaction with acoustics (R^2 = .129). In the first regression analysis with satisfaction with noise as the dependent variable, neither *Screens* nor *Isolation* and *Soundproofing* had significant estimates. However, in the model with the remaining *Room intimacy* and *Flooring*, the p-value of *Flooring* raised above 0.05. A model containing *Room capacity* and *Isolation* performed better (R^2 = .125)

The final regression models have a good fit to the data, indicated by a statistically significant 2-log likelihood test (p <.001) and a non-significant Pearson and Deviance test (p >.05) for each model. Additionally, a non-significant parallel lines test with a p-value above .05 for each model confirms the required assumption of proportional odds. Table 4 summarizes the results of the ordinal regression analyses using the logit link function for each model and taking the highest value of the predictors as the reference category.

Table 4 Estimated coefficients of design variables [value] predicting satisfaction with privacy and noise.

	Visual privacy	Sound privacy	Physical privacy	Noise of others	Acoustic quality
Large room/open space [1]	-1.838**	-1.357**	-1.473**	-1.524**	
Not a small room [1, 2]	-1.230**	-0.949**	-0.805**	-0.818**	
Regular passers-by [1]			-0.528*	-0.479*	
Visual open workspace [1]	-1.181**				
Not visually closed [1, 2]	-0.591**				
Not at all soundproof [1]		-0.868**			-1.334**
Hard/medium flooring [1]					-0.853**

** Wald test (95% confidence) significant at .01 level; * significant at .05 level

All estimated coefficients are negative, which means that users in the categories listed in Table 4 are associated with poorer satisfaction scores compared to users in the remaining categories of the ordinal predictor variable. The absolute value of the coefficients reflects the strength of the association. An empty cell in Table 4 means the predictor variable was not included in the regression model for theoretical or statistical reasons, as previously explained.

Table 4 shows that an intimate room shared by less than four people is the best predictor of satisfaction with noise and any dimension of privacy. People working in a large room with more than six workstations or an open workspace are far more likely to rate their privacy and quiet as poor than people working in small rooms (OR 6.04, 3.88, and 4.36 for visual, sound and physical privacy respectively, and OR 4.59 for noise). For people working in a large/open or medium-sized room, a poor satisfaction score is still two to three times more likely. This aligns with Leder et al. (2016), who found that workstations enclosed by full-height walls and doors contributed more to satisfaction than more subtle acoustic design.

A central position of the workspace with regular passers-by is more likely to trigger dissatisfaction with physical privacy and noise than an isolated workspace (OR 1.70 and 1.61), but this effect is not as strong as for lower levels of room intimacy. An isolated position of the workspace in the building only affects satisfaction with physical privacy together with room intimacy, and it does not significantly affect satisfaction with visual or sound privacy. Apparently, passers-by are not perceived as a threat to visual or speech privacy, but people walking by regularly reduces physical privacy (OR 1.70) and increases noise annoyance (OR 1.61). In contrast, Appel-Meulenbroek et al. (2022) found that office workers preferred a workspace next to a walking route instead of an isolated workspace. Perhaps these preferences result from different needs than a desire for quiet and personal space.

A visually open workspace where people outside can look in from several sides is three times more likely to negatively affect satisfaction with visual privacy (OR 3.25) than a visually enclosed workspace. A workspace that is not entirely closed and transparent at eye level at one or more sides, is still likely to have a negative effect, albeit less than open spaces alone (OR 1.80). This means that adding solid partitions around workstations or covering glass walls may enhance satisfaction with visual privacy, even if one side still is open. As expected, soundproofing of the workspace, i.e. speech transmission, affects satisfaction with sound privacy, the amount of noise from other people, and perceived acoustic quality. However, absorption of the floor covering material only affects satisfaction with acoustics (OR 2.35). Apparently, soft flooring can reduce sound reflection but does not reduce speech transmission.

The hypothesized effects (as depicted in Figure 1) of possibilities for controlling visibility and the presence of privacy screens at the workstation have not been confirmed by the regression analyses. The poor effectiveness of privacy screens could be due to their mostly low height in our sample (see Fig. 3), thereby barely capturing the sound of speech and enabling a standing person to look over them. The effect of a back cover on satisfaction with visual privacy was overruled by the effect of visual openness, which created a more powerful model. Possibly, regarding physical privacy presence of a high back cover is largely captured by room capacity, since in small and medium rooms workstations usually are situated with the chair between desk and wall, automatically providing a high obstacle that prevents people from approaching users from behind.

CONCLUSION & DISCUSSION

This study investigated the joint contribution of a variety of interior design features to satisfaction with noise and privacy in office environments. The results indicate that among the studied design variables, ceiling-high, speech-absorbing enclosure and a relatively isolated position of the workspace best predict satisfaction with privacy and noise, as needed for concentration and confidential work and personal

talks. Privacy screens, a separate back cover, and possibilities for managing visibility in the workspace add little to the prediction. These findings implicate that providing sufficient enclosure and stimulating casual encounters to take place outside the large workspaces may add more to solving problems with noise and privacy than applying acoustic solutions or privacy measures within those workspaces.

Facility managers could use these insights when supervising office renovations to prioritize small-scale workspaces located away from traffic zones and having solid walls and doors above applying acoustic solutions in large open workspaces. They could collaborate with human resources managers to use interior design and signage to steer social interactions towards dedicated social spaces that occupy central positions in the office configuration, for instance by placing attractors such as water coolers (Fayard & Weeks, 2007).

Post-Covid research should confirm the findings using samples with more young office workers and a larger variety of design features and office settings, and analysing possibly interfering variables such as individual differences, situational factors, and organizational culture. Because although this study identified interior design features that significantly increase the probability of satisfaction with workspace privacy, these features do not *determine* satisfaction. Within the field of environmental psychology, it is widely recognized that perception of the physical work environment and perceived fit are influenced by many factors (e.g. see model Bell et al., 2001, pp. 434-435). Research shows that, for instance, a high personal need for privacy reduces perceived privacy-fit (Hoendervanger et al., 2019), negative emotionality reduces satisfaction with acoustic privacy (Marzban et al., 2021), and people who are more extravert, affiliative, and field-oriented have a smaller interpersonal space (Gifford, 2014, p.133). Additional to individual differences, the social situation interferes with the design-perception relationship. For example, the possibility to choose from a variety of settings and adherence of others to protocols contribute to privacy fit (Weber & Gatersleben, 2021). Organizational policies regarding desk-sharing, the employee-desk ratio, and possibilities for identity marking may influence feelings of ownership, which mediate privacy satisfaction. For instance, Laurence et al. (2013) found that workspace personalization reduced the negative effects of low levels of privacy on well-being. Future workplace research could use the design features that were identified in this study to develop more powerful models that predict privacy satisfaction through a path that includes these types of mediators and moderators beyond workplace design and by adding observational data to the self-report measures.

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Can physical characteristics in the interrogation room aid the witness in recalling what happened?

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ABSTRACT

Background and aim – Police interrogations tend to be very stressful. This comes at the expense of the effectiveness of interrogations as stressed suspects and witnesses provide less extensive and accurate statements. A more comfortable environment probably leads to more effective interrogations for all persons involved. The aim of this research is to determine whether particular aspects of the physical environment of an interrogation room may enable self-disclosure and improve accuracy of the recall of information.
Methods / Methodology – An experiment using a 2 x 2 between subjects design was performed investigating the impact of two variables, wall colour (blue/red) and seating comfort (chair/stool), on self-disclosure, and accuracy of information of participants who played the role of witnesses during a simulation of a police interrogation.
Results – Results showed that indeed stress was induced during the experiment. The stool was perceived as less comfortable than the chair, and participants experienced significantly different emotions between the blue and the red wall. However, no significant differences could be shown regarding self-disclosure and accuracy of information in 2x2 design. Possibly, the limited number of participants has influenced the results. A repeat study with a larger sample is recommended.
Originality – Currently, there are limited studies within the field of police interrogations that study the role of the physical environment. This is the first study to show that a (too) comfortable police interrogation room might be not beneficial for the effectiveness of the interrogation.
Practical or social implications – The experiment showed that using physical aspects to appeal to users' emotions is a means of increasing comfort.
Type of paper – Research paper (full)

KEYWORDS
Self-disclosure, accuracy of information, police interrogation, stress.

INTRODUCTION
Nowadays, interrogators aim to collect as much accurate information as possible (Shepherd & Griffiths, 2013; Rispens & van Amelsvoort, 2016; Dekker & Feigenson, 2020). However, suspects still experience high levels of stress during police interrogations (Gudjonsson, 2003). As a result, suspects might struggle in providing details about the alleged crime (May et al., 2021), respond in a defensive way (Verschuere et al., 2004) or even make a false confession (Kassin & Kiechel, 1996; Klaver et al., 2008; Vrij, 2008). This applies to suspects and witnesses. Research focuses mainly on psychological interrogation techniques to lower stress (Vrij, 2008). However, the physical environment might play a role as well.

Generally, the police interrogation room itself is designed in a way that guarantees safety for all persons but thus far little attention has been paid to the atmosphere. Several studies have been performed

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about the effect of the physical environment on people's well-being within other disciplines like general hospitals, psychiatric hospitals and schools (Karlinn & Zeis, 2006; Dijkstra et al., 2006). However, research in the context of police interrogations is very limited as only a few studies were found (Dawson et al., 2017; Hoogesteyn et al., 2019; Kelly et al., 2019). A recent study by Hoogesteyn et al. (2020), postulated that a decorated interrogation room, instead of a standard and rather Spartan one, "corresponded with what the majority of participants described qualitatively to be an environment that promotes disclosure, which should be relaxing, include comfortable chairs, decorations, and appear home-like". However, effect of such an interrogation room on witness' disclosure is absent. Relaxing, comfortable and home-like maybe interpreted as being more hospitable, based on the Experience of Hospitality scale developed by Pijls et al. (2017).

The limited findings regarding the physical environment within police interrogations and the rising need of the Dutch Police Academy regarding knowledge on this subject formed the motivation for this research. This study focuses on the effect of the physical environment by measuring stress, self-disclosure and accuracy of recall among participants while they stay in a room with either a red or blue wall colour, and either a comfortable chair or an uncomfortable stool. The colours blue and red were applied, as literature shows that blue is seen as a calm colour and red as the opposite as it increases stress. Seating comfort was chosen as it is part of the way how we assesses the environment (Knapp et al., 2013), and several studies focussed on seating comfort which could be used as fundamentals for this study. These variables are relevant as a more comfortable environment probably leads to a more effective interrogation, especially since the current environment is far from comfortable.

STRESS AND THE PHYSICAL ENVIRONMENT

In a police interrogation room, suspects and witnesses are placed in an environment with which they are not familiar and in which they do not feel in control (Schrantz et al., 2021). This commonly generates stress. There are many different forms of stressors, for instance traumatic events and daily hassles (Wheaton & Montazer, 2010). However, this study focuses on stress coming from life changing events, which relates to acute stress, resulting in high levels of stress, which is usually referred to as 'distress'. Distress starts with stressors (impulses caused by being in the police interrogation room), in combination with the context of the moment (the alleged crime) and coping with the situation (to what extent the person is able handle the situation).

Being distressed during a police interrogation leads to several changes in behaviour, which can be differentiated into two categories. Experiencing distress during an interrogation affects *self-disclosure*, as suspects and witnesses feel insecure and anxious (May et al., 2021), experience concentration difficulties (May et al., 2021) and respond in a defensively manner (Verschuere et al., 2004), resulting in less extensive statements. Moreover, distress affects the quality of statements (e.g. Morgen III et al., 2004), i.e. it decreases the *accuracy of statements*.

Stress is related to the physical environment as assessing the environment can generate stress (i.e. stressors). This aligns with the theory of Cohen et al. (1997), who link stressors to behaviour. Assessing the environment can, in general, be subdivided into five dimensions (Knapp et al., 2013). The first dimension is *familiarity* of the environment, as people are cautious in a less familiar environment. The second dimension is *constraint* perceptions. The feeling of freedom within the environment influences the level of comfort. The third dimension is the perception of *warmth*, which relates to the psychological feeling of the environment. Fourth, the perception of *privacy* influences behaviour of people as they are more willing to reduce the sitting distance and disclose more personal information in contrast to rooms with less privacy. Behaviour is also affected by *physical and emotional distance*, which is the fifth

dimension. This can be influenced by the distance between seats, but also by the sitting position of people by taking a forward attitude or leaning backwards (Thomas & Tsai, 2012).

The current information gap lies within two of the aforementioned dimensions. Warmth, particularly the creation of a warm feeling, is the first dimension. Within the context of police interrogations creating a warm feeling is most easily achieved by manipulating the wall colour, as previous research shows that colour affects mood and can therefore create a warm perception (RiosVelasco, 2010). Adding loose objects could also influence mood (RiosVelasco, 2010), but could potentially cause harm. To examine this, two contradicting colours have to be selected.

In general, the colour blue is related to calmness and relaxation while red is distressing and increases heart rate (Liu et al., 2014; AL-Avash et al., 2016). However, this needs to be examined. Blue, as a calm colour, and red, as an arousing colour, have been used in other experiments to increase the chance for an effect (Kwallek et al., 1997). An important note to consider is that colour preference can differ between people based on, among others, cultural background (Adams & Osgood, 1973; Gao et al., 2007) and personal preferences (Dijkstra et al., 2008). For instance, the experiment of Weller and Livingston (1998) showed that participants felt more comfortable reading a violent crime from a pink paper than from a blue one while blue is generally seen as more comfortable. Further research is required to find out whether colour also affects suspects and witnesses during police interrogations. Therefore the following hypotheses regarding colour have been formulated:

H1 There is an effect of wall colour (red or blue) on the amount of information disclosed by the participants.

H2 There is an effect of wall colour (red or blue) on the number of disclosed details of participants.

The second information gap concerns the dimension physical and emotional distance. Lam et al. (2011) advocate that seating distance together with the seating quality determines the seating comfort perceived by the user. Manipulating seating distance is challenging within this study considering the required presence of a jury or interrogator(s). Moreover, Hoogesteyn et al. (2019) already investigated the effect of seating distance but no effect was found. Therefore, only seating comfort was manipulated in this study.

No literature has been found regarding seating comfort within police interrogations. That is remarkable as studies in other disciplines show that seating influences feeling comfortable, which might be interpreted as the opposite of feeling stressed. Pijls et al. (2019) examined this in a restaurant by manipulating a comfortable chair and a uncomfortable stool. In addition, the study of Krahé et al. (2018) shows that people who are feeling relaxed, which could be related to feeling comfortable, experience less frustration and therefore less anger and aggression. They manipulated feelings of comfort by focussing on the seating position of people, by comparing the leaning position of participants.

While choosing two kinds of seating furniture to create different perceptions of stress levels, two elements were considered. First, users need to perceive a difference in comfort while seated. Feeling uncomfortable can lead to feeling stressed which is applicable within this study. Second, people sitting on a chair are likely to take a reclining position in contrast to a stool which has no backrest and therefore stimulates a forward position (Krahé et al., 2018). This leads to the following hypotheses:

H3 There is an effect of seating comfort (chair or stool) on the amount of information disclosed by the participants.

H4 There is an effect of seating comfort (chair or stool) on the number of disclosed details of participants.

PRE-TEST ENVIRONMENTAL MANIPULATION

In this experiment we manipulated two room characteristics: seating comfort and wall colour. A manipulation check was performed several weeks prior to the experiment to ensure that participants would indeed perceive the experimental conditions to be different. For the perceived effect of the wall colour it was particularly important to make sure that participants would only perceive differences between the colours themselves and that the level of brightness and the intensity of the colours were perceived to be the same. Participants (ranging from N = 25 to N = 61) gave input to get to the right level of intensity and brightness, and perceived them to be the same after adding 20% more black to the blue colour (RGB 0, 201, 255), and adding 20% white to the red colour (RGB 255, 0, 0). In addition to testing the brightness and intensity, a small pilot was conducted among 61 participants. They assessed blue and red in a Dutch-formulated survey via a 5-point Semantic Differential Scale, which was inspired by the paper of Hanyu (2000). Results are shown in Table 1.

Table 1 Moods associated with the colours, * indicates p <. 001.

N = 61	Blue		Red		T-statistic
Variable	*M*	*SD*	*M*	*SD*	*T*
Pleasant – unpleasant	2.20	1.08	3.02	.99	-4.24*
Exciting – boring	3.36	.82	2.21	.80	7.61*
Relaxing - distressing	2.36	1.10	3.56	.96	-5.49*
Safe – fearful	1.97	.89	3.37	.99	6.73*
Interesting – uninteresting	2.80	1.00	2.51	.94	1.59
Active – inactive	2.87	1.09	2.13	1.06	3.49*

The only difference that was not found between the two colours concerned how interesting the colours were assessed by participants. The significant effects confirm the findings from Liu et al. (2014) for the Dutch population, that blue can be seen as the calm colour in contrast to the arousing red. This is relevant since the experiment of the present study looked for variables which, in general, can be perceived in a comfortable and stressful manner.

Regarding *seating comfort*, the same chair and stool (Figure 1) were chosen as Pijls et al. (2019) used in their experiment in studying the role of, among others, seating comfort in relation to the experience of hospitality in a restaurant setting. The difference in comfort was evaluated via a manipulation check in which ten participants assessed the chair and ten other participants assessed the stool by rating thirteen statements on a 10-point Likert scale. Of these statements, four measured the level of comfort (to what extent the chair/stool feels comfortable, supports the body well, feels soft, feels okay to sit on for several hours) while the nine other statements measured positive emotions in relation to the seating (relaxed, laid-back, unstressed, light-hearted, amused, bright, cheerful, happy, pleased). All four statements regarding seating comfort showed significantly higher comfort of the chair in comparison to the stool, thus the chair can be assumed to be more comfortable than the stool (Table 2). At the same time the chair did hardly elicit more positive emotions than the stool as only one significant effect was found. Participants felt more unstressed while sitting on the chair (M_{chair} = 6.7, SD = 1.06) in comparison to the stool (M_{stool} = 5.4, SD = 1.6; t (18) = 1.43, p <. 001, two-tailed). Consequently, using this chair and this stool proved to be suitable to use as environmental manipulation during the experiment.

Figure 1 Chair with backrest and stool without backrest.

Table 2 Perception of seating comfort, * indicates p <. 05, ** indicates p <. 01, *** indicates p <.001.

N = 20	Comfortable chair		Uncomfortable stool		T-statistic
Variable	*M*	*SD*	*M*	*SD*	*T*
Comfort	5.8	.92	2.7	1.6	5.22***
Support	5.6	1.9	2.5	1.9	3.65**
Softness	4.1	2.02	2.3	1.64	2.19*
Being able to sit on for hours	5.5	1.58	1.9	.99	6.10***

RESEARCH METHODOLOGY

Sample and experimental conditions

The experiment took a 2 (seating comfort) x 2 (wall colour) factorial between subjects design (see Figure 2). Seating comfort was manipulated by the type of seats. Participants were seated on either an uncomfortable stool or a comfortable chair and faced either a red or a blue wall (see Figure 3). The experiment was carried out in June 2021. A convenience sample was drawn among students, faculty, and visitors in the building of Saxion University of Applied Sciences, location Deventer. No quota were used while recruiting participants, i.e. no distinction was made regarding the demographics of potential participants. In total, 52 persons participated in the experiment of whom most were students (*N* = 48). Others were employees (*N* = 2) or visitors (*N* = 2). All participants were from Dutch origin, so the cultural differences described in the literature review are less relevant for the current sample. Being randomly assigned over the groups, each groups contained twelve to fourteen participants. All but one participant finished the experiment. The mean age of participants was 21.8 years and 61.5% were women.

		Seating comfort	
		Chair	Stool
Wall colour	Blue	Setting 1	Setting 2
	Red	Setting 3	Setting 4

Figure 2 Experimental set-up

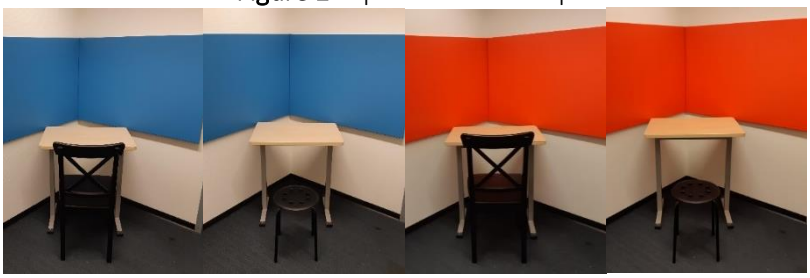

Figure 3 Experimental groups.

Procedures

Figure 4 depicts the procedures used in the experiment. Before the start of the actual experiment, participants were randomly assigned to one of the four experimental groups. While participants were reading and signing the consent form in the neutral room, the researcher performed the randomisation in the experimental room by randomly picking a table tennis ball which contained the number of the

experimental condition. Next, the experimental condition was adjusted by swapping the wall colour (painted canvas) and/ or swapping the seats.

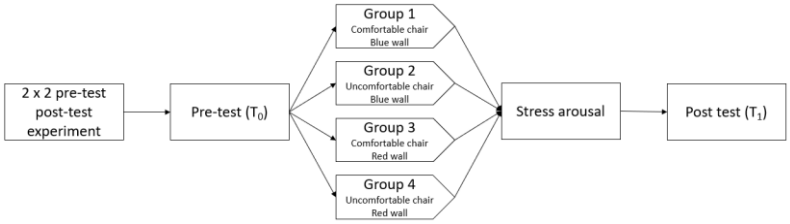

Figure 4 Experimental design.

The first step of the procedure, at T_0, took place in a neutral (pre-experimental) room, where stress levels of participants (N = 52) were measured. In this neutral room participants were shown a picture of a suspect for ten seconds via a tablet, then filled in the stress questionnaire before the start of the experiment (moment T_0), and lastly were asked to describe the suspect in order to measure their abilities to describe a suspect, mimicking a witness testimony. See Figure 5 for photos of the suspects.

Figure 5 Photos of the suspects

In step 2, participants were seated in the experimental room (Figure 6), facing either a blue or a red wall, and sitting on either a comfortable chair or an uncomfortable stool. To be able to measure the (calming) effects of seating comfort and wall colour, stress was induced using a variant of the Trier Social Stress Test. Participants had to perform three tasks of each two minutes (preparing a pitch, performing a pitch, performing a difficult math task). During the final step of the experiment, participants filled in the stress questionnaire with adjusted questions (moment T_1). They also again described a suspect, mimicking a witness testimony.

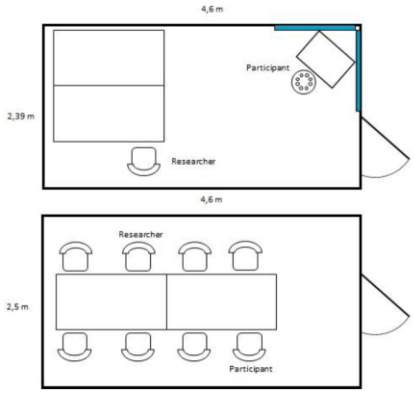

Figure 6 Set-up of the neutral room (bottom) and the experimental room (top).

Measures

Four variables were measured during the experiment: characteristics of the experimental room, stress level, information disclosed and number of details. The characteristics of the room were treated as the independent variable, stress was treated as a constant and information disclosed and number of details were treated as dependent variables. Stress, information disclosed and number of details were measured using a Dutch-language survey based on current English-language measurement instruments.

Stress was measured using the questionnaire of Mendes et al. (2007) that measures acute stress and distinguishes a pre-test and post-test, which enables the researcher to compare stress levels at moment T_0 with stress levels at moment T_1. The questionnaire contains several 5 point Likert scale statements regarding the perceived amount of stress (e.g. demanding nature of a task, feeling uncertain, expecting a lot of effort) and to what extent participants assume they can handle stress (e.g. having the abilities to perform well, feeling in control). To prevent test effect bias, statements were formulated differently and randomised. Disclosed information was measured by counting the number of spoken words and time while describing the suspect. This measurement is based on the study of Hoogesteyn et al. (2019). Finally, the number of details was measured via a list with the 46 most common facial descriptions of the suspects. This list was created by Klare et al. (2014) and measures the number of details in the description of the suspect, irrespective of the correctness of the details. As more details provide more help for policemen in identifying suspects, this was seen as a suitable measurement.

Analysis

Levels of stress measured at moments T_0 and T_1 were compared using a paired-samples t-test to check if stress levels did indeed increase. Next, to test the effects of room characteristics on disclosed information and number of details several statistical techniques were used. An independent t-test was performed to analyse the differences between groups, together with an ANOVA and MANOVA analysis, but these two techniques did not show any significant effects.

RESULTS

Manipulation (stool/chair and red/blue wall colour)

An independent-samples t-test was performed to compare the difference in comfort between the chair and the stool. Only one of the four statements regarding the difference in comfort of the chair and the stool were significant. Results showed a significant difference in how well the body was supported between the chair (M = 4.74, SD = 2.03) and the stool (M = 2.60, SD = 1.32; t (50) = 4.47, p <. 001, two-tailed). None of the three other statements was significantly different (to what extent the chair/ stool feels comfortable, feels soft, feels okay to sit on for several hours). Thus, the manipulation of seating comfort was less successful than in the pre-test. Maybe this is due to the fact that the tasks participants performed required an active posture, so they were less bothered by an uncomfortable chair.

Regarding colour, the emotions related to the colours were measured. Compared to the red wall, the blue wall was perceived to be more pleasant (M_{blue} = 2.32, SD = 1.07, versus M_{red} 3.52, SD = 1.05; t (50) = 4.07, p <. 001, two-tailed). Moreover, red was assessed as more exciting (M_{red} = 2.48, SD = .96, versus M_{blue} = 3.16, SD = .94; t (50) = 2.55, p <. 05, two-tailed), more distressing (M_{red} = 3.59, SD = 1.12, versus M_{blue} = 2.32, SD = 1.03; t (50) = 4.26, p <. 001, two-tailed) and more fearful (M_{red} = 3.37, SD = .93, versus M_{blue} = 2.16, SD = .75; t (50) = 5.16, p <. 001, two-tailed). No significant difference was found in interestingness or activeness between the two colours. Thus, the blue wall was perceived as calmer in comparison to the distressing, arousing red colour, which aligns with the theory in the literature review.

Regarding the stress level, it was crucial for the experiment that participants perceived stress, as this is common for interrogation sessions and the effects of seating comfort and wall colour are specifically expected for participants who experience stress. A paired-samples t-test showed that the stress induction was successful as statements regarding stress scored higher after performing the stress-test. Participants within the comfortable exerted more effort during the tasks than expected (M_{t0} = 2.69, *SD* = 1.11, versus M_{t1} = 4.23, *SD* = .60; *t* (11) = 4.17, *p* <. 001, two-tailed), similar to the uncomfortable setting (M_{t0} = 2.77, *SD* = .73, versus M_{t1} = 4.00, *SD* = .58; *t* (11) = 4.79, *p* <. 001, two-tailed). Furthermore, as the sample was limited, an ANOVA was used to find out whether the four groups showed significant differences in stress at T_0[1]. No significant differences in stress were detected, which means that the initial level stress was the same for all groups. Results regarding the hypotheses are shown in table 3.

Table 3 Results T-test Hypotheses 1-4.

Hypothesis	Variable	Mean	S.D.	Significance
H1 (red/blue)	Time	Red: 50 Blue: 49	Red: 24 Blue: 26	.85
	Word count	Red: 94 Blue: 97	Red: 57 Blue: 56	.88
H2 (red/blue)	Details	Red: 7.8 Blue: 6.9	Red: 2.4 Blue: 2.5	.19
H3(stool/chair)	Time	Stool: 45 Chair: 55	Stool: 17 Chair: 30	.18
	Word count	Stool: 110 Chair: 82	Stool: 43 Chair: 65	.085
H4 (stool/chair)	Details	Stool: 7.6 Chair: 7.1	Stool: 2.6 Chair: 2.3	.48

Information disclosed and number of details

Results of ANOVA showed no main effects of seating comfort and wall colour on the dependent variables (the information disclosed and the number of details). This may be due to the limited size of the sample. This means that the results show no support for the hypotheses. For further analysis only the two most extreme conditions were taken into account, namely the participants who were assigned to the chair and the blue wall (comfortable setting) and the participants assigned to the stool and the red wall (uncomfortable setting). These two groups were thought to shown the largest effect, being the combinations with the least comfortable setting (stool and red wall) and the most comfortable setting (chair and blue wall).

Likewise, no significant differences were found between group 1 and 4 in the amount of disclosed information (number of spoken words and spoken time). However, the effect on the number of details approached significance (*M* = 5.9, *SD* = 1.7; *t* (24) = -2.04, *p* = .052, two-tailed). Participants in the uncomfortable group mentioned more details (*M* = 7.3, *SD* = 1.8) than participants in the comfortable group. Although this effect is not significant, it is worth noting because given the difference in the mean score, a larger sample is likely to show a significant effect. Further research should show whether there

[1] The Cronbach alpha coefficient for the questions regarding stress level after the stress induction was .62 which is a moderate internal consistency according to Pavot et al. (1991). Therefore, determining a mean stress level was considered justified.

is no effect, or whether establishing this effect as a significant effect requires a much larger sample size. Thus, although wall colour and seat comfort separately had no effect, the combination of wall colour and seating comfort seem to have an impact on the number of details. However, the effect was contrary to what was expected. This indicates that, contrary to the expectations, participants in the uncomfortable room provided more elaborate witness statements.

CONCLUSION AND DISCUSSION

First of all, the present research shows that the experiment has successfully created stress, which means that a realistic interrogation setting was created that is important for the ecological validity of the study. However, the results did not lead to evidence that wall colour and/or seating comfort influence disclosing information (H1 and H3). Also no evidence was found for the influence on both independent variables on the number of details of the suspects (H2 and H4). However, the combination of seating comfort and wall colour showed an effect that approached significance. When the two conditions were compared that had a maximal difference, namely the chair and the blue wall, and the stool and the red wall, surprisingly participants within the uncomfortable setting conveyed more details than participants in the comfortable setting. Since stress was not statistically different between these groups no factor can be mentioned, based on the present study, which caused or mediates this effect. Perhaps people need an arousing environment, to a certain limit, in order to function well during an police interrogation. Possibly, the level of comfort within an police interrogation can be described as an optimum curve, as the current environment is too stressful but too much comfort neither supports the effectiveness of interrogations. More research is needed to further examine this effect and the role of arousal and stress in this potential effect. It should be noted that the effect was close to being significant (p = .052), which is probably being caused by the small magnitude of the sample. This is another reason to carry out a follow-up study with a larger sample size to further investigate the effect of the comfort of the setting and the number of details mentioned during a eye-witness testimony. Furthermore, wall colour and seating comfort are just two variables related to the experiences comfort in the interrogation room. Also, other factors may be relevant, such as lighting, personal distance, air quality and background noise (e.g. Frontczak & Wargocki, 2011; Okken, 2012).

As to the manipulations, this study strengthens the evidence regarding the moods evoked by the colours blue and red. Like results from Liu et al. (2014), it was found that blue is perceived as more comfortable than red. The outcome of the manipulation effect of seating comfort turned out differently during the experiment than expected beforehand. Although the pretest of the environmental manipulation and the study of Pijls et al. (2019) provided evidence of the differences in comfort between the chair and the stool, participants during the experiment assessed the comfort of the chair much lower. The researchers expect that the chair in the neutral room played a role, as it was probably too comfortable which changed the context for participants. On top of that, participants in the study of Pijls et al. (2019) were eating in a restaurant (relaxed setting), while participants within the present study were sitting upright in a stressful setting. Although the chair was rated as slightly more comfortable than the stool, results could have been more favourable had this bias been prevented. For future research, it is recommended to select a chair that scores much higher in terms of comfort than the T_0 chair, and a stool that is much less comfortable than the T_0 chair.

This study has several limitations. The sample was limited to 52 participants, as due to Covid measures and lack of resources for financial rewards it was not possible to recruit more students in the time available for the experiment. Comparable experiments (Dawson et al., 2017; Hoogesteyn et al., 2019; Kelly et al., 2019) had a considerably higher number of participants. It is possible that the effect of wall colour and seating comfort would have been significant had the sample been (much) larger. Additional research is suggested to study the role om environmental factors that create comfortable versus uncomfortable settings for performances during police interrogations.

Furthermore, the experimental design carries the same limitations as the experiment of Hoogesteyn et al. (2019) as this experiment was conducted in a university, which is a familiar environment for students. Although stress was induced to the participants, this might have limited the ecological validity as the feeling of a police interrogation was not fully mimicked, which means that the results might not be fully representable. Think of the dimensions of Knapp et al. (2013) in which the dimension familiarity refers to people being cautious in a less familiar environment, which is highly applicable for police interrogations, but not for students in their own university.

Future research is recommended to confirm that participants in the uncomfortable setting mentioned more details while participants in the comfortable setting mentioned less details, using a larger sample size. Furthermore, it would be interesting to research what causes this effect, and whether the level of comfort relates to an optimum curve in order to perform well. The research does show that aspects of the environment (colour, seating) affects people, but also that one cannot assume that the effect is as expected; decision regarding design should be evidence-based not intuition based.

PRACTICAL IMPLICATIONS

Although the present study is limited, mainly because of the limited sample size due to the Covid pandemic, the paper contributes to the FM field. Firstly, it creates awareness that the environmental setting of the interrogation room may have an impact on the quality of eye-witness testimonies. Both literature and indications in this study suggest that environmental factors inducing (dis)comfort may have impact on at least the number of details witnesses are able to provide during a police interrogation. So we must realise that not only interrogation methods, but also the environmental setting seems relevant. Secondly, this study is quite unique in its methodology due to its experimental design, which allows for the identification of specific characteristics of the interrogation room that may be relevant to the quality and richness of eyewitness testimony. Hopefully, this approach will inspire others to investigate this unexplored area further.

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A typology for the university campus as a living lab for Facility Management education and research

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ABSTRACT

Background and aim – The university campus is a built environment facilitating activities centred around learning and knowledge development. This confluence of activities makes the university campus uniquely suited to bring together stakeholders and to generate meaningful experiences to not only learn about but also further develop the facilitation of such experiences in the Facility Management (FM) discipline. This study aims to lower thresholds for universities using their campus as an integral part of FM education and research.
Originality – This paper introduces a typology for FM focused campus living labs (CLL) to help specify university administrators' motives towards implementing living labs on campus.
Methods / Methodology – A conceptual FM CLL typology was developed through literature review on living labs and adapted for use in a FM context.
Results – Four types of FM CLL are suggested primarily based on the distinct purpose, the stakeholder mix, initiator role(s), and the desired/expected output: (1) *Learning company* for practical education, (2) *Incubator* for systems thinking, (3) *Test lab* as a R&D test bed, and (4) *Innovation hub* for knowledge development.
Practical or social implications – This paper provides administrators of higher education institutions with FM related programmes a typology which can aid them in aligning organisation objectives with the specific purposes for using the campus as a living lab for FM education/innovation. In time, this can help administrators/educators to facilitate more active/experiential learning activities, while also providing researchers with opportunities to develop knowledge of FM (practices).
Type of paper – Conceptual research paper (full).

KEYWORDS
Facility Management, Living Lab, Higher Education, Campus Living Lab.

INTRODUCTION
Facility management (FM) is a broad field "concerned with the management, operation and maintenance of FM education development (e.g., Roper, 2017; Awang et al., 2013; Sullivan, 2010). FM as an academic discipline has been considered a practice-led discipline with heavy emphasis on professionalism, requiring both theoretical knowledge and practical skills (Junghans & Olsson, 2014). Even though not well documented in academic research, FM education generally uses problem-based learning techniques and real case studies to develop higher-order thinking skills and apply the knowledge to practical contexts (e.g., Collins et al., 2021; Redlein et al., 2021; Bendiksen et al., 2020). Further, practical skills are trained through internships and various other forms of collaboration with the industry, though in case of a more engineering-oriented approach to FM (hard FM), some practical skills are developed in lab settings. Recent research findings are often incorporated in specific subjects and students take an active part in research through (e.g.) graduation projects.

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Yet, it seems that innovation in the FM industry is slow and mild (Mudrak et al., 2004; Roper, 2017). Professionals have lacked required competencies to drive innovation (Mudrak et al., 2004), and research findings do not reach FM practice 'in time' (Roper, 2017). On the other hand, FM as an academic discipline also needs further development – especially in terms of research (Junghans & Olsson, 2014). Thus, higher education institutions (HEIs) have an opportunity to make stronger connections between research, education and skill development, and the industry. This could be done through (e.g.) innovation pedagogy which emphasises connections between working life, research, and education (Kairisto-Mertanen et al., 2010) and by providing innovative environments for experimentation, collaboration, and learning (e.g., Schaffers et al., 2009). This type of approach supports further development of innovation competencies such as creativity, critical thinking, initiative, teamwork, and networking (Lappalainen, 2020).

Implementing innovation pedagogy requires working-life orientation, flexible curriculum, multidisciplinary approach, new teacher and student roles, active learning methods, assessment changes, integration between studies and R&D activities, and entrepreneurship and internationalisation (Lappalainen, 2020). As innovation in FM mainly relates to specific business operations, support services, and physical spaces (Nazali Mohd Noor & Pitt, 2009; Mudrak et al., 2004; 2005), it requires continuous and close collaboration with a specific organisation, but – in an FM context – this would also need to be supported by the client organisation. Thus, research activities can become scattered, and education is often limited to case study discussions.

The typical HEI campus seems like a natural fit for a so-called living lab (LL) for FM with its inherent complexity making it resemble a 'micro-society': a confluence of stakeholders with different objectives, engaging in multiple (primary) processes, in a combination of built and digital/virtual environment(s) which allow for on-site knowledge sharing, natural synergy between stakeholders, and cost reduction (Jansz et al., 2020).

The binary nature of HEIs makes the synergy apparent, as both learning (education) and developing (research) are at the core of LLs, while also making users more likely to engage in co-creation practices. HEIs can act both as research institutions and as practice spaces, enabling practice-led innovation in FM. A LL for FM education can act as a driver for learning and innovation about and for the FM industry. Therefore, this conceptual paper presents a 'typology' of what Campus Living Labs (CLLs) could look like in the context of FM innovation specifically and depending on the purpose the lab is to serve at the HEI.

DEFINING LIVING LABS

The concept of LLs finds its roots in human-centred development of software (Ståhlbröst, 2008). It was assumed that early involvement of users in software development can bring more knowledge, reduce time to market, and improve adoption rates of the software. Moreover, by adopting the principles of open innovation (Gassmann et al., 2010) through actively inviting stakeholders to co-develop, co-design, and co-test prototypes and solutions, internal innovation can potentially be accelerated and provide information on adoption in new markets.

There are different definitions of a LL. Some refer to a LL as an approach, methodology, or ecosystem for open user-centric innovation which brings together co-creation, research, and innovation in a real-life environment (ENoLL, 2022). In contrast, Westerlund & Leminen (2011, p.20) define LLs as a physical, digital, or virtual 'space', in which a comprehensive mix of stakeholders collaborate to create, design, validate, and test new services/products, technologies, or systems in a real-life environment. These definitions of LLs show overarching themes/similarities corresponding to LL principles as suggested by Steen & Van Bueren, (2017), Bergvall-Kåreborn & Ståhlbröst, (2009) and Hossain et al. (2019) related to

openness, being grounded in reality, and user-involvement/-empowerment aimed at sustainable value creation.

A particular type of LL is the urban living lab (ULL), according to Steen & Van Bueren (2017) these are different from other LLs in that they focus on finding solutions meant to increase sustainable development in urban contexts which are more complex leading to additional challenges related to inclusiveness and democratic decision-making.

Given the definitions presented above, HEI campuses could be considered an ideal environment for a LL with characteristics similar to the ULL, only at a smaller scale. Ståhlbröst & Holst (2012) explain that LLs should have access to a multi-contextual environment, technology, infrastructure, along with a diverse set of capable stakeholders and users. A ULL needs a city, but modern (university) campuses increasingly resemble cities both in their fit with LL requirements (Jansz et al., 2020; Ståhlbröst & Holst, 2012) and in their alignment with the objectives of the organisation (Den Heijer, 2011). Consequently, HEIs – through CLLs – could act not only as a research institution providing research power and infrastructure but also as an organisation in its natural setting with own users, departments, suppliers, businesses and operations for students and researchers to explore and innovate.

TOWARDS A CAMPUS LIVING LAB TYPOLOGY FOR FACILITY MANAGEMENT EDUCATION

ULLs are not a universal solution to every problem, they should be set up for a specific purpose (Steen & Van Bueren, 2017) in a well-defined ecosystem in order to identify relevant stakeholders. To clarify these potential purposes, Puerari et al. (2018) developed a typology of ULLs. In this typology they position LLs on two axes based on their purpose: a) learning versus making and b) product/service systems vs societal systems. Similarly, the purposes of Campus LLs (CLLs) can be positioned based on their purpose on the axes 1) *education-driven* vs *research-driven* and 2) *product-service systems* vs *socio-technical systems*. This first axis relates to the primary objectives of HEIs, the second to the potential impact of the CLL on (sustainable) development. This leads to four distinct types of CLLs. On the educational side, a CLL can serve as a learning company for students to practice skills or as an incubator for stakeholders to deepen understanding of the FM ecosystem. On the research side, a CLL can serve as a real-environment testbed for technology developed by knowledge institutes and business partners. And finally, a CLL can have a knowledge development purpose, for instance related to further FM innovation through observing other types of CLLs. As Puerari et al. (2018) point out, LLs can serve different needs for different stakeholders involved depending on their role and involvement. These four distinct categories differ also by their relationship with education, research, and industry and the setting in which the activities of those LLs take place (see Figure 1).

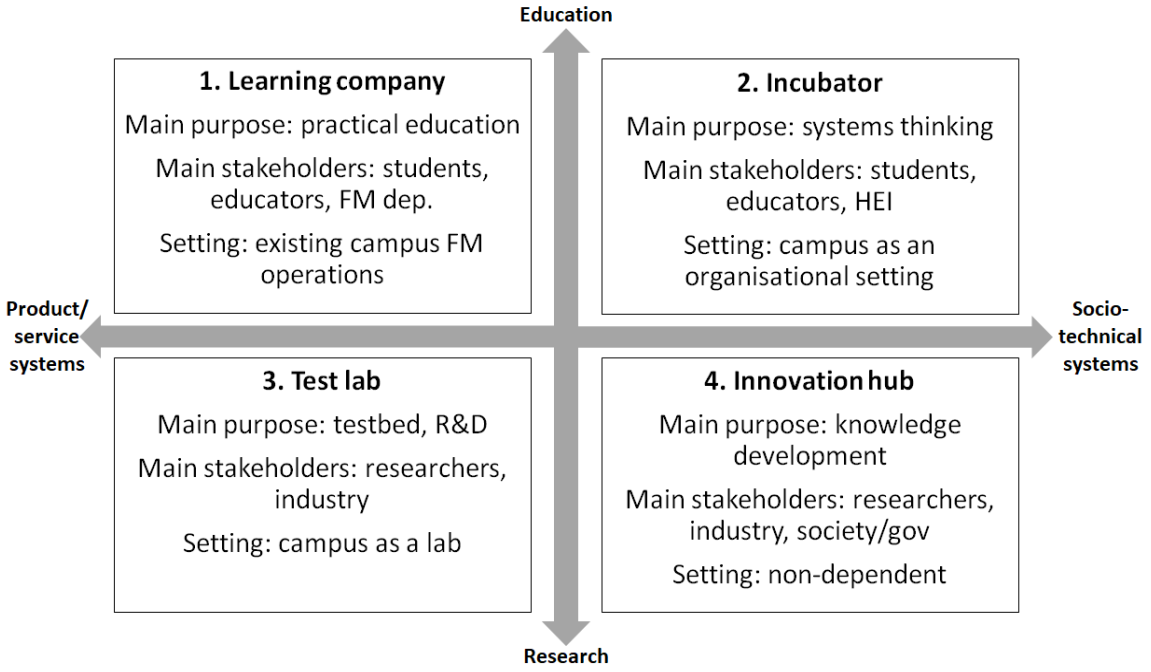

Figure 4 Four typologies of Campus Living Labs for Facility Management.

In the further development of the paper, we describe the types in more detail, specifically regarding the stakeholders involved, the activities performed within each type, and some of the challenges associated with each of the four types. Stakeholders considered were first observed as patterns from literature and were then compared with an existing framework of stakeholder types (Nyström et al. 2014) to ensure no perspectives were neglected. The CLL activities are rooted in categories of innovation activities as suggested by Almirall & Wareham (2011), while the challenges are derived from a comprehensive review on LL literature by Hossain et al. (2019).

1. **Learning company**. A type of a LL which emphasizes skill development of FM through practical education. The main stakeholders are students and educators who interact closely with an internal FM organisation, be it in-house or outsourced FM service providers. The main setting where a LL takes place is related to existing campus FM operations: service points, FM organisational spaces.
   - Initiative for activities will be primarily with educational employees because of the close ties to the curriculum, while students should be expected to take more reactive position. Campus FM departments will serve as the primary facilitator of this CLL's activities, with industry and government representatives involved on case basis.
   - For this CLL the activities are aimed at operational training primarily focusing on producing (selecting, choosing), and executing product/service procedures within the context of campus (FM) operations. Example activities could be learning standard operating procedures (SOPs), functional design of processes, building management through walkthroughs and assessments, FM department observations (e.g., observations of meetings).

2. **Incubator.** A type of a LL which emphasizes more complex knowledge development and systems thinking. Main stakeholders include students and educators as well as HEI acting as a contextual organisation. In this type of a LL, the campus acts as an organisational setting which students can explore and understand the complexities on the tactical and strategical level of FM.

- Initiative still lies with educators primarily, with students taking a reactive role. However, external actors take a more active role in providing the context of the CLL, as the learning objectives in this CLL are less process-based and more organizational (systemic).
- This type of CLL takes a more inside-out perspective, thus exposing students to systemic issues related to FM operations in connection to the macro-environment it operates in (rather than the internal/operational focus of the *learning company*). Example activities could be organisational setting analysis, stakeholder needs analysis, organisational behaviour and change management needs assessments.

3. Test lab. A type of a LL which emphasizes FM innovation testing and validation. The main purpose of the LL is to act as a testbed for both external and internal innovations at a certain readiness level. Here, main stakeholders are researchers and industry, and campus spaces become physical settings for product/service testing with campus users acting as test user groups.
   - Initiative comes mainly from researchers or (external) (private/public) organisations, with all parties involved in innovation-oriented activities.
   - Those activities are primarily focusing on product/service innovation through discovering, capturing, and generating/creating. However, these would also involve less generative activities like testing and refining. Example activities could be experimentation on live scenarios, insight generation through pilot testing of tangibles (furniture, equipment, technology) and intangibles (services, processes).

4. Innovation hub. A type of a LL which emphasizes broader knowledge development and research on societal implications of FM activities. Main stakeholders in this type of a LL are researchers, industry, governments, and society. Here, however, the setting of the campus becomes less relevant as the activities of this type of a LL are not location dependent other than being a hub and a (inspiring) meeting place for stakeholders.
   - The initiative is likely to come from researchers, and more likely to originate from the public sector than private sector compared to the *test lab*.
   - This CLL's outward purpose focuses on the development of knowledge around the FM industry through capturing, discovering, and generation/creation, but moving away from testing/refining. Example activities could be development of FM policies, research on wider ecosystem implication of FM innovations, FM innovation and concept development.

DISCUSSION AND/OR CONCLUSIONS

This paper suggests a typology of CLLs for FM education and research, thus providing an illustrative framework for HEI educators/administrators with FM curricula who are considering setting up a LL. The distinctions between the four types may also introduce distinct challenges related to each type's characteristics.

For the *learning company* the challenges stem from its direct connection to the educational curriculum, thus forcing a CLL to adhere to standards/conditions which may limit emergence. For the educational programme managers, it may prove difficult to adequately measure the quality of education in such a setting. Due to the dependence on the available facilities and infrastructure, this CLL type is sensitive to constraints related to these factors. Additionally, another challenge with a learning company CLL is the actual service environment where learning happens, which from an efficiency point of view is most likely not optimal. Depending on the FM organisation's KPIs, it might receive high resistance.

The *incubator* CLL type may suffer similarly from the connection to a defined curriculum, and it provides a similar challenge for quality control. Because of the system-orientation, existing diversity issues within

higher education may limit the learning capacity within these types of CLLs, as they may not sufficiently represent society at large. Additionally, as HEI would act as a case study for educational purposes, the resistance to allow these types of activities might come from organisation's management and employee sides.

Whereas the *test lab* is less connected to the educational curricula, it may see difficulties related to the essential involvement of industry. Especially in securing funding, it may be imperative to demonstrate return on investment, which may prove difficult for a CLL. And although this type is less system-oriented, a homogenous (student) population may still hamper innovation based on limited diversity. For long-term projects the transience of student-involvement may prove difficult, as continuity among co-creators and researchers is less guaranteed. This type of a LL might lead to more sporadic and short-term activities that might cause disruption to normal campus activities.

As opposed to the former, the *innovation hub* – because of its focus on systemic issues – may have more opportunities to secure government funding and thus suffer less from not being able to clearly justify ROI beforehand. However, that same focus on systemic issues opens it up for issues related to (for example) representativeness of the population for research and innovation purposes. Here the diminished ability of students to commit long-term may also hinder continuity within development teams. This type of setup requires strong knowledge base inside HEI, collaboration with other departments as well as commitment from HEI (e.g., through a dedicated research team).

As one of the main goals of LLs is to provide applied learning opportunities, all four types of CLLs offer that as well. However, the focus of the learning is different. *Learning company* focuses more on the individual learning and personalised experience of students, while *Incubator* offers more organisational learning for FM and HEI. *Testlab* promises more ecosystem and real-world learning for broader set of stakeholders while *Innovation hub* explores societal learning occurrences. Of course, this means that the complexity of those LLs increases as more stakeholders get involved and they take more complex roles. This type of complexity growth can also be reflected with learning activities throughout the curriculum and years of studies. Moreover, even though CLLs for FM seem to be a natural setting for both education and research in FM, varying from practical skill development studying a specific case organisation, to various research activities, specific inter-stakeholder dynamics and curricular conditions might limit the possibilities of applying all four types of LLs on a certain campus. As the typology of CLLs for FM has been developed by having in mind a specific organisational context, this might prove to be a limitation as well. It requires further validation and testing (also in other HEIs). We hope to receive feedback and any considerations about the typologies in order to develop a more generalizable framework.

The FM CLL typology could lead to further research, identifying readiness or maturity levels of these typologies and providing a list of specific requirements necessary for implementation of each typology.

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