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

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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:

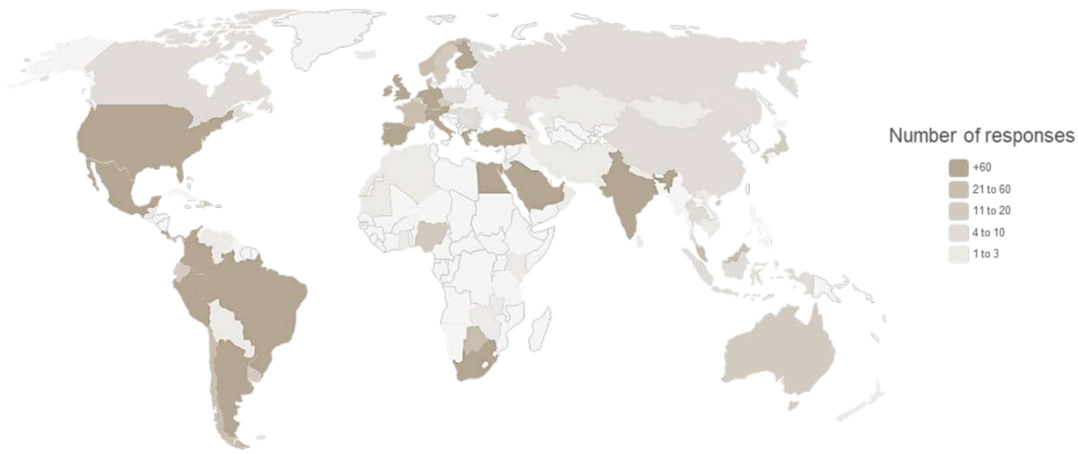

Figure 3: Distribution of responses by country.

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.

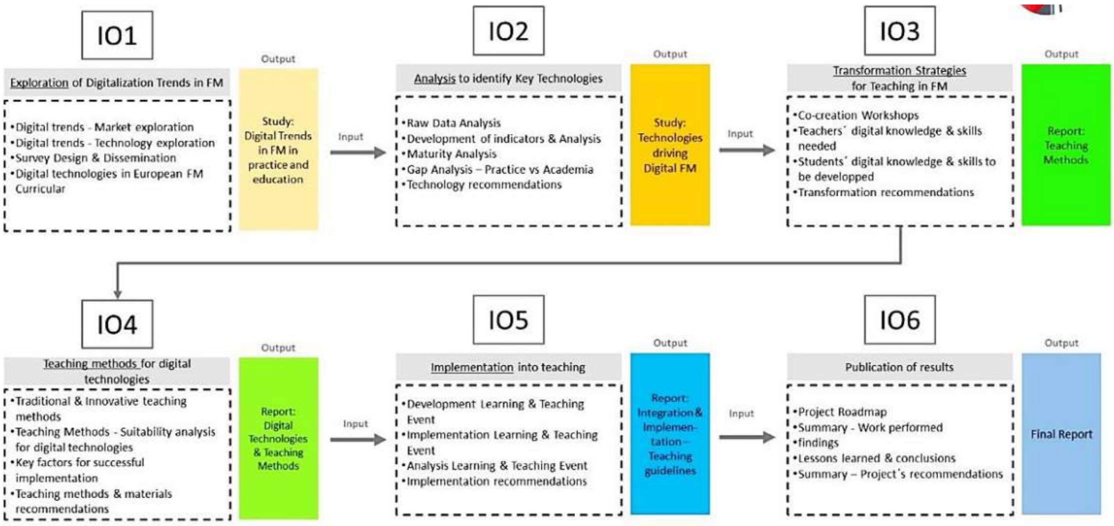

Figure 4: Project Overview FMgoesDigi – Intellectual outputs.

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.

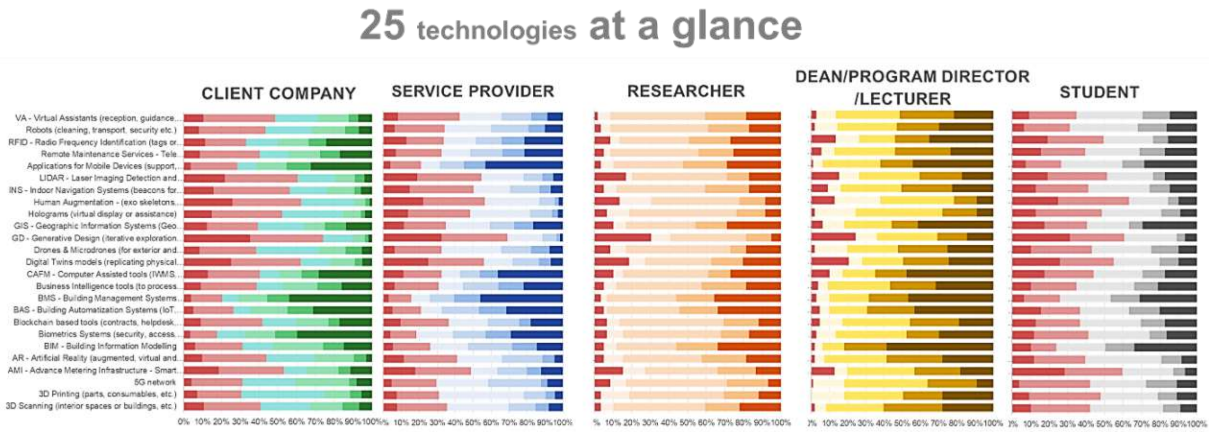

Figure 5: Profiles of perception of 25 digital technologies.

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.

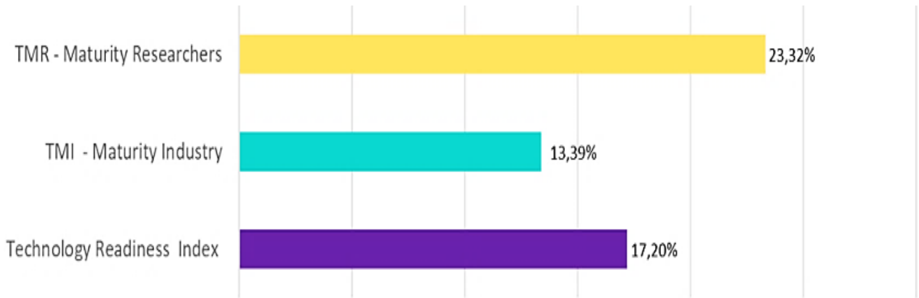

Figure 6: TRI Graph – Technology Readiness Index & Maturity perception

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.

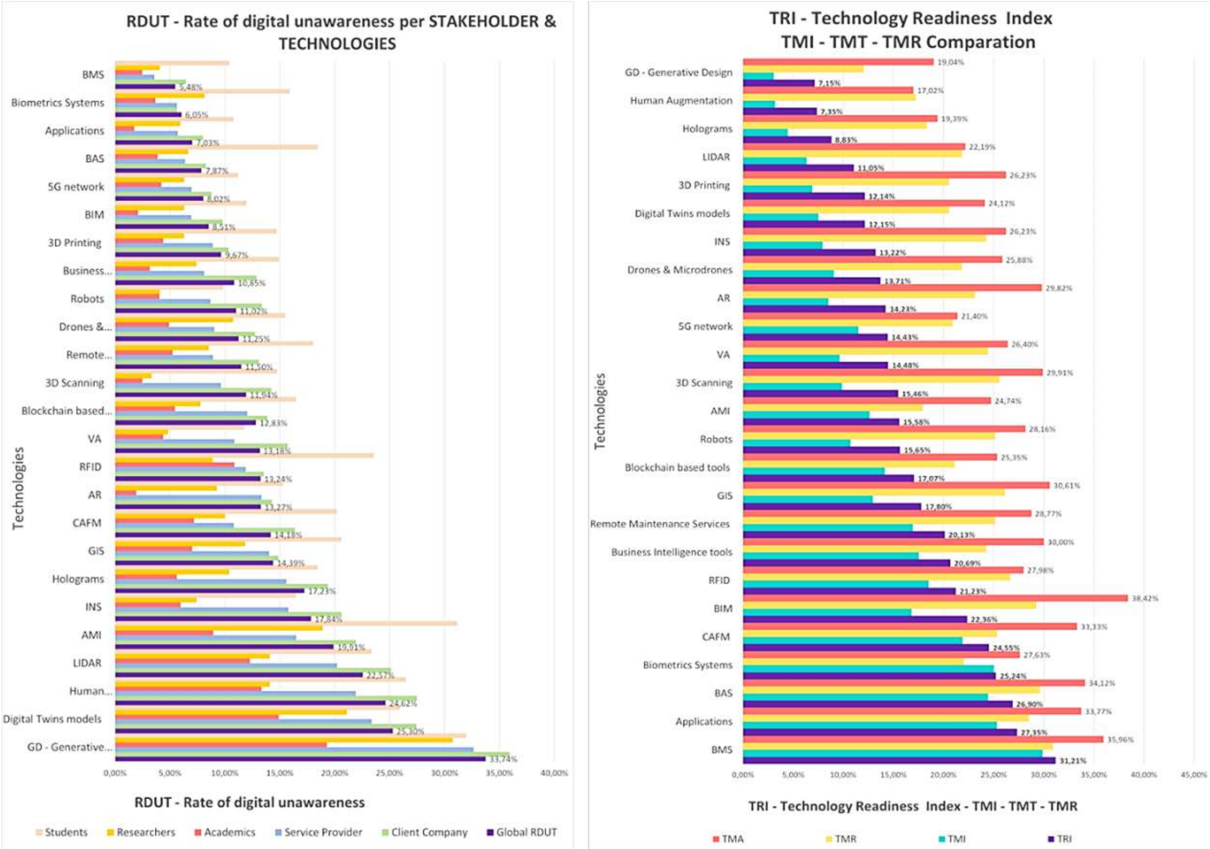

Figure 6: REDUT & TRI-TMI-TMA-TMR graphs per technologies

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.

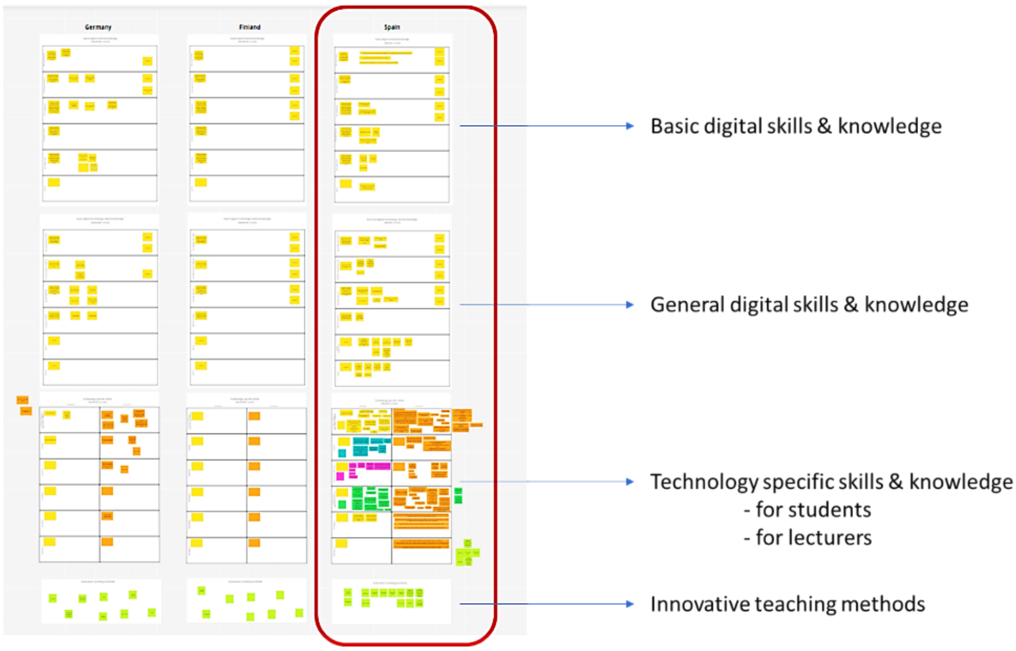

Figure 7: Workshop 3 – Matching required digital skills & knowledge with teaching methods

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*

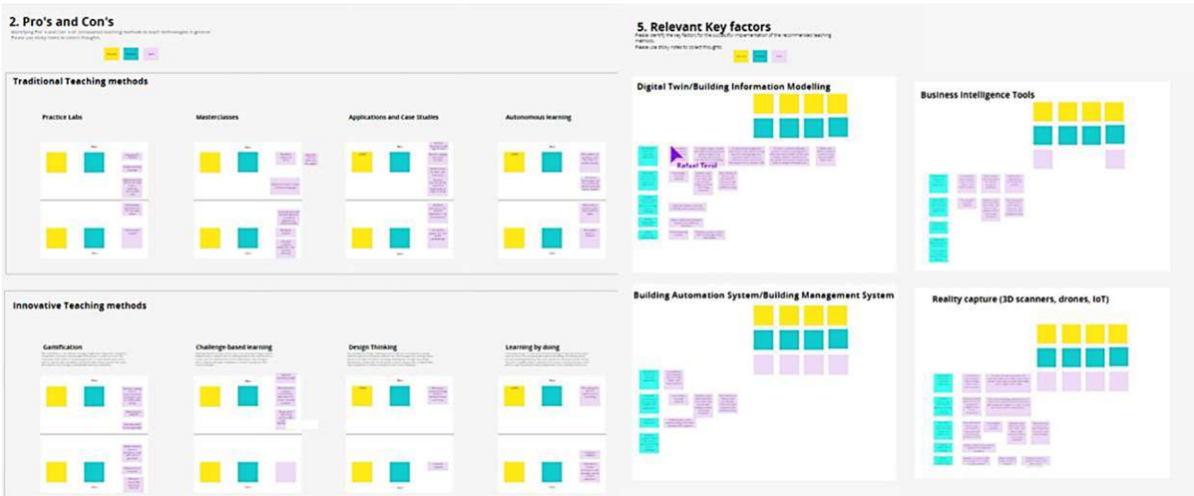

Figure 8: From teaching to learning - Identifying relevant key factors

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.

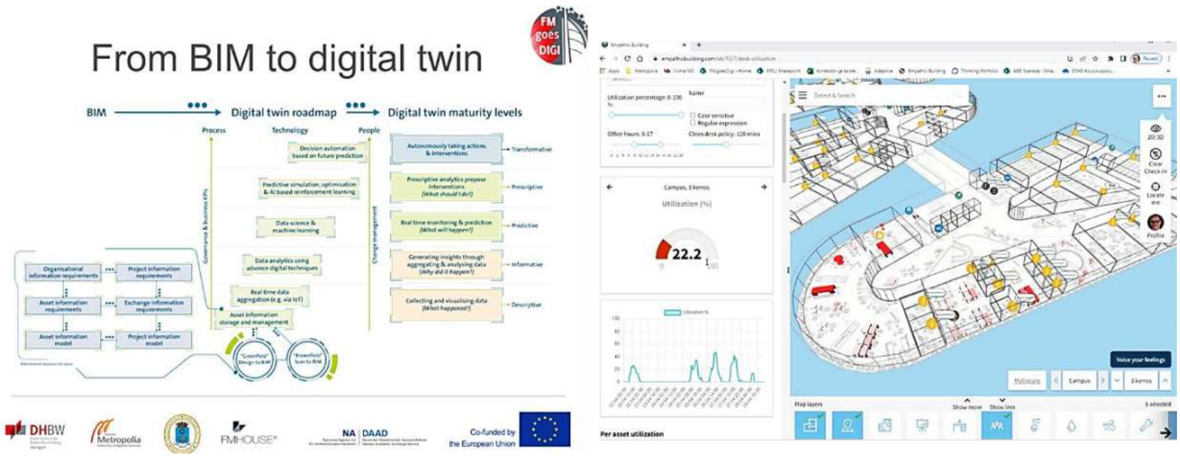

Figure 9: Screenshots from digital twin presentation

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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