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Preface of the publisher

23. Journal for Facility Management: Science meets Practice

Working from home, hybrid offices and the demand for workplace experience are asking for flexibility and customized offerings. Digitalisation of real estate is playing a vital role in enabling the fulfilment of this demand in an effective and efficient way. But what does digitalisation and the digital transformation of real estate and facility management mean?

It is not that we issue laptops, tablets and smartphones to our employees and the asset and facility management team. Digital transformation does also NOT mean to add as many sensors and IT tools to a building as possible. A friend of mine, Larry Leifer the founder of the design thinking methodology once asked, "DO your users really want so much technology? Or do they want fulfilment of their demand, needs and the resolution of their pains in an innovative way?"

To follow his approach means to define the "new" demand of the END USERS. According to the design thinking approach it is necessary to define the personas representing our target groups with their needs, demands, pains and their personal background in a way that we understand how they are ticking. Then we can define the new infrastructure and service offerings to enable and empower them and support the full triangle of people, pace and process. This will not only make people more productive, happy and increase the well-being and health, but also boost the productivity of the company in general and help winning the war for talents and retaining the talents in the company. In other words, this will ensure the sustainable success of our companies as a whole.

This issue of Journal für Facility Management provides you with hands-on suggestions what the digital transformation can look like and how to set the proper management steps for a successful implementation:

- *Reifegradmodelle als Grundlage für den digitalen Veränderungsprozess im Facility Management in Healthcare – Eine integrative Literaturrecherche*
- *Digital Transformation of Real Estate & Facility Management – Innovative Technologies require innovative teaching methods*
- *The Current State of BIM on Existing Buildings: The Case of Germany*

The goal of the first paper is to identify the digital maturity of the company to set the baseline for the next steps of the digital transformation. Especially healthcare organizations frequently lack the knowledge about the digital maturity of their non-medical support services to which facility management (FM) belongs. However, it would be important for FM organizations to understanding their current digital capabilities in order to draw strategic decisions. Overall, the integrative review demonstrates the need to develop a holistic maturity model for FM in healthcare, that includes transformational capabilities, rather than just technological applications. As such a maturity model should offer a level of adaptability for healthcare organizations to align the model to their organizational characteristics.

The second paper focuses on the knowledge transfer in the area of digitalization within RE/FM. Based on a worldwide survey the paper provides multiple and varied information on the technologies, and the differences in perception between industry and academia. This paper helps to identify the most promising technologies that we should incorporate into the curricula of future professionals and how to make their learning more effective with innovative educational methods.

The third paper presents how the digitalization of the Architecture, Engineering, and Construction (AEC) industry in Germany, particularly through the Building Information Modeling (BIM) method, presents opportunities for delivering facility management (FM) services more efficiently. BIM is primarily used in the planning and construction phase of buildings. In contrast, the usage of BIM in FM – that is, BIM-based FM – is limited to less than 1% of all buildings internationally. The paper states that the chief obstacle to BIM-based FM for existing buildings is the increased effort required for data acquisition and the lack of exchange between planners and operators. The paper provides valuable information for decision-makers and FM organizations about the optimization of the use of BIM in existing buildings.

At this point, I want to thank all international researchers who sent us numerous abstracts and papers for the double-blind review. The decline rate was kept high with more than 50%. I also want to thank the members of the editorial and the scientific board for their terrific work. They supported me in reviewing first the abstracts and then the full papers and gave a lot of input to the authors.

The high decline rate, the high reputed members of the editorial and the scientific board and the supporting universities ensure that the articles are not only highly scientifically qualified, but also that practitioners can put them into practice easily.
I also want to thank my team, especially Barbara Gurdet, Antonia Heil, Christian Lau and Lisa Thrainer. Without their personal engagement the journal would not be available in this high quality.

I wish you all the best from Vienna, an enjoyable read, a lot of input for your research and/or for your daily work. I look forward to new striking research in the next IFM Journal and a refreshing exchange at the 15th IFM Congress from 17th to 18th of November 2022.

Yours,
Alexander Redlein

Head of Editorial Board
To my family Barbara, Caroline Sidonie und Alexander David

Scientific Committee

Herausgeber / Editorial Board

Organisation

Vielen Dank an alle KollegInnen des IFM für die Mithilfe bei der Organisation!

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Thomas Vorbeck and Nadine Wills

University of Applied Sciences Mittelhessen, Faculty of Business Engineering, Engineering Management Real Estate, Wilhelm-Leuschner-Str. 13, 61169 Friedberg, Germany

Science meets Practice I:
Digital Transformation

Reifegradmodelle als Grundlage für den digitalen Veränderungsprozess im Facility Management in Healthcare – Eine integrative Literaturrecherche

Ilyas Kirecci[1], Paul Schmitter[1], Thomas Hanne[2], Philipp Gachnang[2] and Stella Gatziu Grivas[2]

[1] Institute of Facility Management, Zurich University of Applied Sciences (ZHAW), Seestrasse 55 / RA, 8820 Waedenswil, Switzerland
ilyas.kirecci@zhaw.ch, paul.schmitter@zhaw.ch
[2] Institute for Information Systems, University of Applied Sciences and Arts Northwestern Switzerland, 4600 Olten, Switzerland;
stella.gatziugrivas@fhnw.ch, thomas.hanne@fhnw.ch, phillip.gachnang@fhnw.ch

Abstract

Healthcare organizations frequently lack the knowledge about the digital maturity of their non-medical support services to which facility management (FM) belongs. However, there is a significant leveraging effect in the digital transformation. It would be important for FM organizations to understanding their current digital capabilities in order to draw strategic decisions. Despite the extensive variety of maturity models, a comprehensive framework for this domain is lacking. The aim of this paper is to create a fundamental understanding, from which to develop a dedicated model. An integrative review was performed to systematically collect, screen and review the literature. A total of 124 articles were screened. Of these, 96 articles were further reviewed. The findings show that none of the identified maturity models cover all organizational domains and systems of healthcare organizations. Moreover, there is a clear contrast observed with digital maturity models in the FM domain. These maturity models mostly address individual technology applications, which limits the effectiveness of such models for an FM organization. Overall, the integrative review demonstrates the need to develop a holistic maturity model for FM in healthcare, that includes transformational capabilities, rather than just technological applications. As such a maturity model should offer a level of adaptability for healthcare organizations to align the model to their organizational characteristics.

Keywords: Facility Management, healthcare, digital transformation, digital maturity, maturity model

1. Einleitung und Relevanz der Thematik

Durch die COVID-19 Pandemie konnte eine allgemeine Beschleunigung der Digitalisierung in den Gesundheitseinrichtungen beobachtet werden. So zeigt auch die Trendstudie vom Gottlieb Duttweiler Institute (Gürtler et al. 2018), dass die Strukturen insgesamt zukünftig stark von der Digitalen Transformation geprägt sein werden. Gleichzeitig steigt der Druck, die Kosten zu kontrollieren, bei gleichbleibender Qualität (Alessio et al. 2015, Christen et al. 2015, Honegger et al. 2016, Horisberger 2013). Abel und Lennerts (2006) haben eruiert, dass FM Dienstleistungen durchschnittlich bis zu einem Drittel aller entstehenden Kosten einer stationären Gesundheitseinrichtung verantworten. Der Ansatz der nicht-medizinischen Supportleistungen – die FM-Leistungen miteingeschlossen – wurde von Gerber und Kuchen (2019), in ihrem Leistungszuordnungsmodell für nicht-medizinische Leistungen in Spitälern (LemoS) definiert. Es wurde speziell entwickelt, um die Systematik und Klarheit der Leistungen des FM im Gesundheitswesen zu verbessern. Im Hinblick auf Investitionen in die Digitale Transformation, liegt in diesen Leistungen ein signifikanter Hebel zur Kostenreduktion. Es stellt sich die Frage, wie eine klare Standortbestimmung und gezielte Ressourcenallokation diesen Prozess unterstützen können.

2. Theoretischer Hintergrund und Problemstellung

Der Ansatz des Reifegrades für das Management von Information- und Kommunikationssystemen und Technologien (ICT) geht auf Richard Nolan's vierstufiges Reifegradmodel zur Reifegradbemessung von KIS-Systemen zurück (Carvalho et. al. 2016). Weitläufige Bekanntheit erlangte das Capability Maturity Model (CMM) von Watts Humphrey als Weiterentwicklung des Ursprungsmodells (Humphrey 1988). Das CMM Begriff die digitale Reife als das Ausmaß, der Prozessqualität. Das CMM klassifiziert fünf Reifegradstufen, in welchen lediglich die wichtigsten Punkte identifiziert werden, welche den Aufstieg auf die nächste Stufe verhindern (Raos 2021). Der Aufbau von Reifegradmodellen unterscheidet sich für gewöhnlich zwischen einem holistischen Ansatz, welcher den Anspruch hat, das ganze Unternehmen und deren Prozesse abzubilden und branchen- oder domänenspezifischen Ansätzen von Reifegradaspekten (Wendler 2012). Mittlerweile erschien eine Vielzahl von Veröffentlichungen zu Reifegradmodellen mit unterschiedlichen Ausprägungen, Stufen und Dimensionen (Lee et al. 2019, Wendler 2012). Dabei halten sich die Modelle aus der Wissenschaft und diejenigen, welche aus der Praxis entwickelt werden, in etwa die Waage (Felch et al. 2019, Teichert 2019). Carvalho et al. (2016) identifizierten bereits 2016 vierzehn verschiedene Reifegradmodelle im Gesundheitswesen, welche für unterschiedliche Zwecke eingesetzt werden. Carvalho et al. (2016) haben den Eindruck, dass das CMM und seine Nachfolger, das Referenzmodell für die Entwicklung von Reifegradmodellen im Gesundheitssektor sind. Tatsächlich basieren sechs von den eingangs erwähnten vierzehn, identifizierten Modellen in ihrer Struktur auf dem CMM-Modell.

Die Problematik hat Kytömäki (2020) dargelegt, dass ein Verständnis der vielfältigen digitalen Technologien vor allem für Manager wichtig ist, die Schwierigkeiten haben, Entscheidungen in Bezug auf Innovation und Digitalisierung zu treffen. Gleichzeigt haben Honegger et al. (2019) aufgezeigt, dass sich nur wenige Gesundheitsinstitutionen auf strategischer Ebene mit FM, bzw. den dazugehörigen neuen Technologien beschäftigen. Es besteht auch ein geringer Wissensstand, wie der eigene Reifegrad diesbezüglich ermittelt werden kann (Kirecci & Schmitter 2020).

Graf et al. (2019), Grivas & Graf (2020) und Peter et al. (2018) haben mit der ABILI-Methodik den Ansatz des digitalen Reifegradmodells weiterentwickelt, mittels einem Transformation Compass, welcher einen strukturierten Rahmen bietet, um Fokusbereiche der Digitalen Transformation zu definieren und einer Methode zur Definition der digitalen Strategie und abzuleitenden Maßnahmen.

3. Zielsetzung und Fragestellung

Das Ziel dieser Studie ist es, ein grundlegendes Verständnis zu schaffen, auf dessen Basis ein digitales Reifegradmodell für die nicht-medizinischen Supportservices (inkl. FM Leistungen) entwickelt werden kann. Hierzu sollen Beziehungen von Dimensionen und Elementen, welche die digitalen Reifegrade bestimmen, aufgezeigt werden. Es soll dabei aus der Perspektive des FM, aufgezeigt werden, wie der aktuelle Stand der digitalen Reifegradmodellen ist. Die übergeordnete Forschungsfrage lautet: *Was ist der Stand der Technik bei digitalen Reifegradmodellen im Gesundheitswesen aus einer FM-Perspektive?*

4. Methodik der integrativen Literaturrecherche

Eine integrative Literaturrecherche wurde durchgeführt, basierend auf den Methodiken von Snyder (2019) und Torraco (2005). Das Ziel war es die Literatur systematisch zu sammeln, sichten, auszuwählen und rezensieren. Die Literaturrecherche gliedert sich in zwei getrennte Teilbereiche: A) Digitale Reifegradmodelle und B) Digitale Transformation des FM in Healthcare. Die Intension ist, das Thema aus FM-Perspektive extern (Reifegradmodelle) und intern (Digitale Transformation) zu beleuchten. Die erste Sichtung der Literatur hat gezeigt, dass digitale Reifegradmodelle im FM praktisch inexistent sind und umgekehrt, die meisten Reifegradmodelle FM-Themen nicht berücksichtigen. Daraus ergab sich der Bedarf für zwei gezielte Recherchen zu den jeweiligen Themen. Während der Aufbau des Frameworks eines zukünftigen digitalen Reifegradmodells für das FM in Healthcare aus der Literatur im Teilbereich A entnommen werden kann, erfordern die Details für die einzelnen Dimensionen spezifisches Themenwissen aus Teilbereich B. Das Vorgehen für beide Teile der Literaturrecherche sind wie folgt (angelehnt an Snyder (2019) und Torraco (2005)):

1. *Auswahl einer konzeptionellen Struktur (als Guiding Theory)*
2. *Festlegung des Umfangs und Formulierung der Fragestellungen*
3. *Auswahl von Suchbegriffen und Forschungsdatenbanken*
4. *Festlegung von Ein- und Ausschlusskriterien*
5. *Pilottest und Neukonfiguration der Suche*
6. *Systematische Suche (Erfassung von übergeordneten Inhalten)*
7. *Sichtung der zu überprüfenden Literatur (anhand von Einschluss-/Ausschlusskriterien)*
8. *Endgültige Festlegung der Stichprobe: Autoren, Erscheinungsjahr, Thema, Art der Studie*
9. *Durchsicht der Artikel und thematische Kodierung auf der Grundlage von Flick (2007)*
10. *Analyse, Synthese und Zusammenfassung der Ergebnisse*

4.1. Teilbereich A: Digitale Reifegradmodelle

Für den Teilbereich A orientiert sich die Literaturrecherche am Verständnis von Fokusbereichen der Digitalen Transformation wie dies in der ABILI-Methodik (Graf et al. 2019, Grivas & Graf 2020, Peter et al. 2018) beschrieben wird. Der Gegenstand der Literaturrecherche umfasst digitale Reifegradmodelle und deren Dimensionen und Themen. Sie berücksichtigt auch die übergeordnete Digitale Transformation (wenn in der Literatur zu den Reifegradmodellen darauf Bezug genommen wird). Die nachfolgenden Fragestellungen dienen als Grundlage für die Recherche:

1. *Was ist der State-of-the-Art bei digitalen Reifegradmodellen in der Literatur?*
2. *Welche digitalen Reifegradmodelle sind repräsentativ für den FM in Healthcare Markt und/oder für die nicht-medizinische Supportprozesse?*
3. *Wie sind die digitalen Reifegradmodelle konzipiert?*
4. *Welche Elemente (Dimensionen) und Themen (Kategorien und Unterkategorien) werden in den digitalen Reifegradmodellen abgebildet?*
5. *Wie spiegeln sich die Digitale Transformation und die damit verbundenen Themen in den digitalen Reifegradmodellen wider?*

Aus diesen Fragestellungen sind spezifische Suchbegriffe abgeleitet und auf der Grundlage, der im Vorfeld des Forschungsprojekts durchgeführten Vorrecherche, erweitert worden. Insgesamt wurden 7 verschiedene Datenbanken gewählt. Die Suche erfolgte zwischen dem 10.06.2022 bis 10.08.2022, sowohl mit englischen als auch deutschen Begriffen. Die Einschlusskriterien für die Wahl der Artikel waren alle digitalen Reifegradmodelle und deren Dimensionen, sowie die Digitale Transformation in Bezug auf die digitale Maturität. Ausgeschlossen wurden Reifegradmodelle, welche nicht im Zusammenhang mit der Digitalen Transformation standen und Artikel, welche vor 2018 erschienen sind.

Alle relevanten Artikel wurden anhand der thematischen Kodierung nach Flick (2007) analysiert. Ausgehend von der konzeptionellen Struktur der ABILI-Methodik wurden die Codes am Anfang deduktiv festgelegt. Nach der Sichtung der Artikel wurden zunehmend weitere Codes induktiv generiert.

4.2. Teilbereich B: Digitale Transformation des Facility Management in Healthcare

Die Literaturrecherche für Teilbereich B orientierte sich an der Grundlage des LemoS-Modells von Gerber und Kuchen (2019). Der Umfang der Literaturrecherche umfasst die relevanten Themen im Hinblick auf die Digitale Transformation und die digitale Reife aller nicht-medizinischen Supportleistungen. Als Leitfrage für die Recherche und Analyse diente die folgende Fragestellung:

> *Welche Theorien, Ansätze, Systeme, Technologien, Dienstleistungen, Prozesse, Lösungen und Herausforderungen von Facility Management in Healthcare und nicht-medizinischen Supportservices in Bezug auf die Digitale Transformation (inkl. Digitalisierung und digitale Reife) sind in der Literatur dargestellt?*

Insgesamt wurden 5 Datenbanken abgefragt. Die Datenbanksuche erfolgte vom 21.09.2021 bis 22.09.2021. Einschlusskriterien für die Wahl der Artikel waren alle nicht-medizinischen Themen, gemäß dem LemoS-Modell und FM, die sich auf die Digitale Transformation und der Digitalisierung beziehen. Ausschlusskriterien sind reine IT- und Software-Produkte und Themen, welche nicht den nicht-medizinischen Supportprozessen zugeordnet werden können und Artikel, die vor 2018 publiziert wurden. Der Vorgang der Selektion, Überprüfung und Kodierung erfolgte analog zu Teilbereich A.

5. Resultate integrative Literaturrecherche

Nachfolgend in der Abbildung 1 wird der schematische Ablauf der integrativen Literaturrecherche gezeigt, um ausgehend von den Datenbankfunden relevante Artikel, und daraus wiederrum einzelne Wissensobjekte zu extrahieren. Das Vorgehen ist für die beiden Teilbereiche A und B sind gleich.

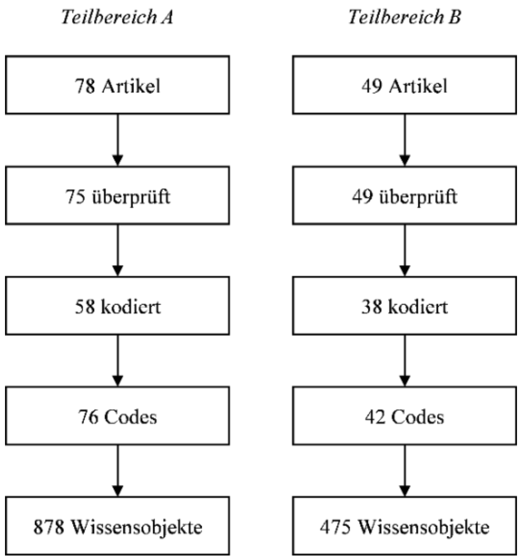

Abbildung 1: Ablaufschema integrative Literaturrecherche

5.1. Teilbereich A: Digitale Reifegradmodelle

Für den Teilbereich A der Literaturrecherche wurden insgesamt 78 Artikel zunächst anhand der Einschluss- und Ausschlusskriterien überprüft (siehe Abb. 1). Daraus wurden 75 Artikel für die Durchsicht und thematische Kodierung gewählt. Insgesamt wurden 58 unterschiedliche Codes (deduktiv und induktiv) generiert (davon 878 einzelne Wissensobjekte, d.h. Textabschnitte, Tabellen oder Grafiken kodiert) und zu Kategorien und Sub-Kategorien gebündelt.

Ausgehend von den analysierten Artikeln zu digitalen Reifegradmodellen, konnten keine Modelle eruiert werden, welche speziell und zusammenfassend für die nicht-medizinischen Supportprozesse im Gesundheitswesen konzipiert wären. Auch kommt in der Literatur keine klare Abgrenzung zwischen Dimensionen, Sub-Dimensionen und Reifegradindikatoren vor. Verschiedene Aspekte sowie Beziehungen von Dimensionen und Indikatoren, welche die digitalen Reifegrade bestimmen, konnten aus der Perspektive des FM, jedoch als relevant definiert werden.

So lässt sich feststellen, dass bezüglich des übergeordneten Frameworks, bzw. des Designs der angewandten Reifegradmodelle im Gesundheitswesen, kein identifiziertes Modell einen ausreichend breiten Umfang hat, alle Bereiche und Subsysteme von Gesundheitsorganisationen abzudecken (Burmann & Meister 2021). Da die Akteure in Gesundheitsorganisationen keiner zentralen Strategie unterworfen sind, sondern in verschiedenen Organisationseinheiten, teils widersprüchliche Ziele verfolgen, führt dies eher zur Verwendung von domänen-spezifischen, anstelle von holistischen Modellen (Burmann & Meister 2021). Carvalho et al. (2016) streichen explizit heraus, dass ein holistisches Modell mit ganzheitlichem Ansatz nicht versuchen sollte alle Teilsysteme des Gesundheitswesens einzubeziehen, sondern die wichtigsten Einflussfaktoren mit unterschiedlicher Gewichtung aufzuführen. Im Kontext von Reifegradmodellen versteht sich ein holistischer Ansatz als ein Framework (Ordnungsrahmen), von dem aus der Digitalen Transformation gesamtheitlich betrachtet wird und dessen Dimensionen und Teilbereiche die Organisation insgesamt miteinbezieht. Nach Teichert (2019) sollten Transformationsfähigkeiten und nicht digital-technologische Fähigkeiten adressiert werden. Ein weiteres Merkmal ist die Statik der gängigen Modelle. Viele Modelle messen den digitalen Reifegrad organisiert in individuelle Reifegrade (Levels) (Snowdon 2017). Andere orientieren sich nach Dimensionen und jede dieser Dimensionen hat verschiedene, mögliche Maturitäts-Stufen (Kljajić et al. 2021). Jedoch sind Veränderungsprozesse, die zur Erreichung der Maturitätsziele erforderlich sind, in hochkomplexen 7/24-Betriebsorganisationen anspruchsvoll (Mettler & Pinto 2018). Daher ist ein starres Bewertungssystem mit wenigen Metriken schwer haltbar - vielmehr wird ein umfassender Ansatz benötigt (Flott et al. 2016). Hierzu ist auch die Anpassungsfähigkeit von Reifegradmodelle an die Besonderheiten der Organisation essenziell (Felch et al. 2019).

Infolgedessen sollte der Fokus auf den Veränderungsprozess der Organisationskultur liegen und Hand in Hand mit einem strategischen Innovationsmanagement und konkreten Maßnahmen zum Change-Management erfolgen (Mergel 2019, Deiters et al. 2018). So sehen Burmann et al. (2019) digitale Reife als das Ausmaß, in dem ein Prozess explizit definiert, gemanagt, gemessen, und kontrolliert wird. Desweitern sind nahezu alle digitalen Reifegradmodelle deskriptiver Natur und beschränken ihren Umfang auf die Bewertung des digitalen Reifegrads. Zugegebenermaßen steht dies im Wiederspruch zu dem Verständnis der Transformation, welches ein dynamischer Prozess darstellt. Demgegenüber schreibt Teichert (2019), dass es einen klaren Fahrplan geben soll, wie ein höherer Reifegrad präskriptiv erreicht werden kann. Auch Deiters et al. (2018) zeigt auf, dass aus einer Gegenüberstellung verschiedener entwickelter Teilmodelle eine Roadmap zur weiteren Digitalisierung abgeleitet werden kann.

Dabei besteht ein häufiger Mangel am Prozess der digitalen Maturität hauptsächlich darin, die inkrementelle Entwicklung zu unterstützen, aber die Vision des zukünftigen digitalen Krankenhauses nicht zu formulieren (Burmann & Meister, 2021). Allen voran wird die Organisationskultur immer mehr als Hürde Nummer eins der Digitalen Transformation und als wichtigste Barriere für digitale Effektivität gesehen. Infolgedessen beinhalten mehr als die Hälfte der untersuchten digitalen Reifegradmodelle „Kultur" als eigene Dimension (Teichert 2019).

Die Digitalisierung kann daher nicht nur aus einer technischen Sicht erfolgen, sondern erfordert die digitale Souveränität der Mitarbeiter sicherzustellen sowie deren Bereitschaft und Maturität zu erhöhen. Dies kann mit auf Personas abgestimmte Trainingsprogrammen designt werden und um die digitalen Kompetenzen der Mitarbeiter zu verbessern (Deiters et al. 2018, Mergel 2019). Da besser ausgebildetes und informiertes Personal ein vertieftes Verständnis hat was Digitalisierung zu leisten vermag und eher dazu neigt den digitalen Reifegrad positiv zu beurteilen, sollte das Management die Nutzer bei der Gestaltung ihrer Erwartungen unterstützen und nicht nur technische Entwicklung leisten (Mettler & Pinto 2018).

In den technologischen Aspekten erkennt Basl (2018) zudem den dringenden Bedarf die Bereitschaft des Unternehmensinformationssystems und des ERP-Systems zu verbessern, da sie die zentralen Drehscheiben sind, um den Fortschritt zu steuern und zu ermöglichen. Obwohl Reifegradmodelle komplex sind, legen sie oft keinen Fokus auf das ERP in Form einer eigenen Unternehmensinformationssystem-Dimension und enthalten auch sonst oft keine detaillierten Informationen über Unternehmensinformationssysteme (Basl 2018). Gerade das Zusammenführen von Daten- und Informationsströmen erlaubt gemäß Dieters et al. (2018) eine Kooperations- und Kommunikationskultur, was zu massiven Entlastungspotentialen für die Mitarbeiter durch Unterstützung in den primär aber insbesondere auch in den Sekundärprozessen führen kann. Durch die erzeugte Transparenz eines integrierten Systems wird auch „Predictive Maintenance", effiziente Ressourcenplanung und digital unterstütztes „Taskmanagement" möglich, was es in Echtzeit ermöglicht, überlastete Funktionsbereiche zu erkennen und sogar vorherzusagen (Deiters et al. 2018). Es gilt hier nach Mettler & Pinto (2018) zu beachten, dass wenn das externe geschäftliche und soziale Umfeld fortschrittlicher und anspruchsvoller wird und das Anwendungsportfolio nicht mehr den Erwartungen und Best Practices des eigenen Ökosystems entspricht, die digitale Reife abnehmen kann.

5.2. Digitale Transformation von FM in Healthcare

Für den Teilbereich B der Literaturrecherche wurden insgesamt 49 Artikel zunächst anhand der Einschluss- und Ausschlusskriterien überprüft (siehe Abb. 1). Daraus wurden 38 Artikel für die Durchsicht und thematische Kodierung gewählt. Insgesamt wurden 42 unterschiedliche Codes (deduktiv und induktiv) generiert (davon 475 einzelne Wissensobjekte) und zu Kategorien und Sub-Kategorien gebündelt.

Insgesamt gibt es nur vereinzelt Literatur aus dem FM bzw. nicht-medizinischen Bereich zum Thema digitale Reifegradmodelle. Diese Artikel selbst beziehen sich auf spezifische Teilbereiche des FM. Hierzu beschreiben Yilmaz et al. (2019) und Ahmed und Kassem (2018) verschiedene BIM-Fähigkeitsstufen (Building Information Modelling Capabilities), mit dem der Reifegrad einer Organisation gemessen werden kann. Obwohl Lindblad und Guerrero (2020) kein Reifegradmodell an sich präsentieren, unterteilen sie die BIM-Implementation in verschiedene Bereiche (Produkt, Organisation und Prozess) anhand dieser Dimensionen gebildet werden können. Abgesehen von den BIM-Reifegradmodellen lassen sich keine weiteren Modelle in der Literatur finden.

Ausgehend von einer übergeordneten strategischen Perspektive wurden Artikel zur Strategie und dem strategischen Real Estate und Facility Management unterteilt. Darin werden Kernkompetenzen für die Digitale Transformation in den Bereichen Datenintegration, Leadership und Strategie, Betrieb und Instandhaltung, Property Management, Risikomanagement, Nachhaltigkeit und IT Management beschrieben. Datengestützte Entscheidungsfindung wird als ein wichtiger Vorteil der Digitalen Transformation angesehen (Godager et al. 2021). Um dies zu erreichen, muss, wie Talamo und Bonanomi (2020) feststellen, die Integration und Zusammenarbeit zwischen den Akteuren erleichtert und verstärkt werden. Außerdem müssen Standards und Verfahren innerhalb der Organisation sowie mit externen Interessengruppen festgelegt werden. Führung und Strategie sind weitere Aspekte, dessen Bedeutung für die Digitale Transformation in der Literatur hervorgehoben werden. Übergeordnet wird auf die Notwendigkeit der strategischen Ausrichtung des FM auf die Digitale Transformation hingewiesen, obwohl dies in der Literatur nicht explizit genannt wird. Lindblad und Guerrero (2020) beschreiben die Wichtigkeit der strategischen Ausrichtung von BIM-Projekten auf Basis der Geschäftsordnungen der verschiedenen Stakeholder. Wiederum nennen Mannino et al. (2021) unter anderem die strategische Planung und Ausrichtung als eines von sieben Kernkompetenzen des Facility Managements. Somit lässt sich auf eine strategische Ausrichtung folgern.

Die Operationalisierung, insbesondere auf taktischer und operativer Ebene, erfolgt dann in den jeweiligen Bereichen, wie dem Betrieb, der Infrastruktur, der Hotellerie, dem Qualitätsmanagement, usw. Wie in vielen Fällen beschrieben, sind die übergeordneten strategischen Ziele der Digitalen Transformation gekennzeichnet durch Qualitätssteigerung, Zeitersparnis, Kosteneinsparung, Effizienzsteigerung und Risikominimierung (Chakravorty et al. 2018, Mannino et al. 2021, Martin et al. 2020, Yadav & Pavlou 2020, Yousefli et al. 2020). Darüber hinaus ist hier auch die erhöhte Servicequalität zu nennen, die teils auf die digitalen Technologien zurückzuführen ist. In Krankenhäusern werden dem Kundenservice und der patientenzentrierten Versorgung zunehmend Priorität eingeräumt. Dank neuen smarten Infrastrukturen, die auf Algorithmen basieren, können personalisierte Dienste und Schnittstellen mit einfacher Skalierbarkeit angeboten werden (Valtolina et al. 2020, Yadav & Pavlou, 2020). Durch eine abgestimmte Integration dieser Technologien in die bestehenden Prozesse bietet sich die Möglichkeit der Qualitätssteigerung ohne einen großen Kostenanstieg.

Letztlich wird die operative, bzw. die technologische Ebene der Digitalen Transformation thematisiert. In der Mehrzahl bezieht sich die Literatur auf die spezifischen Technologien und technischen Lösungen. Die meist-genannten Technologien, die aufgeführt werden, sind BIM, Internet of Things (IoT), CAFM-Syteme, Digital Twins und Blockchain. Hierbei beziehen sich die Artikel insbesondere auf die (technischen) Funktionen, Ziele, Voraussetzungen, Vorteile und Anwendungsszenarien. BIM als technologische Lösung steht in vielen Fällen im Vordergrund. Gemäß der Literatur sind seine technologischen Fähigkeiten entscheidend für die Digitale Transformation im FM. Viele der genannten Technologien, Anwendungen und Daten sind Bestandteil der BIM-Lösung. Dies gilt im Besonderen für die IoT-Integration (Carbonari et al. 2020, Mannino et al. 2021). Des Weiteren werden die Anbindung und der Datenaustausch mit Applikationen von Drittanbietern über Schnittstellen in der Literatur hervorgehoben (Huynh & Nguyen-Ky, 2020) und die gemeinsame Nutzung von Informationen mit Hilfe der Digital Ledger Technologie (DLT) (Li et al., 2019).

Viele Use-Cases finden sich im Bereich Infrastruktur. Vor allem das Instandhaltungsmanagement wird im Zusammenhang mit der Digitalen Transformation oft genannt (Bortolini & Forcada, 2020, Godager et al. 2021, Mannino et al. 2021, Moretti et al. 2021, Nota et al. 2021, Yousefli et al. 2020). Die Vorteile digitaler Technologien bieten Facility Managern die Möglichkeit, leistungsbasierte Instandhaltungsmanagementmethoden einzusetzen (Nota et al. 2021). Wie Moretti et al. (2021) schreiben, werden die Instandhaltungsmaßnahmen von den Systemen automatisch ausgelöst, sobald ein bestimmter

Schwellenwert erreicht ist. Die Daten werden z. B. von IoT-Geräten Multi-Tracking-Systemen oder anderen Datenquellen (z. B. durch Text-Mining von Daten aus Wartungsaufträgen (Gunay et al. 2019)) eingespeist. Die Daten können auch mit weiteren Systemen verknüpft und integriert werden. Anhand des Bereichs der Infrastruktur zeigt sich anschaulich wie die Digitale Transformation auf der operativen Ebene umgesetzt wird, um die vorhin genannten strategischen Ziele zu erreichen.

6. Diskussion

Die FM-Literatur zur Digitalen Transformation ist primär domänen-spezifisch und deckt sich kaum mit dem Konzept der Digitalen Transformation. Zudem gibt es kaum digitale Reifegradmodelle. So liegt der Fokus auf einzelnen Technologien, wie BIM, welches aus FM-Perspektive, die am häufigsten verwendeten Technologie ist. Da anstelle von digital-technologische Fähigkeiten, jedoch eher Transformationsfähigkeiten adressiert werden sollten (vgl. Teichert (2019)), könnte dies als Hinderungsgrund für die Adaption gesehen werden. Auch erfordert die Komplexität, welche in Gesundheitsorganisationen vorzufinden sind, ein ganzheitliches und flexibles Modell – insbesondere auch für die nicht-medizinischen Leistungen. Dem gegenüber steht die Erkenntnis, dass die Akteure in Gesundheitsorganisationen oftmals keine zentrale, sondern Organisationseinheiten-spezifische Strategien und Ziele verfolgen, was eher domänen-spezifische, anstelle von holistischen Modellen begünstigt. Auch „weiche Faktoren" wie das Vorhandensein einer klaren Vision, der Kultivierung einer digitalen Kultur, Kenntnis des digitalen Reifegrades der Mitarbeitenden und Förderung deren digitalen Kompetenzen, spielen eine zentrale Rolle, werden aber zu wenig berücksichtigt.

6.1. Schlussfolgerung

Das Fehlen von Modellen für die Digitale Transformation im FM-Kontext macht sich in der übergeordneten, strategischen Sichtweise bemerkbar, welche für die Digitale Transformation essenziell ist, und nur in wenigen Fällen in der FM Literatur aufgegriffen wird (vgl. Honegger et al. (2019)). Dies wäre jedoch elementar, um den digitalen Veränderungsprozess der nicht-medizinischen Supportprozesse, durch ein strategisches Innovationsmanagement und konkrete Maßnahmen im Change-Management zu ermöglichen (vgl. Teichert (2019), Mergel (2019), Deiters et al (2018)). Ein weiterer Umstand ist die Tatsache, dass nahezu alle digitalen Reifegradmodelle deskriptiver Natur sind und sich auf die Bewertung des digitalen Reifegrads beschränken, jedoch keine präskriptive Anleitung für einen höheren Reifegrad bieten, obwohl es möglich wäre eine Roadmap zur weiteren Digitalisierung abzuleiten (vgl. Teichert (2019) und Deiters et al. (2018)). Die technologischen Lösungen haben ebenfalls einen direkten Einfluss auf die Kooperations- und Kommunikationskultur und begünstigen die Entlastungspotentiale sowie Prozessoptimierung, insbesondere in den Sekundärprozessen (vgl. Deiters et al. 2018, Mettler & Pinto).

Dank der Doppelgliederungen der Literaturrecherche konnten beide Perspektiven einzeln untersucht und mittels fundierten Aussagen gegenübergestellt werden. Somit wurde auch die Diskrepanz zwischen den beiden Sichtweisen offenkundig. Aus der Untersuchung des Stands der Technik bei digitalen Reifegradmodellen im Gesundheitswesen aus einer FM-Perspektive, ergeben sich zwei grundsätzliche Ansätze für die Entwicklung; Erstens die Integration von FM in einen übergreifenden holistischen Ordnungsrahmen, im Sinne eines Reifegradmodelles, welches den Anspruch hat, die ganze Organisation abzudecken. Hierzu könnten bestehende Modelle weiterentwickelt werden. Zweitens die Entwicklung eines domänenspezifischen Reifegradmodells für das FM. Hierzu eignet sich die nicht-medizinische Betrachtungsweise, welches die gesamten Supportleistungen abdeckt. Durch die Konzentrierung auf die Supportprozesse reduziert sich die zusätzliche Komplexität welches aus den medizinisch-pflegerischen Prozesse ergeben. Hierbei sollte das Modell nicht technologie-orientiert sein, sondern die Aspekte der Transformationsfähigkeiten, den nicht digital-technologische Fähigkeiten und dem Veränderungsprozess berücksichtigen, sowie übergeordnete Thematiken wie die Strategie miteinbeziehen und Schnittstellen zu den Kernprozessen erfassen. Gerade die Berücksichtigung der Transformationsfähigkeit bedingt auch, dass ein Reifegradmodell die Entwicklung der Organisation (Change Prozess) über die Zeit miteinbezieht.

7. Ausblick

Die weitere Untersuchung des Dilemmas der organisationseinheiten-spezifischen Strategien, versus einer zentralen Strategie, bzw. die Begünstigung von domänen-spezifischen, anstelle von holistischen Modellen, sollte weiter untersucht werden.

Ebenfalls essenziell zur weiteren Untersuchung stellt sich die präskriptive Anleitung für einen höheren Reifegrad, in Form einer Roadmap dar. In diesem Zusammenhang ist eine weitere Erforschung der konkreten Maßnahmen im Change-Management, bzw. dem strategischen Innovationsmanagement, in Bezug auf den digitalen Veränderungsprozess der nicht-medizinischen Supportprozesse, notwendig.

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Digital Transformation of Real Estate & Facility Management Innovative Technologies require innovative teaching methods

[1] Prof. Dr. Klaus Homann, [2] Prof. Sergio Vega Sánchez, [3] Jorma Säteri, [4] David Martinez, Judit Klein-Wiele, [5] Jaqueline Privenau

[1] Baden-Württemberg Cooperative State University Stuttgart

[2] Universidad Politécnica Madrid

[3] Metropolia University of Apllied Sciences, Helsinki

[4] FMHOUSE, Madrid

[5] Baden-Württemberg Cooperative State University Stuttgart

Abstract

Digitalisation is changing the Real Estate and Facility Management industry. Challenges arising from digitalisation do not only concern companies, but Academia has a key role to play in their dynamization. In this context, the Erasmus+ Project "FMgoesDIGI" studies trends and digital technologies that will have the biggest influence on FM and deepens the question, how to provide knowledge and skills to future professionals. A worldwide survey was designed to assess the perception of the maturity of "digital" technologies in Facility Management among industry representatives and academics. Through international workshops with professionals and digitalisation specialists, the results of the work performed have been analysed, leading to interesting conclusions. The study provides multiple and varied information on the technologies, and the differences in perception between industry and academia. The paper will however focus on the conclusions on how to train the knowledge and skills of future professionals on the most promising technologies identified, in which some innovative teaching methods can be key drivers for successful learning. This paper helps to identify the most promising technologies that we should incorporate into the curricula of future professionals and how to make their learning more effective with innovative educational methods.

Keywords: Digital transformation, teaching methods, digital trends

1. 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, such as the Facility Services industry, which is the third-biggest industry in terms of employment in the EU (Stopajnik/Redlein 2017).

The consequences of DT will therefore affect almost all European sectors and is expected to be a key driver for successful European economy for many years to come. Furthermore, DT is happening at increasing speed, provoking an urgent need to be able to identify and address the current and future challenges for economy and society, to evaluate the impact and to provide 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 companies C3 and Trilliant.

Beyond this economic potential, 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. (Hossenfelder and Ball 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 findings of an international study, conducted during the 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.

2. Background

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 & 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 (Hossenfelder and Ball 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. The study of Stopajnik and Redlein (2017) shows the impact of digitalisation on the Facility Service Industry. They estimated that typical FS activities (Deutsches Institut für Normung 2004) 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 automatized (Peneder et. al. 2016).

Hüttenmeyer & 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 Zillmann (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 DT 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.

Finally, digital technologies have the potential to enhance and improve teaching and learning strategies in multiple ways. The ubiquity of digital devices and the duty to help students become digitally competent requires educators to develop their own digital competence. However, regardless of whatever educational strategy or approach is chosen, the specific digital competence of the educator comes from effectively orchestrating the use of digital technologies in the various stages and environments of the learning process. Digital competencies in teaching become key (Redecker 2017).

3. Research Methodology

The starting point of this project was to assume the key role of university education for future FM professionals to support the digitalisation process in the RE&FM industry. Immediately two questions needed to be answered: How can FM professionals of tomorrow be educated to meet the upcoming demands of digitalization? What technologies will drive the future of FM and what skill sets will be needed to provide a good professional service?

The nature of the research of the Erasmus+ FMgoesDigi project is explorative and follows this main approach:

Figure 1: Main approach in FMgoesDigi research.

The process of identifying relevant technologies in DFM was divided into two steps. In the first step an extensive international desk research of scientific publications and a review of practice journals aiming at the identification of digital technologies that bear a potential to be applied to FM practice, was conducted. Additionally, existing use cases in DFM and suppliers have been searched and reviewed. In total, the study collected 593 use cases (from the field Real Estate Management or FM; or - if not assignable – from a near industrial field). Every use case was assigned to the areas of FM (Workplace Management, Project Management, Facility Services, Asset Management, Energy & Sustainability, Corporate Real Estate Management) they are applicable to.

In the second step, the project partners evaluated the potential of each technology quantitatively (frequency of use cases) and qualitatively (expert discussions). As a result, a list of relevant technologies in DFM was regrouped and consolidated. Finally, a list of 25 technologies and knowledge areas (Table 1) was drawn up to follow in the next project phase.

Table 1: Digital technologies included in the FMgoesDIGI survey.

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.

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. The survey was disseminated internationally via social networks and through international and national FM associations to their memberships. Data analysis was made through expert workshops, with discussions about indicators for cross-analysis, formulas to these indicators, technologies selection, knowledge and skills needed by professors and students, innovative teaching methods and key drivers for successful students learning. Conclusions from this comprehensive studio are on process and they will be wrapped in different reports and teaching guides.

Global Survey. The survey was designed to answer 4 questions (three qualifying questions and one qualitative assessment of the chosen technologies) in approx. 3 minutes, allowing to collect meaningful information on the perception of different stakeholders and professional profiles (10 in total), and on the 25 technologies defined.

For the end-user profiles - **client company** - three sub-profiles have been considered, as we wanted to observe if there were differences in perception between them: Director/Head of FM, Specialist/Area Coordinator and Support/Assistant. In the case of **service providers**, the three sub-profiles considered are Director/Head of Area, Implant/In-house in client, and Operational

Staff. For **Academia**, four different profiles have been selected: Dean/Program Director, Professor, Researcher and Student.

The question to be answered was: "What is your relationship with the following technologies in your daily work?" (This was for the professionals. For academics it was formulated as "What is your position on the following technologies to become FM research topics?"). The assessment of each of the 25 technologies analysed was in qualitative terms with similar response scales, adjusted to each profile. For practitioners, they were: "I am using it", "Sporadic use", "Exploring its use", "I have heard of it but it is not relevant", "I would like to know more" and "I have never heard of it".

The survey was widely disseminated through professional associations in different countries and social networks with a very selective target of professionals and academics 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, which summarizes both the overall responses and those of the European respondents:

Figure 2: Distribution of responses by professional profile.

We have collected responses from 104 countries around the world, 34 of them from Europe. Only Africa is under-represented although it is equally representative of the underdevelopment of the FM industry. The distribution of responses by country and continent was as follows:

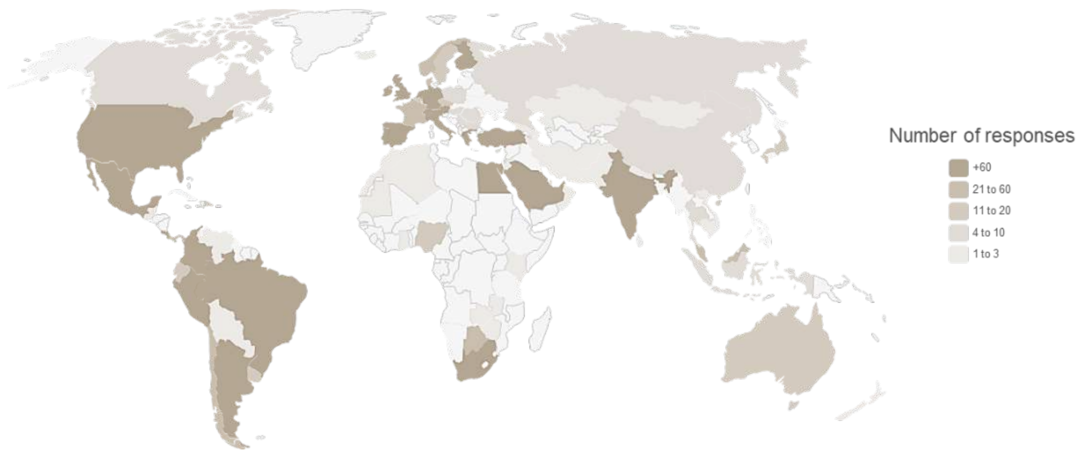

Figure 3: Distribution of responses by country.

The data analysis was carried out at two levels, one based on the analysis of raw data, and the second through the design and cross-analysis of a series of indicators designed for this purpose. The definition of indicators, their formulas, and the analysis was conducted with the help of more than 30 experts articulated in the different workshops held.

Workshops. Alongside conducting the survey and developing the set of indicators for its cross analysis, the third key methodological driver is to have a diverse group of specialists with practitioners, professors, researchers, and specialists in artificial intelligence and digitalisation.

Four three-day workshop rounds have been held. each one consisting of five workshop sessions with collaborative working groups of about 8-10 parallel specialists in Finland, Germany, and two in Spain: one focused on practitioners, and one focused on training and research, plus a common merge session of analysis and definition of joint conclusions. In total, each workshop involved about 6 hours of collective reflection, with the participation of about 30 persons.

The following section describes the work carried out in each workshop and discusses the main findings.

Student Events. The collaborative work of the students has also played an important role in a double sense. On the one hand, they participated in the exploration of the market, and on the other hand, they participated in several teaching activities. From the project´s perspective, an international seminar on the topic Digital Twin – Generating Data for FM & Data Governance was of particular importance a reference is made to this in the following.

Outputs. Figure 4 illustrates the intellectual outputs foreseen for the FMgoesDIGI project.

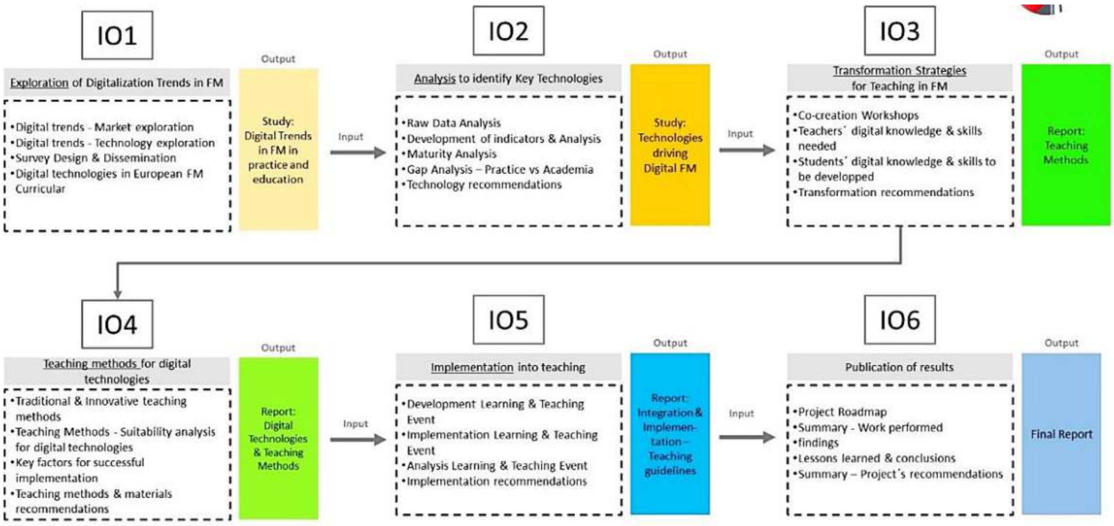

Figure 4: Project Overview FMgoesDigi – Intellectual outputs.

4. Workshops performed and discussion

Workshop 1: In this first workshop, the work focused on exposing and analysing the global graphs of the technologies analysed and each of the professional profiles included. As an example of this last type of graphs, Figure 5 shows the comparison of profiles of the main stakeholders.

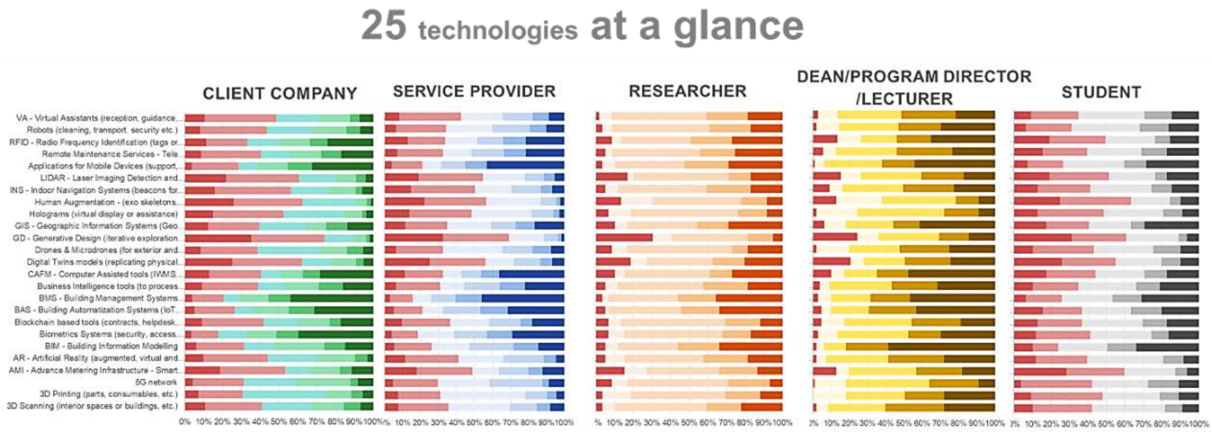

Figure 5: Profiles of perception of 25 digital technologies.

The red bands on the left show the lack of knowledge on the technologies, while the bands on the right show the degree of use of them. As can be seen, significant differences are observed between professional profiles and academic profiles, who declare to have greater knowledge and greater application of them in teaching and research.

The willingness to include these technologies in the future in teaching and research is also much higher in academic profiles than in professionals. Probably the origin of these differences observed between industry and academia is that the 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 innovation when the technology is sufficiently mature, with less risk to the business. In this sense, their assessment is more objective and realistic. More mature.

Based on the - throughout academia, industry, and policy-making increasingly recognized - concept of evaluating and communicating a technology's maturity with Technology Readiness Levels TRLs (Buchner et. al. 2019), the project consortium developed together with technology experts from the Polytechnic University of Madrid a set of 14 indicators for the purpose of deeper analysis (cross 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, and indicators to characterise more precisely the potential of each one of the technologies and enabling their comparison and ranking as well.

Furthermore, the consortium discussed and agreed on indicators to measure the level of digital awareness of the profiles towards the different technologies, to measure the level of digital use and interest and to measure the proactivity of the academia in teaching these technologies. Finally, coordinated indicators measure the perception of the degree of maturity and technology readiness of the 25 selected technologies.

Workshop 2: Based on the set of indicators for the cross-analysis, the results were summarized in a plurality of figures on global, European and national level. In the workshops, participants discussed the results in order to identify the most relevant technologies to be incorporated into students' curricula.

The analysis of the multiple graphs gives a comprehensive approach with a lot of information and nuances. By way of example we give three indicators, one reflecting the different perception of technology availability, and two graphs that have been used for technology selection.

TRI – Technology Readiness Index is an indicator to measure the readiness of the technology for the market, and it is calculated as a weighted average of technology maturity perception according to the following formula discussed and agreed in workshop 1:

TRI = 70% TMI+10% TMR+ 20% TMA (1)

Whereas **TMI - Technology Maturity for FM Industry** 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 formula agreed in workshop 1:

50% using it + 30% sporadic use + 20% exploring to use)/ (technology sample) (2)

Similar indexes as **TMA - Technology maturity for Academia, TMR - Technology maturity** for Researchers, are calculated in a similar approach.

RDUT - Rate of FM digital unawareness per technology is an indicator to measure the percentage of responders that do not know the technology for each stakeholder. It is calculated with a weighted average according to the following formula agreed in workshop 1:

*∑ (80% * sample Never heard +20% *sample would like to know/it's not relevant/Not valid for FM)/(25*sample).* (3)

It has been calculated for each of the 10 stakeholders, and for each of the 25 technologies.

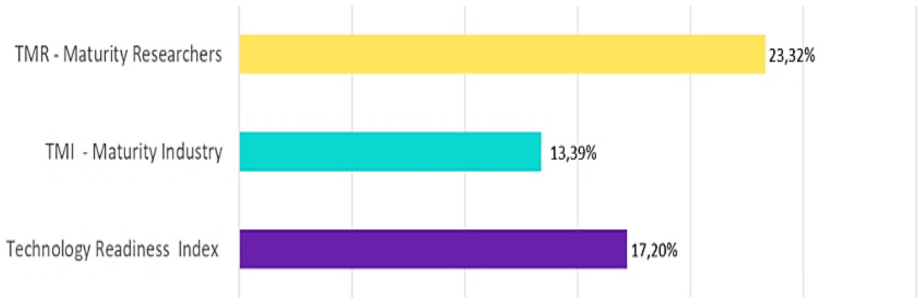

Figure 6: TRI Graph – Technology Readiness Index & Maturity perception

Figure 6 shows that academics (27.46%) and researchers (23.32%) have a more optimistic perception of maturity than industry (13.39%), which is less than half that of academics. The estimated TRI - Technology Readiness Index is 17.20%, an indicator with 70% of the weight of the industry's perception.

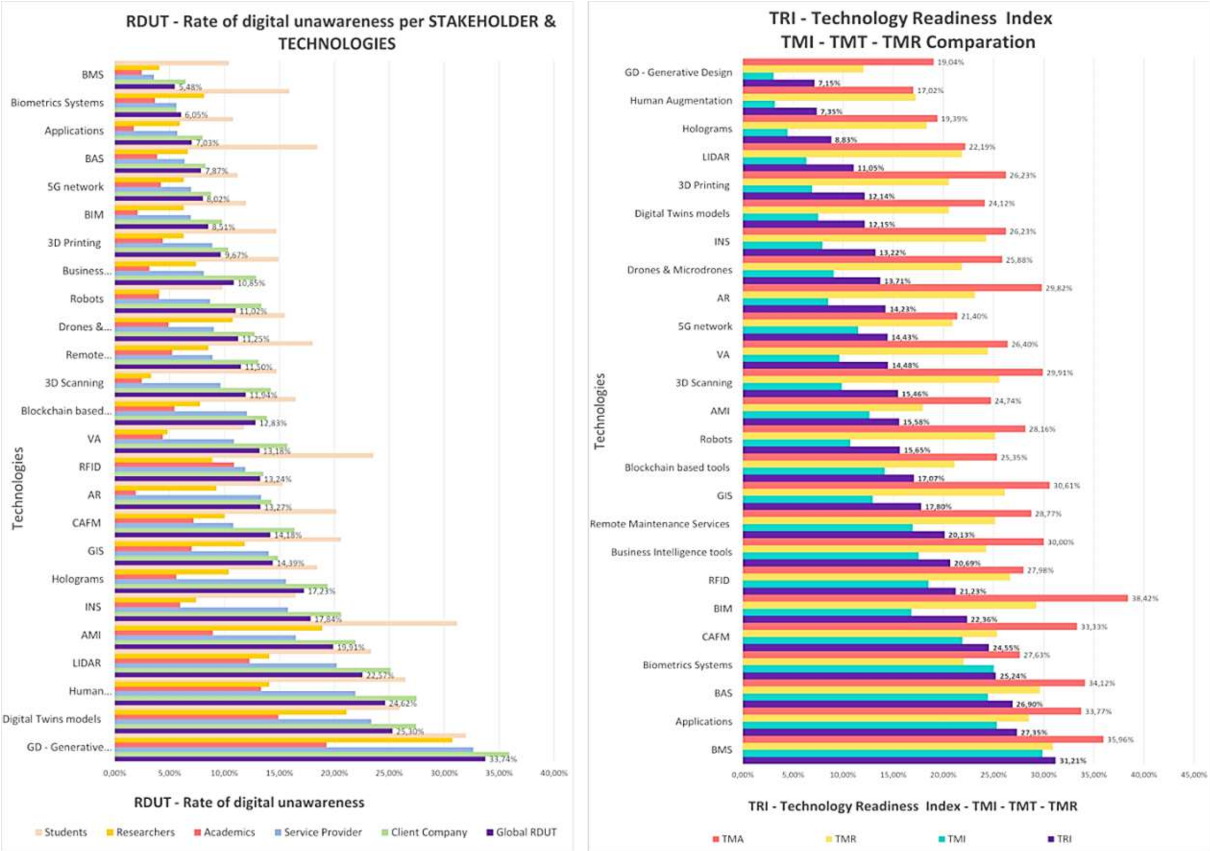

Figure 6: REDUT & TRI-TMI-TMA-TMR graphs per technologies

In Figure 7, RDUT - Rate of FM digital unawareness per technology, shows that the least known technologies are Generative Design (33.74%), Digital Twins, Human Augmentation and LIDAR, all with an RDUT of more than 20%, the best-known being BMS, Biometrics Systems, APPs, and BAS, with RDUTs of less than 8%.

It is the latter technologies with low RDUT that have the highest TRI - Technology Readiness Index, although once again we must highlight the notable differences in the perception of maturity of the technologies observed between academia, professors and researchers, compared to FM professionals, both in absolute and relative terms. TMA is three to five times higher than TMI in some digital technologies such as AR, Drones, INS, Digital Twins, 3D Printing, Holograms, Human Augmentations, or Generative Design. The highest perception of maturity for Academia is observed in BIM, BMS, BAS, APPs, CAFM, GIS and Business intelligence tool, all of them with a TMA above 30%.

After the analysis, we identified which technologies should be incorporated into the students' curricula, analysing three alternative approaches: FM Services, technical building operation and Energy&Sustainability. Finally, four groups of technologies were selected that were considered advisable to incorporate:

- *Digital Twins/Building Information modelling*
- *Business Intelligence Tools*
- *Building Automation System/Building Management System*
- *Reality Capture (3D scanners, drones, IoT)*

Workshop 3. It was focused on identifying how to develop the digital competences of our students, both at a general level and at the specific level of the selected technologies. In the discussions, a previous difficulty soon emerged, which was how to get professors, specialists in Facility Management, but with a very limited digital background, to train digital natives in the technologies identified as promising for their professional future. The emphasis of the teaching that we had to propose should be focused on instructing students on how these digital tools support FM. The focus should be on what these tools are for, how they work, and how to exploit their potential, and not so much on "playing" with them, which is probably where the students feel most comfortable and where the lecturers' contribution is residual.

Therefore, we discussed and defined in it what knowledge and skills should be developed (Fig. 8) both by professors (let us remember that they are not digital natives) and by the students we train.

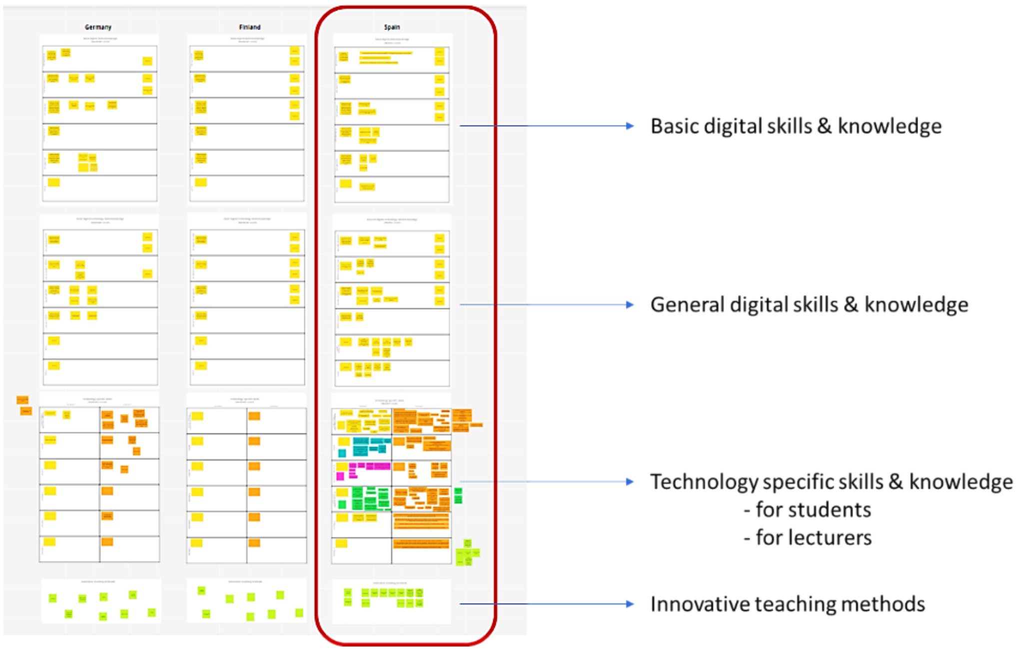

Figure 7: Workshop 3 – Matching required digital skills & knowledge with teaching methods

Workshop 4. The focus of this workshop was on the best teaching methods to develop the transversal skills and knowledge that we previously identified to be incorporated into our students' curricula. In a progressive process from the general to the particular of the selected technologies, a systematic analysis was made articulated in 5 progressive brainstorming sessions (see also Fig. 9):

- *Comprehensive approach of all teaching methods both traditional and innovative, gathering our perceptions and experiences with them.*
- *Brainstorming about pros and cons of traditional & Innovative teaching methods*
- *Brainstorming & Discussion about selection of traditional & Innovative teaching methods with interest to train in FM digital trends*
- *Discussion about selection of traditional & Innovative teaching methods tailored to train the selected technologies*
- *Brainstorming & Discussion about key drivers for successful application of these teaching methods for selected technologies*

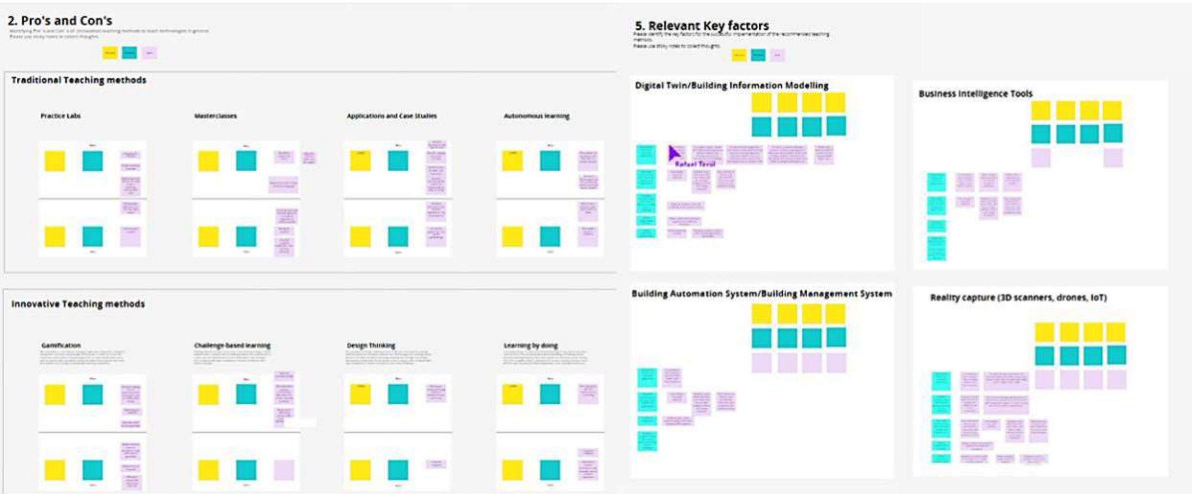

Figure 8: From teaching to learning - Identifying relevant key factors

From all ideas generated, one of the main conclusions was that while some masterclass will always be necessary to focus and prioritise thinking, skill development and knowledge acquisition can be fostered by active student participation, using innovative learning methods such as Flipped Classroom, Project Based Learning, Challenge Based Learning, or Research Based Learning. The unanimous conclusion was that innovative technologies require innovative teaching methods and the key is to identify the most appropriate combination of traditional and innovative learning and teaching methods. The team agrees that there is no "most" suitable teaching method for an innovative technology, it depends on several factors, and there are many ideas that are still in the analysis phase.

Students Event. Finally, the knowledge and ideas gained were tested in a one-day international student seminar, called "Innovative Technologies in Facility Management: Digital Twin -

Generating Data for FM & Data Governance". Students mostly from Metropolia and DHBW Stuttgart participated in this carefully planned activity. The aim of the activity was to promote the knowledge of Digital Twin and Data Governance in FM, the way they work and the application potential in FM those technologies provide. The seminar introduced and dealt with fundamental questions on the extraction and use of data for FM, derived from a digital twin model and the role of data governance.

A short inspiring masterclass explained the why and how of technologies, and the what for data mining and governance to foster efficient building operation. The masterclass delivered the necessary input to solve brief assignments in two sessions of collaborative student work – one dedicated to the development of use cases for digital twins (Fig. 10) and the second to the development of a framework for data governance.

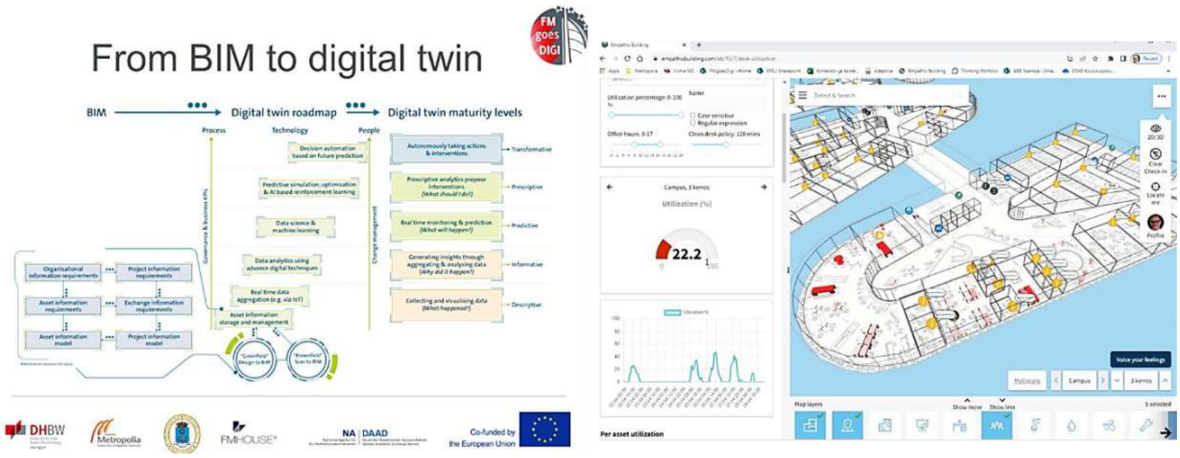

Figure 9: Screenshots from digital twin presentation

Following to the input, the students collaborated in mixed teams virtually on the assignments. Every team was instructed to load up their findings and proposals for solutions before presenting in 10 minutes plenary pitches to the lecturers, consortial members and specialists, supervising the seminar. Students were encouraged to use different applications to collaborate online, such as Whiteboard in MS Teams or Conceptboard. The supervising group evaluated the individual group outcomes and gave a dedicated feedback in return. Finally, lecturing teachers as well as participating students were asked to give a questionnaire-based reflection on their experiences.

5. Conclusion

The chosen methodology provided a wealth of useful information for the objectives pursued. The analysis of the survey results on a global scale, as well as the indicator based cross analysis, allow a differentiated analysis by region/country, professional profile or technology. In this sense and in accordance with the professional associations involved in the dissemination of the study, multiple country reports will be open to the public through the project´s webpage.

In four successive workshops, the collaborative methodology connected a multidisciplinary project team with different external stakeholders and experts. Thus, leading to the identification of a set of four technologies to be incorporate into FM curricula, the definition of necessary skills and the recommendation of suitable, combined teaching methods to deliver content and to build up professional competences.

The conclusion that Innovative Technologies require innovative teaching methods has led to a reflection on what are the key drivers for a successful application of these methodologies in learning, which will undoubtedly prove useful to our peers. Finally, the implementation of a seminar for students, testing the conclusions, has been a very positive experience and was very well rated by the students in the evaluation surveys. A new training activity is already planned in January 2023 to improve the formative experience of the students.

In the final stretch of this project of more than three years of development, we are recapitulating the multiple analyses carried out and the conclusions drawn from them, which will be published later this year.

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Science meets Practice II:

BIM

The Current State of BIM on Existing Buildings: The Case of Germany

Thomas Vorbeck, Nadine Wills

University of Applied Sciences Mittelhessen, Faculty of Business Engineering, Engineering Management Real Estate, Wilhelm-Leuschner-Str. 13, 61169 Friedberg, Germany.

Abstract:

At 44 %, the occupancy costs of a building are the most significant cost component in the life cycle of a building. The digitalization of the Architecture, Engineering, and Construction (AEC) industry in Germany, particularly through the Building Information Modeling (BIM) method, presents opportunities for delivering facility management (FM) services more efficiently. BIM is primarily used in the planning and construction phase of buildings. In contrast, the usage of BIM in FM – that is, BIM-based FM – is limited to less than 1% of all buildings internationally. Though universities and research institutes focus primarily on the planning and construction phase of buildings, there is a trend of exploring BIM in FM. This study aims to develop a neutral, cross-manufacturer understanding of the complexities of BIM, including BIM in FM for existing buildings in Germany, and to identify both fields of action and target audiences, which may be key to broader use of the BIM method in the future. Data were collected from an online survey of German private and public sector organizations that was conducted in the first quarter of 2022. These data include the opinions of facility managers, architects, engineers, building contractors, project managers, architects, and expert planners on the application of BIM to as-built buildings. The study found that the chief obstacle to BIM-based FM for existing buildings was the increased effort required for data acquisition and the lack of exchange between planners and operators. The survey conducted in this paper provides valuable information for decision-makers and FM organizations about the use of BIM in existing buildings.

Keywords: facility management (FM), building information modeling (BIM), BIM-based FM, as-built buildings

1. Introduction

The built environment is the most significant economic capital of industrial nations. The total value of all buildings in Germany is approximately 9.2 billion euro. Construction of these buildings is presently managed by an industry that, although qualified in certain areas, has not yet demonstrated satisfactory performance in all essential areas. Digital transformation is in full swing and productivity rates are rising across sectors, such as in the automotive or mechanical engineering industries. However, improvements in the Architecture, Engineering, and Construction (AEC) industry are still lacking (Sommer, 2016). The successive digitalization of the AEC industry in Germany, particularly in Building Information Modeling (BIM) and sensor technologies, has created opportunities for delivering facility management (FM) services in a more efficient way (Wills and Diaz, 2022). BIM has been gradually implemented in infrastructure projects in Germany since 2020 (Bundesministerium für Verkehr und digitale Infrastruktur, 2015). Through BIM, information can be used from a building's planning phase to its use phase. While working with BIM, it is particularly important that project stakeholders collaborate because mistakes, discrepancies, and duplicate work in the AEC industry can be avoided if the parties involved in a project work together. A BIM-based working method enables networking and cooperative planning, as well as the execution and management of buildings (Wills *et al.*, 2018). However, until now, BIM has been primarily used only in the planning and construction phases of buildings (Succar, 2009). Despite their well-known advantages, BIM-based approaches in FM are rare (Bender *et al.*, 2018; Bartels, 2020). Practitioners have enjoyed government support for the use of BIM – for example, by the "Road Map for Digital Design and Construction" from the Federal Ministry for Digital and Transport –, but BIM applications are only mapped out internally and do not involve all parties. A legal obligation to apply the BIM method will not come into force in Germany for federal buildings until the end of 2022. In comparison, a legal obligation to use BIM has existed Scandinavia since 2006 to 2010, and the United Kingdom since 2016 (Herrmann and Westphal, 2017). Germany is thus an outlier for its conspicuous lack of BIM-based methods.

The objective of this paper is to investigate the status quo of BIM in the German real estate industry in general, and its application to existing buildings in particular, from an intrinsic view of BIM stakeholders. Moreover, the study focuses on BIM-based working methods, which in turn serve as an indicator of collaboration between the stakeholders of a building. Data are taken from an online survey of 76 German private and public sector organizations that was conducted in the first quarter of 2022. The data include the opinions that facility managers, architects, engineers, contractors, project managers, architects, expert planners, and BIM managers shared about using BIM and its associated working method throughout a building life cycle.

The first part of this study analyzes the criteria by which the respondents and organizations were classified. The second part of the survey investigates the BIM-based working method. The results of the study are compared to previous surveys from 2013 and 2017 to provide decision-makers with valuable information on the use of BIM throughout a property's life cycle and highlight further research for BIM-based FM. Finally, the paper concludes with a summary and with an overview of potential future research directions.

2. BIM and FM Literature Review

BIM consists of three branches. The first branch is the building information model, which is a structured data set that forms an intelligent digital representation of all data relevant to a building. The second branch is building information modeling, which is the collaborative process of combining diverse building-relevant data and of creating building information models. The third branch is the system of building information management, which includes the coordination of activities (e.g., building-relevant workflows, such as media supply or maintenance) between a building's stakeholders that help to increase the quality and the efficiency of building management (Wills *et al.*, 2018; US Institut of Building Sciences, 2007). The term Building Information Modeling describes "[...] the process of creating, modifying and managing such a digital building model using appropriate software tools" (Borrmann *et al.*, 2021, p. 4). In addition to the value of using BIM and FM described by Ashworth and May (2022), the main benefits can be summarized as follows: 1.) it provides consistent models for all stakeholders involved in the life cycle of a building and 2.) it is an information technology that has various software applications for the support of FM processes. Moreover, a BIM-based working method enables early validation and simulation of buildings, thus delivering constructive, functional, ecological, design and economic information. The BIM-based working method improves decision-making by making reliable information available (Both *et al.*, 2013, p. 26). BIM in FM can be applied to the following soft facility services: space management support (occupancy planning); contract management (transfer of tenant data into the BIM model); or realizing FM sustainability targets according to "German Facility Management Association" (GEFMA) guideline 160 "Sustainability in Facility Management" (Wills *et al.*, 2018). Furthermore, it can be applied to the following hard facility services: maintenance and repair (Hu *et al.*, 2018; GEFMA, 2019); the planning of remodeling and new construction measures; and simulations for energy optimization (GEFMA, 2019). Combinations of hard and soft facility services can also be supported by BIM, as Chiu and Lai (2020) investigated (e.g., for building service engineering). To use BIM in FM, FM-relevant information for facility service provisions must be considered as early as in the planning phase of buildings (GEFMA, 2019). The requirements, therefore, must be integrated into the Employers Information Requirements (EIR), which aim to ensure that the appropriate quality and quantity of information are available in the right places simultaneously (VDI Verein Deutscher Ingenieure, 2020; GEFMA, 2019). The detailed requirements of FM stipulated in the EIR can help stakeholders avoid conflict (Kassem *et al.*, 2015; Becerik-Gerber *et al.*, 2012). However, BIM faces the following difficulties: higher planning expenditures (especially in early project phases); training costs for participants; the need to purchase new solutions; demand for additional management capacity to ensure that the data model functions properly; and the proper involvement of all stakeholders in the implementation of the BIM method (Albrecht, 2014). At the international level, BIM in FM is limited to less than 1 % of all new and as-built buildings (GEFMA, 2019). In addition to the reasons that Teicholz (2013) cited for the rare use of BIM in FM, it may also be attributed to the lack of information required for facility service delivery and the poor quality and quantity of information (Giel and Issa, 2016; Bartels, 2020). Additionally, standards are lacking and companies rarely appreciate the benefits of the life-cycle approach (CAFM Ring e.V., 2017). Moreover, FM-relevant data are not known in the planning phase of buildings but must be provided by the client. Paradoxically, the client is not assigned to perform facility services until the building's use phase (Wills and Diaz, 2022). In practice, FM receives more information than is relevant for actual facility service delivery (Kassem *et al.*, 2015), and unnecessary information requires more management and structuring (Dias and Ergan, 2020). The integration of data to existing buildings creates another barrier to utilizing BIM in FM (Altohami *et al.*, 2021). Although BIM makes more information available to FM, this information is not necessarily represented in FM-compliant semantic formats (GEFMA, 2019). Krämer *et al.* (2022) note that most universities and research institutions focus on the design and construction phases, rather BIM in FM, what might be another reason for the underrepresentation of using BIM in FM.

3. Methodology

3.1. Survey

To determine the status of BIM in Germany, an online survey among German private and public sector organizations was conducted in the first quarter of 2022. The survey questions were adapted from the surveys conducted by Both *et al.* (2013) (N=176) and Herrmann and Westphal

(2017) (N=312). These previous surveys enable comparison between this study's results and the results of previous studies on BIM and the BIM-based working method. The 2022 survey's main objective was to create a neutral database on the use of the BIM-based working method in the real estate industry and, more generally, on the state of BIM in Germany. Respondents filled out the surveys between January and April 2022. A link to the survey, along with a cover letter briefly explaining the survey topic, structure, and time required, was sent to the target group by e-mail (N=1,510). The selection criteria for determining the target group were based on the application of BIM in a real estate business context. Therefore, private and public sector organizations listed in real estate (society of property researchers Germany), facility management (GEFMA, CAFM-Ring, RealFM) and BIM associations (buildingsmart, Planen Bauen 4.0, BIM Deutschland), societies, and organizations were selected as potential participants. Additionally, the survey was shared via the target group's relevant platforms and viewed 799 times. By the end of the collection period, 76 valid responses had been submitted, and then the results were evaluated. "Google Forms" was used for the review because its configuration management allows for the logical linking of questions. This service made it possible to change the length of the questionnaire by using logical connections to change the answer options available for respondents to select. Specific versions of the questionnaire were designed for BIM users, BIM switchers, and non-BIM users. First, the respondents indicated to which of these categories they belonged. The survey sought respondents' opinions about the benefits of the BIM-based working method and what obstacles must be overcome in the future. BIM users and BIM switchers were asked about the pros and cons of BIM and about the scope of its application. Furthermore, respondents were asked to which life cycle phase their organization applied the BIM-based working method. Non-BIM users were asked about the reasons for not working with BIM and possible incentives for introducing a BIM-based working method.

The first portion of the survey categorized the participants. The participants, therefore, had to answer qualitative and quantitative free-text and multiple-choice questions. In the second part of the survey, the participants were asked about the state of BIM in Germany, their familiarity with BIM and the BIM-based working method, and their opinion on BIM as applied to existing buildings. Questions were presented in both single and multiple-choice formats, as well as free-text. Pre-defined answers in the form of statements that the participants could select helped to simplify the execution of the survey.

The survey’s objective was protected by defining clear data entry requirements for closed questions. The questionnaire was completed by independent testers prior to the start of the survey to test for content consistency. Because the questions sought subjective experiences, purely quantitative evaluations are not meaningful would not have been productive. The answers of the respondents reflect the degree of satisfaction that those in the respective categories have with the BIM-based working method.

3.2. Surveyed organization and respondents

Tab. 1 shows the data that the respondents provided. 70% of the participants are planners; 11% are contractors; and only 3% are facility managers. The small proportion of facility manager respondents likely skewed the survey's representativeness only to a minor extent because the topic of BIM in existing buildings is also relevant in the disciplines of architecture and project management, the latter already including aspects of FM.

Tab. 1: Categorization of survey participants

Categories	Number of responses	Percentage
planners (general and expert planners, architects)	53	70 %
project controller / project manager	3	4 %
executors (prime contractor, construction company)	8	11 %
public sector	1	1 %
facility management / construction operations	2	3 %
builders and investors	1	1 %
other	8	11 %

The buildings that the respondents manage are located in Germany (N=100%), Switzerland (N=15%), Austria (N=12%), other European countries (N=20%), and non-European countries (N=25%). Fig. 1 shows the business operating areas of the organization where multiple answers were possible. Organizations with 31 to 300 employees make up 51% of respondents and is the most heavily represented organization. Organizations with more than 300 employees make up 20% of the pool. Many of the participants hold a higher position in the organization. For instance, “Owner” is the most frequent job title among respondents (i.e., 20 out of 76 titles). Employees in management make up 24% of participants, followed by Project Managers at 22%. The category "Other" includes various employees who deal with BIM implementation in the company.

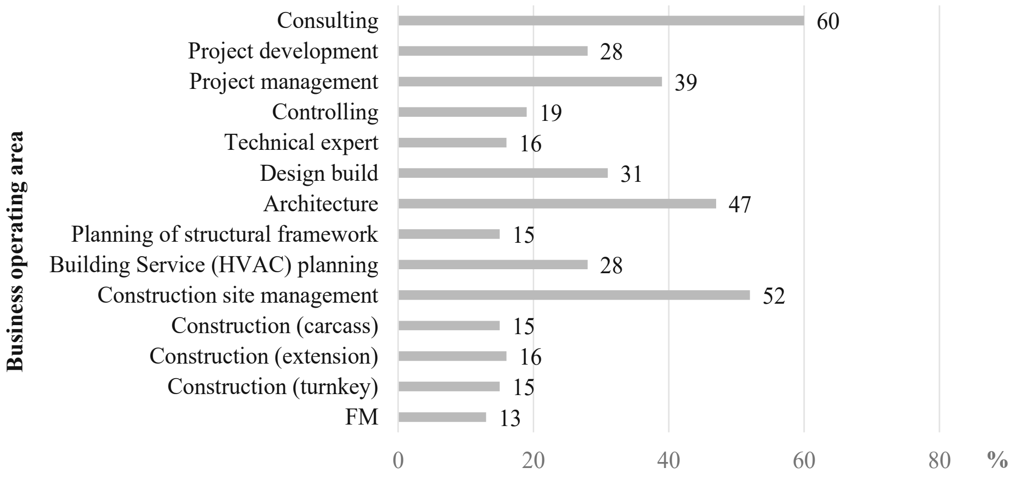

Fig. 1: Business operating areas

4. Results

4.1. Familiarity with BIM

To evaluate their level of familiarity with BIM, the participants were first asked whether they were already working with BIM and when they first heard of BIM. As shown in Fig. 2, 78% of the participants already use BIM. This percentage marks an increase from 2017 and 2013. Only 14% of the participants do not use BIM, which is an increase from previous studies, and 8% of the participants plan to introduce BIM. Furthermore, 84% of respondents stated that they had heard of BIM more than five years ago, and 13 % three to five years ago.

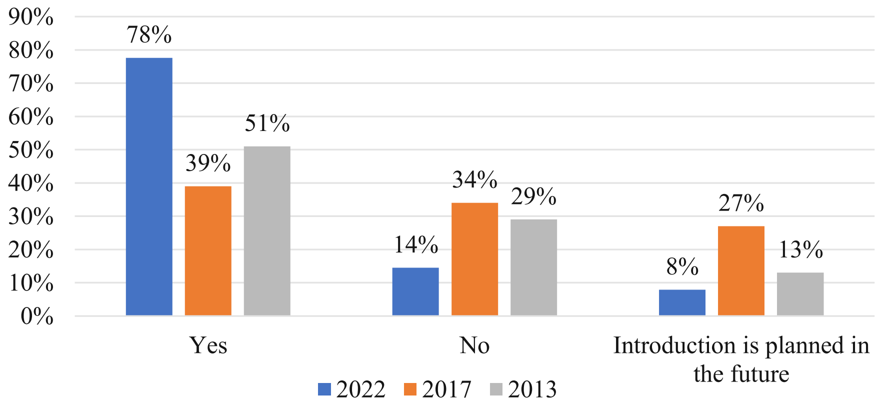

Fig. 2: Familiarity with BIM

Non-BIM users were then asked their reasons for not using this method. The primary reason for not introducing BIM (90 % of responses) is that the strategic approach of their organization, which has not changed since the last survey in 2017, does not accommodate it. Those respondents (N=11) were then asked a free-text question about their reasons for not using BIM.

The two main reasons provided are that, 1.) the costs for the software license to use BIM are too high, and 2.) compensation may not provide enough of an incentive (N=6). Moreover, clients are not asking for BIM (N=6). Non-BIM users also mentioned the lack of incentives as a barrier to implementation even if the building owners were to request it (60%).

4.2. BIM-based working method

This section of the survey addresses the goals, obstacles, and advantages of the BIM-based working method. Additionally, other aspects of BIM-based working methods, such as methods for the exchange of data, are addressed. The participants were asked about the pros and cons of collaboration between project stakeholders; 64% of the respondents stated that one of the pros of the BIM-based working method is improved coordination with project partners while 52% stated that the value of the entire project increased as a result. Another benefit that some reported is a reduction in the amount of time spent completing follow-ups and other related procedures. With respect to the cons of the BIM-based working method, 45% of the participants agree that the Fee Structure for Architects and Engineers (HOAI) makes BIM less appealing. Notably, 100% agree with the statement: "The service provision and remuneration for the creation of digital building models are not sufficiently considered in the Fee Structure for Architects and Engineers." Another disincentive for many participants is that different contracts are drawn up for different phases in a building's life cycle. In fact, 34% of 52 respondents are disappointed with the fact that cross-life cycle contracts are not used. One explanation for the lack of this kind of contract is that values covering the entire life cycle of the building have never been created.

Additionally, the lack of investment capital for BIM-based working methods was cited as a minor problem. Specifically, investment capital lacking for BIM is funding for software, tools, and training courses. However, 67% of the respondents disagree with the thesis that "There is no capital for using the BIM-based working method and new investments." On the other hand, 85% of the respondents believe greater data accuracy, improved communication (63%), and a reduction in the potential for errors (97%) are the main advantages of using the BIM-based working methods, which is consistent with the survey results from 2017. In terms of the software environment, Open BIM is preferred. Thus, 62 % of the participants use software products from different manufacturers. To date, the open data exchange format Industry Foundation Classes (IFC) is primarily used for data exchange. While IFC was rarely used in 2013, 84% of the respondents use it now.

4.3. Change of working by BIM-based working method

After the identification of goals, obstacles, and advantages of the BIM-based working method, this section of the study focuses on the ways in which working with BIM has changed. To this end, accounts of positive or negative experiences with the BIM-based working method were requested. The participants reported predominantly positive experiences with BIM and only reported negative experiences concerning value creation within a company. The effectiveness of BIM is following a more positive trend today than five years ago. While today 69% of the respondents state that efficiency has increased with the help of BIM, in 2017, it was only 52%. Finally, the focus turned to the future. Fig. 3 portrays the answers of the respondents to the following question: "BIM: More of a curse or a blessing?" As reflected in Fig. 3, 62% of the participants see a future for BIM, while 27% consider the method an essential working tool that will increase efficiency.

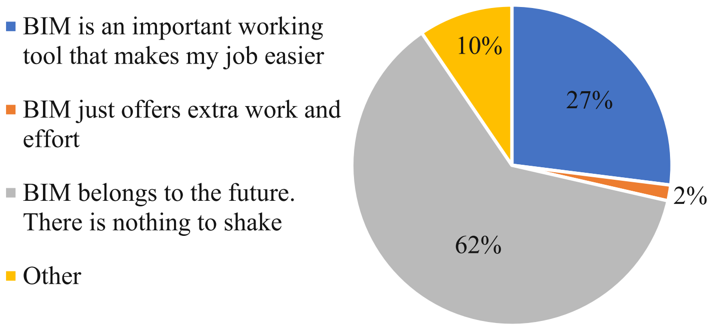

Fig. 3: Future awareness of BIM

4.4. Challenges for the implementation of BIM in existing buildings

Contrary to the expectation that BIM is predominantly used in new buildings, 63% of 65 respondents state that they use BIM across the life cycle for new and existing buildings. Just 22% stated that they would like to operate BIM solely on existing buildings, and only 14% use BIM only at the beginning of the life cycle of a building. Fig. 4 shows the use of BIM by different building types.

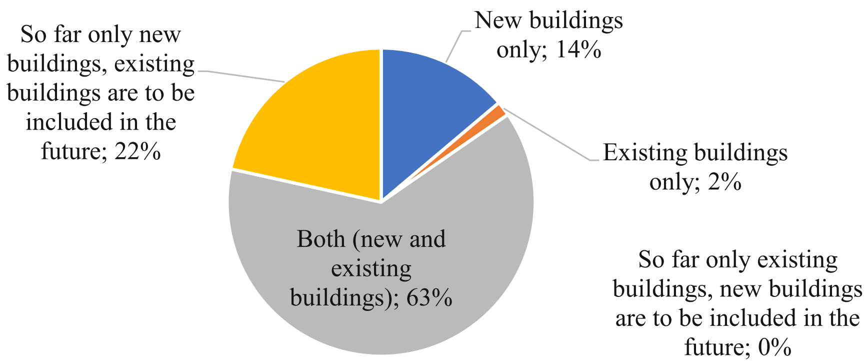

Fig. 4: Applicability of BIM in a building life cycle

Those who use the BIM-based working method only on new buildings (9) were asked to provide their reasons for not using BIM for existing buildings. The respondents were allowed to supply multiple answers. The results are shown in Fig. 5.

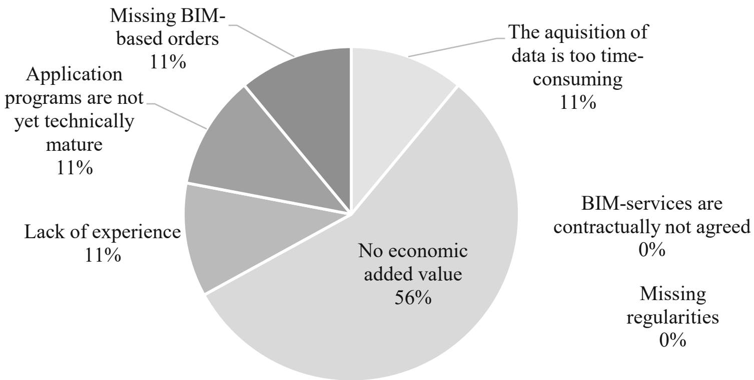

Fig. 5: Reasons for not using BIM in existing buildings

The main argument for not using BIM on existing buildings was that it does not add economic value (5 out of 9 statements). Moreover, the participants stated that BIM services for existing buildings are not bound by contracts and lack regulations.

Finally, participants were asked to explain the biggest obstacles to introducing BIM in existing buildings. A common response was that data collection requires additional effort and the databases are often insufficient. This response suggests that the transition of the as-built model to FM is unreliable. An evaluation of these responses can identify the incentives that will motivate companies to apply BIM to existing buildings. The participants recommended the introduction of BIM in existing buildings only if the client requests this and digitized as-built plans exist. Furthermore, the creation of the basic model should be remunerated, and application programs for BIM in FM should be better developed. Facility managers also stated that required information is often low-quality and transmitted improperly, which is inefficient and leads to extra work.

5. Discussion and conclusion

This paper empirically investigates the familiarity with and usage of BIM that 76 representatives from the German real estate industry reported. A questionnaire was used to investigate what kind of obstacles the implementation of BIM faces. In addition, areas for improvement are discussed, for example, addressing the problem of insufficient data preparation. The present study forms a basis for further investigations, especially for future property management. In addition, this study should help to provide all stakeholders of a property with an up-to-date evaluation of BIM in the German real estate industry. The results of the survey indicate that awareness of BIM is steadily growing. The fact that the survey was filled out predominantly by founders of companies and other people in leadership roles suggests a growing interest in the industry. Compared to 2013 and 2017, the prospects of BIM implementation in the coming years are promising. Though many participants cite enhanced efficiency, such as improved coordination with project partners and a reduced number of multiple inputs, as a benefit of BIM, they also claim that HOAI is a significant barrier to implementation. It, therefore, seems that the creation of new digital building models should be better examined along with proper remuneration.

Compared to a survey conducted in 2021 regarding the use of BIM in Turkey, BIM is already used much more frequently in Germany. While only 11% of respondents in Turkey use BIM, this figure is seven times higher in Germany (Tezel *et al.*, 2021). Moreover, a study from 2022, in which the research activities on BIM in FM are placed to the standardization activities of the respective countries shows that the pioneer in research and standardization is the UK. Moreover, many publications on BIM in FM coming from Italy. However, these are purely research papers, as case studies will not be applied in Italy until 2025 due to the lack of legal regulations on BIM in FM. At this point, Germany is already ahead of the legal obligation to use BIM from the end of 2022 (Pinti *et al.*, 2022).

The surveys conducted for this paper have indicated that BIM, as well as the BIM-based working method, are already well-known. The results of the survey from 2022 indicate a growing awareness of BIM in comparison with the results from 2017 and 2013. Furthermore, organizations use BIM more often than before. This study shows that BIM is indispensable for all companies along the construction value chain. In order to make the implementation of BIM more attractive to companies and to make it more application-friendly, incentives and remunerations must be offered. For this reason, it is essential to find out what obstacles BIM faces in building operations so that the appropriate recommendations can be made. Though the survey was sent equally to all groups of participants, facility managers were underrepresented.

The low participation of facility managers may indicate that BIM is less important or less practiced in FM in general and in its application to existing buildings in particular. It is also possible that the low participation of facility managers does not indicate a lack of interest in BIM but rather in the survey itself. A study is therefore needed to explain the use of BIM on existing buildings in greater detail and suggest ways to make the benefits of BIM more appealing. The real estate industry is still in its infancy compared to other sectors of the economy where virtual reality is already improving development processes, and the potential of virtual applications is exceptionally high. An improvement of using BIM on existing buildings requires contracts and regulations of using BIM services.

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