Knowledge Transfer of Data Analytics & Machine Learning Applications

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applied to a dashboard for Remote Building Services

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EINDHOVEN UNIVERSITY OF TECHNOLOGY

Stan Ackermans Institute

SMART BUILDINGS & CITIES

Knowledge Transfer of Data Analytics & Machine Learning Applications

Applied to a dashboard for Remote Building Services

By

Mohammad Samir Ahmed

A thesis submitted in partial fulfilment of the requirements for the degree of Professional Doctorate of Engineering

The design described in this thesis has been carried out in accordance with the TU/e Code of Scientific Conduct

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ir. J.A.J. (Joep) van der Velden, company coach

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Abstract

The rapid change in technology use and required competencies of professionals in the field of building services made learning an essential requirement on the job. However, professionals remain busy with their ongoing project work. As a result, arranging time is challenging for personal development. Online learning in this case is preferred by organizations which can be arranged with minor disruption on the job responsibilities. However, the motivation of professionals to learn and share their knowledge is still not prominent in the building services sector. The feeling of being a part of a community and appreciation for knowledge-sharing activities can motivate professionals to remain active in a digital platform. This project focuses on identifying the challenges and a suitable solution for bringing the benefits of data analytics to professionals.

For developing an internal learning community, a combination of digital tools was designed and introduced to professionals. Interactions of professionals on those platforms and learning activities on the e-learning portal were analysed. Based on the findings, a new visualization tool for Remote Services was designed and introduced to the professionals. The feedback on the tool demonstrated the benefits of such a tool for initiating the exchange of ideas and knowledge between different stakeholders.

Along with formal learning networks like online training and physical workshops, informal learning occurs through communication over the phone, email or physical interaction. The designed tools will bring most of those valuable and relevant communications within the digital platform which can be accessed and utilized by other professionals of the organization. In addition, the easy-to-use tools will contribute to changing the culture of communities to adopt lifelong learning on the job.

Acknowledgement

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1. Introduction

For a sustainable comfortable healthy indoor climate with efficient energy usage, buildings need to be carefully operated and maintained. With recent developments in sensor and communication technologies, modern buildings generate a large amount of operational data at small time intervals. These data provide the opportunity for in-depth investigation and assessment of the operational performance of buildings [1]. The increasing use of Machine Learning (ML) combined with Big Data in the building services sector has shown the potential to increase energy efficiency and cost-effectiveness [2–4]. This domain needs cohesive knowledge of engineers/ scientists from different backgrounds (i.e., electrical, mechanical, civil, computer etc.) and data engineering. Governments have recognized the need for building the capability of the future workforce [5], and accordingly, new courses have been introduced to the education system. However, that will take decades before undergraduate education influences energy efficiency performance in the workplace [6]. Upskilling and reskilling the current workforce can provide sufficient professionals to realize the use of new technologies [7].

This report represents the activities carried out within the NWO 'TransAct' project. The consortium brings together expertise in educational technology from TU Eindhoven, TU Delft/ LDE-CEL, educational innovation from The Hague University of Applied Sciences (THUAS), and professional education from Avans+, TVVL, ISSO and WijTechniek. Companies are committed to collaborating (Kropman, Halmos, Caleffi), as well as KPE (Knowledge and Practice centre for the Energy Transition) and BTIC (Bouw en Techniek Innovatiecentrum-TNO) platforms, resulting in a unique research ecosystem [18]. In four years, TransAct will research and develop a lifelong learning network model. Approaches will be developed to empower individuals in the exploration, monitoring, and planning of personal knowledge and competencies. The project will also identify the main motivation and barriers to knowledge adoption, transfer and exchange between different stakeholders ranging from producers, and installers, to maintenance [19]. The project will support communities in learning building operation monitoring and data-driven diagnosis and maintenance.

To facilitate the personal development of professionals through training, online learning is experiencing phenomenal growth [8]. Due to the COVID pandemic, formal education practices have become reliant on technology which accelerated online learning enormously [9]. However, Weller M. [10] showed that no or limited face-to-face interaction in such programs, the associated feelings of isolation which, in turn, can lead to displeasure, poor performance, and high drop-out. Weller M. also found that learners' feelings about the community significantly affect the performance of e-learning. Hung DWL et al. [11] defined situatedness, commonality, and interdependency as fundamentals of an online community. Along with learning, sharing expert knowledge is also important for developing new skills and competencies. Hall [12] mentioned that anticipated exchange, reputation in the community, altruism, and tangible rewards as four main reasons that could motivate community members to share knowledge.

Russell and Ginsburg [13] defined an Online Learning Community (OLC) as an extension of the physical learning community to the electronic one. In addition, the definition of a learning community can include different contexts like a group of people with a shared will to learn [14] or an instructional design model for e-learning [15]. Throughout the study, OLC was considered as a developed activity system in which a group of learners, unified by a common cause and empowered by a supportive virtual environment, engage in collaborative learning within an atmosphere of trust and commitment [16].

To identify a suitable method of establishing an OLC within organizations, a Professional Doctorate in Engineering (PDEng) position was hosted in the project frame of 'TransAct'. The PDEng program falls within the 3rd cycle of higher education, as do the doctorate PhD programmes [17]. It is a 2-year post-master program with exposure to the latest design methods and professional skills. Although the project has a PhD researcher, the PDEng position will complement a high-level position in the industry.

1.1 Problem description

The rapid change in technology use and required changing competencies made learning an essential requirement on the job. In companies of building services, not all professionals are comfortable with online courses. Along with formal learning networks like online training and physical workshops, informal learning occurs through communication over the phone, email or physical interaction. Considering these facts and by reviewing the current literature ([18], [7], [10], [19], [8] etc.), a lack of experimental research was identified for understanding the motivation for learning and incentives for sharing knowledge of professionals in the building services sector, especially about the data analytics and ML applications.

The target group are professionals who have access to building data to optimize energy performance and apply Fault Detection and Diagnosis (FDD) in building equipment. Despite the availability of different methods, FDD tools are not yet applied in practice for an application to energy performance diagnosis. There are two main categories of FDD methods; knowledge-driven-based methods and data-driven-based methods [20]. In Figure 1 Zhao et al. [20] pointed out that, especially the combination of information (data-driven) and experience (knowledge-driven) is important for the learning processes within a company.

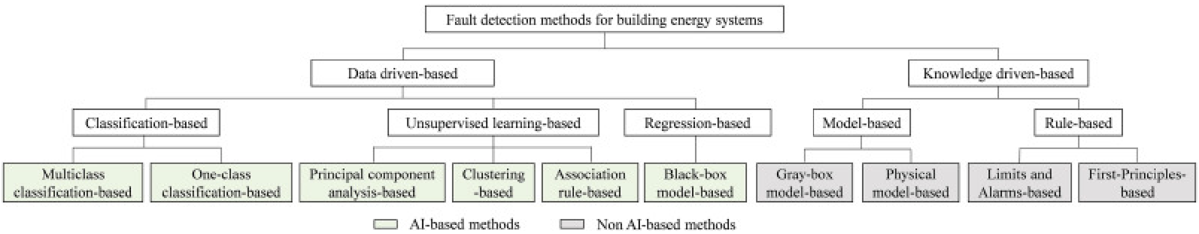

Figure 1: Classification of the fault detection methods for building energy systems [20].

The key experienced engineering professionals who are directly involved with FDD in the building services sector are still not completely aware of the potential of data analytics and the different applications of ML. In addition, they often lack the time and motivation to learn on the job and implement the techniques in their regular job activities. Therefore, it is important to design and implement a methodology that will clear the benefits of smart building operation through a data-driven decision-making technique. As a result, the built environment will have sustainable operations with existing building services installations.

1.2 Project objectives and scopes

Under the TransAct project, the PDEng project started on September 1, 2020, at TU/e. A prototype of a learning network was developed during this period. A learning network refers to the learning communities (professional and/ or academician), that integrate services of individual and peer-driven knowledge assessment, knowledge documentation, learning resource management, and individualized professional development. The behaviour of the learning network leads to the implementation of a visualization tool to bring the benefits of data analytics and machine learning applications. Following research questions were developed to be addressed by the PDEng program:

1. Which approaches can increase learning on the job by professionals?
2. Which incentive models are effective for professionals to share their knowledge?
3. How professionals can get benefit from data analytics and ML techniques?

Figure 2 clarifies abode research questions which can be experimented with and addressed in two phases.

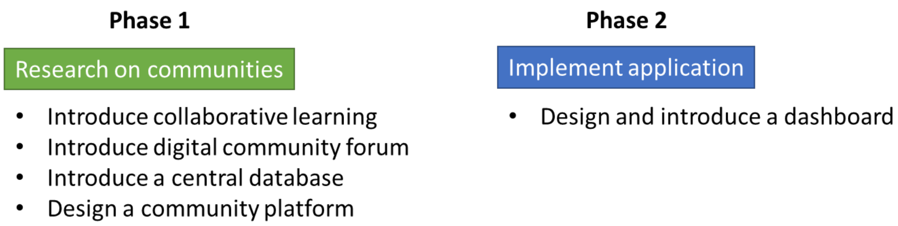

Figure 2: Design tasks within the PDEng program

In this report, first, the methodology is presented followed by the details of the experiments conducted. Then, the results obtained from the experiments are mentioned. The insights from the learning and knowledge-sharing tools are presented with some recommendations. Later, details of designing and introducing a visualization tool are explained. The potential of the tool to add value to different stakeholders is then mentioned. The report ends with a discussion on the project outputs and prospects for future works.

2. Methodology

2.1 The first phase: Learning and knowledge-sharing communities

To understand the learning and knowledge-sharing practices, interviews were conducted with the professionals and researchers. How different tools are used for communication, preserving and sharing project information, and learning on the job and outside the job was explored. Usage records from those tools were used to understand the interest and interactions among the professionals. Figure 3 shows the overview of the methodology of the project.

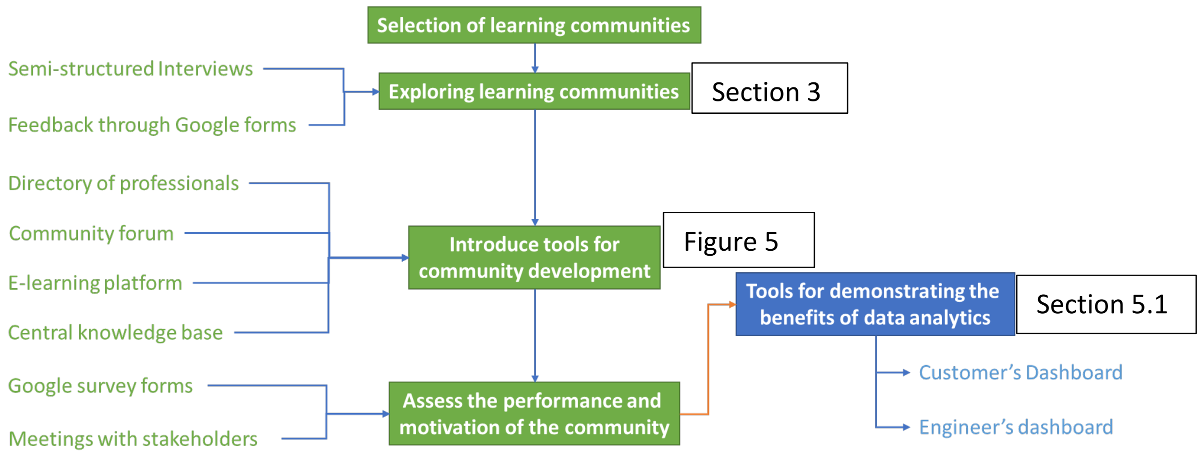

Figure 3: Methodology followed for the experiment in two phases with communities and deployment of a dashboard

Experienced professionals from the building services sector were the main focus. Besides employees also trainees, and researchers working at companies, universities, or research institutes were considered, especially professionals with a background in (smart) building monitoring and operations. All the participants have access to data generated from buildings and energy systems. In a community, people are unified by a common cause, in this case, to improve the value proposition of remote service to the client.

As the knowledge to be developed is around data analytics and ML applications, an online learning community can serve the learning and knowledge sharing requirements. Therefore, the first phase of the project introduced a community development platform which is described in section 3.1. At first, a directory of professionals was introduced where individuals can look for experts and feel the existence of such a community. They should be able to communicate on a community level and a personal level. It was revealed from an overview of relevant articles ([21], [22], [23]) that social media-enabled professional development allows professionals to connect with like-minded individuals [19]. The possibility to explore ongoing projects and previous projects is mandatory for gaining knowledge from the projects done by others. In addition, preserving the knowledge in an accessible and structured way will transform the central database into a knowledge base. A combination of digital tools was introduced to support collaborative learning within the organization for a lifelong learning experience. An E-learning platform can be a good option to track the learning progress of professionals and appoint new courses to the community members.

A series of interviews were conducted to understand the ability of professionals in data analytics and ML applications. The focus of the interviews was also to explore the incentives and motivations behind sharing and gaining knowledge, main challenges in learning, and future development plans. In addition to the interviews, webinars were used as a medium to explore the status of professionals. Questionnaires were circulated before and after the webinars and feedback was received. Details of the webinars can be found in sections 3.1 and 3.2.

The number of new courses followed, innovative data-driven projects delivered, and the online activities within the community-based platform can represent the acceptance and the effectiveness of the community development platform. To extend the experiment further, collaboration with the internal communication department and several research projects with researchers and trainees were made.

2.2 The second phase: Demonstrate the benefits of data analytics

To address the third goal of the project which is to bring the benefits of data analytics to professionals to assist in the data-driven decision-making process, a method is needed which enables professionals to get the benefit out of their available data.

As a first step, current practices of the remote services department were explored and are presented in section 5. This department is responsible to support customers and mechanics remotely. Therefore, they have access to data from customers and different internal platforms of the company. In addition, they can arrange support for any issues by communicating with internal experts from different departments (i.e., ICT, Building automation, Design and technology etc.). By maximizing the insights of data from different platforms, efficiency in their daily activities can be increased a lot. Interviews were conducted with the employees and their manager. Monitoring the daily activities of the remote service employees was helpful to understand the tools used by the employees for reporting to the client, communication and record-keeping. Interaction with different stakeholders was also explored.

To visualize data, it is important to know the job description and the background knowledge of the users. Because the same data may not be interesting and relevant to all the stakeholders. According to the interest, three main categories were identified. From individual categories, one user type was considered to focus. Facility manager as a customer, remote service engineer as a technical person, and contract manager to represent the management. Operational time-series data from customers' locations, log data of the service activities, and component details of different installations can be analysed and visualized in a dashboard. Integrating different data in one place can bring insights to users. In addition, Key Performance Indicators (KPIs) can assist in making a data-driven decision.

To collect feedback from different users, a prototype was developed using Dash which is a low-code Python-based framework for rapidly building data apps in Python, R or Julia [24]. Dash is an open-source library under the permissive MIT license. Therefore, the code and different features can be shared with other stakeholders of the project.

3. Experiments: Learning and knowledge sharing within communities

To understand the learning and knowledge-sharing culture and explore different improvement opportunities, several communities were identified (Kropman, TVVL, Eindhoven Engine, B4B project and the Building Services department of TU/e) and explored through interviews and questionnaires. See ANNEX IV for an overview of different learning communities about their organisational culture and education network. The questionnaires used to explore the learning communities are available at ANNEX V. Details of the experiments on different communities are discussed below:

3.1 Community of Kropman

Kropman Installatietechniek BV (mentioned Kropman later) is one of the front liners in implementing innovations in the building installation and services sector. They have a large network of operations within the Netherlands with thirteen offices and more than nine hundred employees. They have a close collaboration with universities and offer internships and research projects funded by government entities to bring the latest knowledge to the company's expertise.

The in-company learning community of Kropman consists of all the employees of Kropman. However, to conduct the research a few departments were chosen and their members were shortlisted who are involved with some sort of data analytics on different projects. The departments are O & T (Design and Technology), TCC (Technical Competence Centre), ICT, GBA (Building automation), Process management, remote services and P & O (People & Organization). In total twenty-three employees were approached for the experiment of which fifteen employees participated each in an hour-long interview. The key queries and discovered challenges during the interviews can be found in ANNEX I.

Design and implementation of a community development platform

The tools currently used by the employees of the company are visualized in Figure 4. In addition, a communication site named 'KRIS' is available on SharePoint pages. The platform has a central news board. It also hosts individual pages for different departments, business lines and locations. Based on the current practices, challenges were identified in finding the right knowledge when they are needed. Valuable communication occurs off-the-record which is lost when that particular employee leaves the organization. Moreover, many of the employees are working on similar projects without the awareness of the knowledge available to their colleagues which could be utilized for better results and satisfaction from customers.

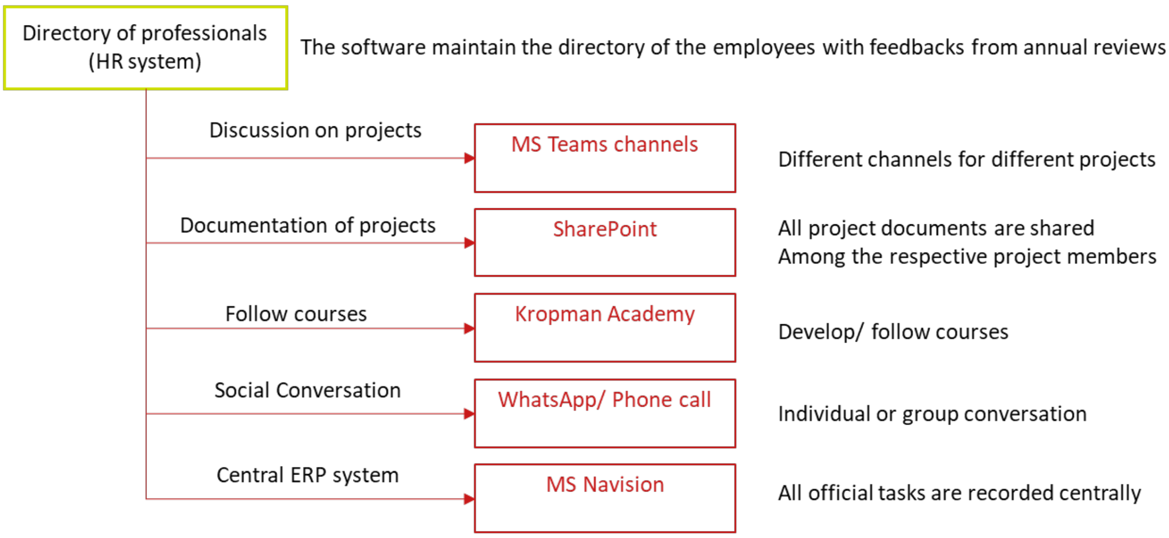

Figure 4: Communication and knowledge-sharing tools used in Kropman

To conduct the study, a combination of digital platforms was introduced among the employees. As most of the companies in the Netherlands have a subscription to Microsoft (MS) products, MS-based tools were selected to develop the digital collaborative community. Therefore, the experiment result could be a role model for other companies and the project partners. Figure 5 shows the collaboration of different tools and represents the journey of employees for on-the-job learning and knowledge sharing.

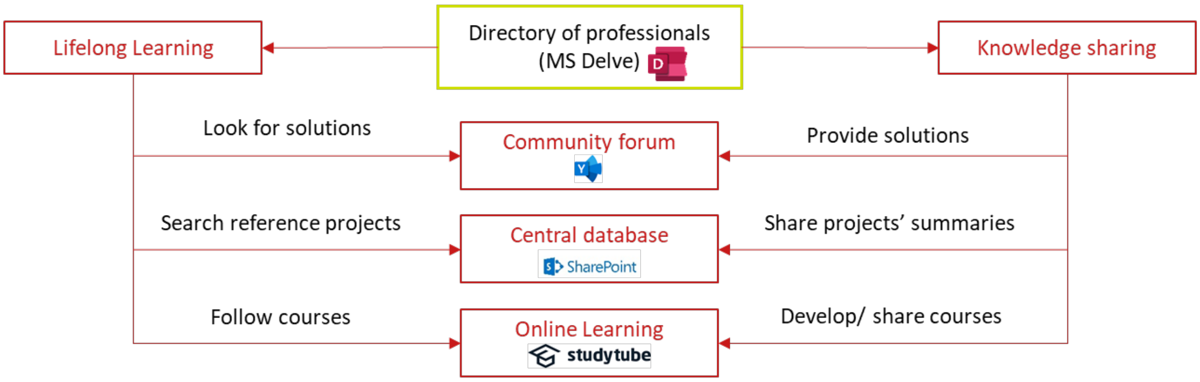

Figure 5: Tools introduced to conduct the experiment and develop a learning community

The tools altogether are named after the project name 'TransAct'. The community members have individual profiles in the MS Delve environment which is the directory of professionals. In this environment, current projects, existing skills, and expertise on which others can inquire can be viewed. As a result, other professionals can search for skilled colleagues and can approach them for support.

The learning path and the path for sharing knowledge are integrated into the community forum at Yammer where employees will ask for solutions and experts will provide solutions based on their experience and knowledge. The latest and the best possible solutions can be received from experts working at different departments and locations. Yammer at a foundational level is gamified with basic game elements. e.g., like, comment, share, tag, mention, follow etc. [20]. Then a central database at SharePoint was introduced where employees will look for reference projects and project engineers will share summaries and learning points from different projects. This can convert a database into a knowledge base by preserving different resources. A smart search engine to look for contents not only in the file name but also within files made this tool convenient to find necessary information. In addition, the version control made this location suitable for sustainable knowledgebase with the possibility of updating the latest information on the old data.

Finally, the online learning platform of the company was used where employees will follow courses and expert employees can develop or recommend courses for their colleagues. The admin can appoint courses to particular employees or keep courses optional for self-development during personal time. Some of the mandatory courses can be followed during office hours.

At the beginning of the study, a SharePoint page was introduced on the existing intranet platform of the company called KRIS. Figure 6 shows how the page hosts the Yammer community page, a news board and the directory of the professionals in MS Delve. The company's e-learning platform can also be accessed from the homepage of the intranet environment. A database was introduced to host project reports related to data analytics. The MS tools generate the usage report. In addition, the office 365 admin account was used to generate reports of the usage by the participants.

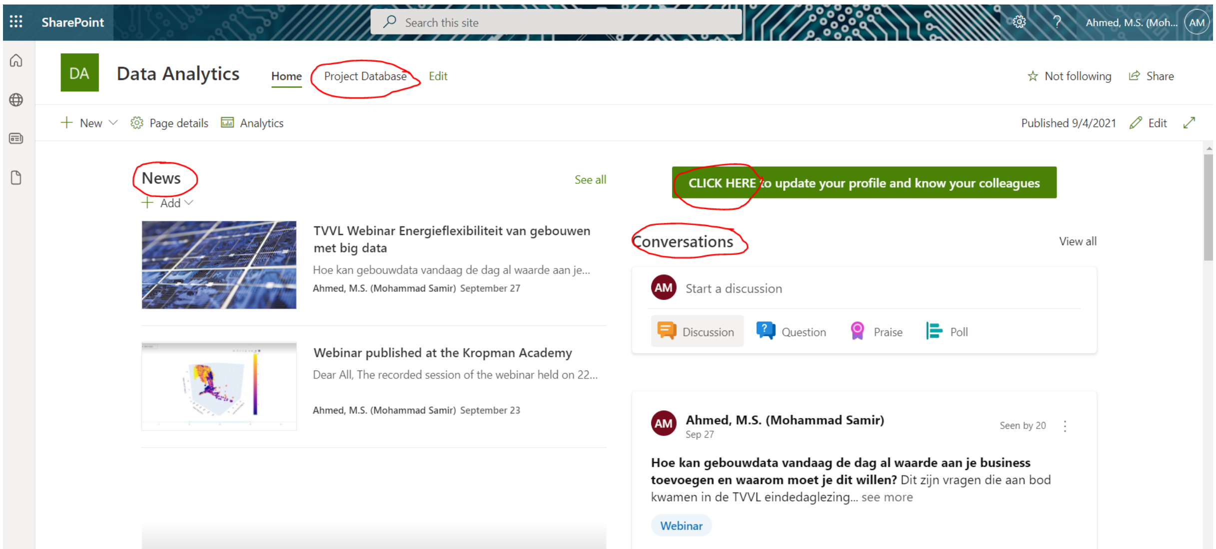

Figure 6: Community page in KRIS

Online learning via Kropman Academy

To train professionals on new skills and competencies, Kropman contracted StudyTube, a Learning Management System (LMS) provider to manage their online learning platform Kropman Academy. The platform is in operation since 2018. As the applications of ML and data analytics are increasing in the built environment, the company is expecting its professionals to be competent in this field. However, there are no courses on these topics. In addition, most of the employees are not regular in following online courses. Therefore, an interactive digital tool was searched to facilitate the lifelong learning of the professionals.

There are multiple community management platforms available in the market like Hiverbrite, knowledge management software like SABIO, Intranet software like Jostle, opensource LMS like Moodle and paid LMS like StudyTube, 360 Learning, TalentLMS, Docebo etc. All the platforms were assessed based on the features listed in Table 6. However, the management of Kropman did not prefer to replace their existing platform with StudyTube which was the 'Best online educator in the Netherlands' in 2015 [25]. In 2017, StudyTube ranked 10th place in 'Deloitte Technology Fast 50'. In addition, in 2018, they had more than 200 customers. In the end, it was decided to continue with the available features of StudyTube. The missing features expected in Table 6 will be supported by the 'TransAct' tool introduced as the community platform.

To begin the learning of professionals about sustainability in buildings and building-data analytics techniques, primarily following two long courses were introduced at the Kropman Academy.

1. Buildings as Sustainable Energy Systems (edX MOOCs by prof. Laure Itard, TU Delft) – 27 hours long
    a) Energy Demand in Buildings
    b) Energy Supply Systems for Buildings
    c) Thermal Comfort in Buildings
    d) Efficient HVAC Systems
    e) Dynamic Energy Modelling of Buildings: Thermal Simulation
2. Intelligent Buildings (5 ECTs Masters course by Prof Wim Zeiler at TU/e)

To analyse data and use machine learning algorithms, there are multiple tools available in the market. Python was found the most suitable one to introduce among the professionals because of the following reasons:

1. It is easy to learn
2. It is open source
3. It is well supported by academic and industrial experts
4. Learning communities like Stack Overflow, Kaggle and GitHub consist of professionals from all over the world with solutions and innovative projects by Python.

On the e-learning platform of Kropman, a three-hour-long course on 'Data Analysis with Python' developed by Cognitive Class was introduced. After completion of the course, participants will receive a certificate. The participation in the courses was none due to the length. Therefore, short courses of half an hour or 15 minutes were introduced. In those courses, applications of Python were demonstrated. In addition, recorded sessions of webinars on data analytics were also made available for all the employees in Kropman. However, recorded webinars had no views as they were around an hour long.

At this stage of the learning experiment, to facilitate employees with coding with python without installing python on their computer or laptop, a tutorial on Google Colab was introduced to Kropman Academy. The duration was 15 minutes. As a result, 50% of the participants completed the tutorial. Inspired by this experience, all the following tutorials were made below 15 minutes. Moreover, the courses were appointed to the participants with a deadline from the platform. A few weeks were provided to complete the course.

The employees were informed through email, discussion forums, the news board of the SharePoint page and face-to-face meetings about the availability of new courses. Some motivational speech was tagged with the email and a learning goal for the month was promoted among the participants. From time to time, feedback was collected through google forms and interviews. Accordingly, new courses were introduced on 'Predicting building energy demand', 'Machine Learning Algorithms', Webinar series of TVVL on 'The (Big) data potential' and so on. The participation in the courses, comments from the participants and their feedback were recorded to understand their motivation and barrier on the job. It was expected from the employees that they will update their MS profile at Delve with the gained new skills and competencies every quarter of the year or at least during the annual performance assessment meeting.

Webinars as a learning and knowledge-sharing media

Webinars were conducted to share knowledge related to data analytics techniques among professionals. With Google forms, some questionnaires were circulated to understand the level of knowledge and expectations of the participants to improve their experience in webinars. One of the internal webinars was analysed thoroughly with an open-source tool Otter [26]. The tool provided insights based on the script of the webinar. Later another tool for turning data into qualitative insights named Atlas.ti was used to conduct sentiment analysis [27]. The details are described below:

Topic: Fault detection and diagnosis of Low dT syndrome

Presenter: ir. Anand Thamban, PDEng trainee, TU/e

Two google forms were circulated to attended and absent employees of Kropman. Some important feedback was received as follows:

	Recommendations with potential for improved user satisfaction	Effect
1	Practical implementation of the cases	High
2	Brief and to the point	High
3	Make a connection to the daily practice of Kropman	High
4	Start with basic python code (Tutorials are available for basic concepts)	Low

The feedback on the content and the delivery method of the webinar shows a positive feeling from the participants. To transcribe the entire recorded conversation, otter.ai was used and found keywords shown in Figure 7. The Low dT syndrome-related components and parameters were mostly discussed during the webinar (i.e., cooling coil, mass flow rate, temperature). The performance of the machine learning model for predicting anomalies was also discussed. This means participants discussed the topic and brought no irrelevant matters. That made the recorded session highly efficient for the listeners. Moreover, in total six out of ten actively participated in the discussion which proves an interactive environment.

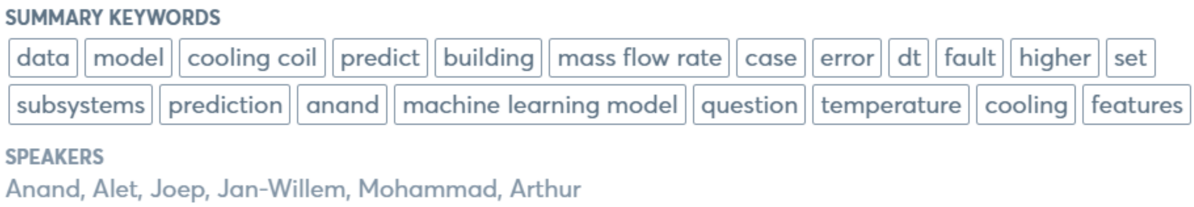

Figure 7: Keywords and speakers from the webinar transcript extracted by Otter.ai

Later, Atlas.ti was used for sentiment analysis. A total of 20 positive sentiments were found in the entire conversation without any negative sentiments. This proves the satisfaction of most of the participants. For thematic content analysis, coding or indexing on the paragraphs showed that, along with the machine learning model, the prediction performance of the model was associated eight times. Hence, it was identified as a big concern of the audience. Based on this observation, a tutorial was introduced to explain how the machine learning model works.

3.2 Community of TVVL

TVVL (Dutch Society for Building Services in the Built Environment) is one of the knowledge partners in the Netherlands in the technology sector. They have an online platform called TVVL Connect through which installation technology professionals can collaborate, develop and share knowledge online. It was founded in 1959 and now has more than 1,000 personnel and 500 company members [28]. Specialists such as technical advisors, installers, scientific researchers, architects, manufacturers, suppliers, owners and users of buildings and students are affiliated.

The background and job fields of the members of this community were found relevant to the TransAct project focus. Therefore, to assess the current skills and disseminate the latest analytics techniques among the professionals, four online webinars were conducted among the TVVL members on the theme “The (big) data potential”. The details of the webinars are as follows:

a) 18th October 2021: Energie Flexibility of Buildings

Key discussion points: scientific insights in the field of big data applications in building installations.

b) 8th November 2021: Fault Detection & Diagnosis
Key discussion points: latest developments in the field of Data Analysis and ML techniques, new possibilities are created to support error detection and diagnosis. As a result, abnormalities can be detected earlier and diagnoses can be made.
c) 14th February 2022: Data management and storage Haystack versus Bricks
Key discussion points:
    - Map out the possibilities for data storage and give examples of data storage in a Brick, Haystack, and Linked Building Data approach.
    - Applications with sensor networks. How are these systems configured and integrated into a network while maintaining security? And how do we enable the use of semantic and statistical artificial intelligence?
d) 14th March 2022: Predictive condition-dependent maintenance
Key discussion points: how structure can be applied to achieve generic error detection and improved building performance. Both the application of rule-based algorithms and ML are discussed.

Pre and post-webinar survey forms, and skill assessment rubrics of the participants on the data analytics and the ML techniques were circulated. The date and time of the webinars were circulated among different communities to increase the number of participants and responses on the survey forms.

The personal skill assessment form contains a table with the level of expertise/ knowledge in data analysis techniques and ML applications (see ANNEX I). The interesting topics to explore in near future were also asked from the participants with four example topics as follows:

a. Energy generation/ demand prediction based on previous records
b. Fault detection and diagnosis in equipment based on data analytics
c. Building HVAC system operation optimization
d. Energy system (heating/ cooling/ electricity) operation optimization

A few additional interesting topics by the participants were found as follows:

a. Cold storage forecast, Peak shaving for an appropriate energy profile
b. Data analytics for Services
c. Preparing good/clear/simple graphs
d. Differentiation of energy use in buildings
e. Ventilation effectiveness
f. Renewable heating and cooling
g. Smart buildings

Throughout the webinars, 57 professionals responded to the skills assessment survey form. Out of them, 23 participants were from Universities and the rest were from companies. Figure 8 shows the designation and role of participants. The average age of the professionals from the universities was found 30 without the 3 faculty members. They were removed from the age calculation to represent the young workforce that is entering the job market in near future. The average job experience is 3.25 years and the experience of working with data is 2.41 years.

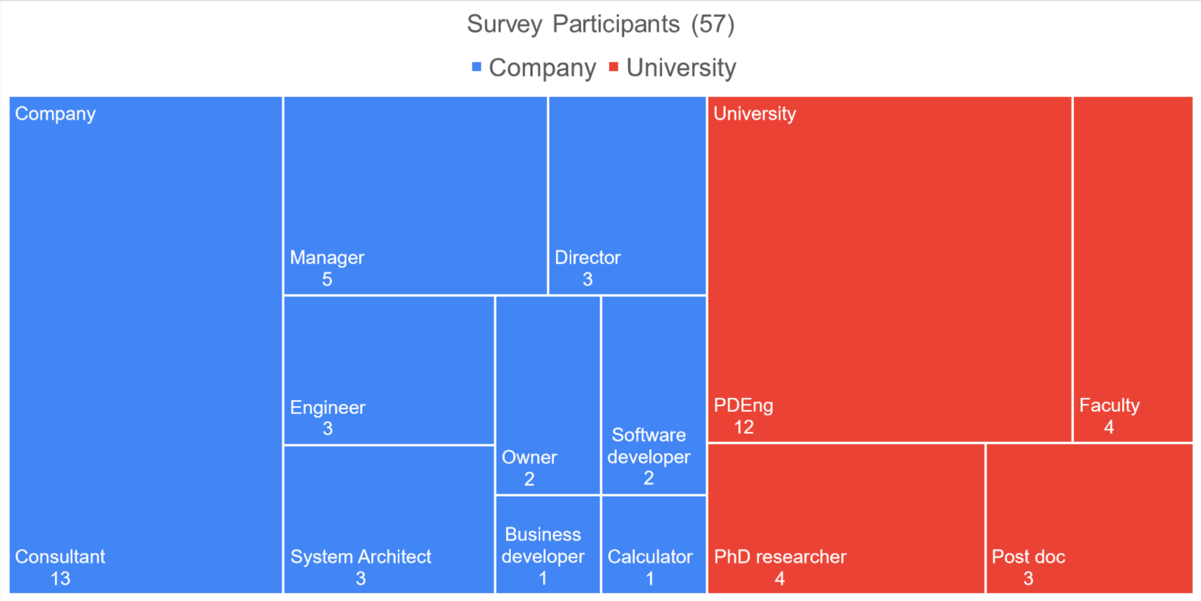

Figure 8: Background of participants in the skill assessment form

On the other hand, the employees of companies including the faculty members from universities have a higher average age of 46. This means these professionals are going to serve for another 15 to 20 years and going to require skills in data analytics to handle the market demand. The average job experience is 20.66 years out of which, on average, they worked for 7.7 years with data analytics.

3.3 Communitiy of Eindhoven Engine

Eindhoven Engine (currently named 'Disruptor') accelerates innovation in the Brainport Region of Eindhoven through challenge-based research in its public-private research facility at the TU/e Campus. Teams of the North Brabant region's most talented researchers from industry, knowledge institutes and students cooperate in Eindhoven Engine research programs to deliver breakthrough technological solutions [29]. Therefore, they were looking for a solution which could bring their project partners closer to each other and initiate collaboration among different projects. As a result, knowledge sharing and innovation will be increased. The expectation of the management and the aim of the TransAct project were found similar especially when it comes to the professionals who work with data analytics and applications of ML. So, the community was selected to explore. During one meeting with the manager of business affairs; the following issues were identified:

- No central database for project reports.
- A SharePoint-based database has recently been created by the manager. However, all the project members have to agree officially to consider it as a central database for sharing reports. Hence, the folders were empty.
- MS teams and email is used for regular communication.
- Experts are known in person and are communicated when needed. No directory of the professionals exists.

There were 19 projects ongoing in collaboration with Eindhoven Engine. In total 7 projects were shortlisted based on the project nature related to data analytics for exploring the learning and knowledge-sharing practices. However, interviews were only possible to arrange with members of 3 projects. The learning and knowledge-sharing practices were explored through those interviews.

Since the beginning of October 2021, MentorJam was introduced to some of the project members. The tool facilitates exchanging knowledge through the mentoring program along with different community-building features [30]. The experiment continued for two months. The forum activities were monitored to further develop the platform. There was also a questionnaire to explore the experience of the participants (see ANNEX V).

3.4 Community of B4B project

The Brains for Buildings' Energy Systems (B4B) project aims to add operational intelligence to buildings to realize the transition to energy efficiency and flexibility. Buildings need "brains" to respond to user behaviour and enable self-diagnosis and self-optimization. The ambition is to develop scalable and modular solutions that achieve 20-30% energy savings. The market value is high due to the impact of these "brains" on energy bills, operating and maintenance costs and ease of use.

The consortium consists of 39 organizations. The project is organized into 5 work packages. The project has a central database for all work packages. General meetings were organized with project partners. Webinars were also conducted for knowledge dissemination. Workpackage 1 consists of 19 organizations which are led by the work package leader prof. Wim Zeiler from TU/e. Therefore, members of this work package were considered to have been interviewed. In total six companies had interviews on their culture of learning and knowledge sharing.

3.5 Community of Building services at TU/e

At the built environment department in TU/e, researchers and trainees of the building services team were considered for the experiment. In total 11 members participated in the experiment. Most of them are involved in projects with Kropman. Therefore, a community of PDEng trainees was introduced at the Yammer community forum of Kropman. It was introduced to initiate knowledge exchange between communities.

A community developing platform was introduced to all the participants similar to the one for the Kropman community. As everyone has a Microsoft license from the university, they had access to all the available tools. Yammer was the community forum. At SharePoint, reports, presentations and different relevant documents were preserved. A page was created for the community to host different MS tools. MS Delve account was used for representing personal competencies. All the members were invited to webinars from Kropman, TVVL and B4B projects. Interviews were conducted with individuals. Survey forms were also circulated among the members to collect feedback on different events.

4. Results and recommendations

After conducting experiments, with the help of social network analysis, interview decoding and feedback from survey forms were used to generate results. In this chapter, findings from different communities are discussed.

4.1 Community of Kropman

a. Developing an in-company learning community

To form a learning community, it is important to make the professionals aware of the existence of such a community. Therefore, they should have the visibility of the link to the community platform from their regular used software environments or other digital platforms. The recommendation is that users should not be pulled to the platform. Instead, they should have smooth access without searching or opening an additional window on their screen. MS teams, MS outlook, KRIS intranet environment of Kropman are some of the tools regularly used by most of the employees. Therefore, a SharePoint page was created and introduced through an access link on the homepage of KRIS.

The online activities of the participants showed the following behaviour with different tools:

Yammer: Employees mostly read others' posts without posting comments or questions. Table 1 shows the statistics for six months of usage. Initiators are required to be more active with posts and questions. If posts are shared by the member of the community who is mostly known by others, the community activities increase. Another observation is that the discussion forum is more active during the weekdays compared to the weekends. That means employees visit the page for their interests related to job responsibilities during their office hours.

MS SharePoint: A lot of data was made available from the personal drive or the secured folder in the central server to all the employees of Kropman via this database. Table 1 shows the average online activities on the Sharepoint page for six months by the employees.

Table 1: Usage of the TransAct tool

Tools	Category	Usage
Average total monthly use by members of Yammer	Read counts	268
	Posts by the members	8
	Reactions to messages	3.63
Average total monthly use of Sharepoint	Total data shared	10.8 GB
	Site visit counts	189.17
	Unique viewers	51.17

Some of the key reports and projects shared in the database of data analytics are as follows which represent the potential of good quality in the upcoming similar innovative projects from customers.

1. Energy balance of Aquifer Thermal Energy Storage (ATES) system
2. Systematic energy performance assessment
3. Balancing ATES using continuous commissioning and model predictive control
4. Building monitoring with the energy profile

Employees are interested to find the right information when they are needed. To facilitate this, the following recommendations can be followed:

- Standard templates for preparing reports
- Keyword section within the file for a better searchability
- The individual database should contain reports from similar types of projects
- Instead of sharing files via email, they could be shared via the link to the database location
- To avoid sharing confidential information of a customer, a separate summary report should be prepared and shared in the openly accessible database
- Annual review sessions of employees should include the number of reports shared in the central database as a performance indicator

MS Delve: it is important to know the skills and competencies of all employees to know whom to communicate with for what. Although senior employees claim that they know everyone, over time, new skills are gained by employees and individuals can support more colleagues on various matters. For new employees, it is very challenging to know the skills of other colleagues. MS delve can solve this problem. A few recommendations are listed below to make better use of the tool:

- All the employees should fill in the profile with available details and a personal photo.
- Annual review sessions should include the skills added after one year and skills to gain in the following year. Accordingly, the profile at MS Delve can be updated.
- Managers/ supervisors should follow up on the profiles of their team members.

b. Online Learning

Introduced Learning materials and lessons learnt during the process:

Since the beginning of the experiment, different kinds of learning materials were uploaded to the online learning platform of Kropman. Based on the interest of the participants, the types and duration of learning contents were changed. Table 2 shows the lessons learnt from the experiment.

Table 2: Lessons learnt from the participation in online courses

Sl	Tutorial	Type	Lessons learnt
1	University course from TU/e	Lecture video and presentation files	Not effective. Professionals are not interested in the academic content which are prepared for students
2	Long courses on sustainable buildings prepared by TU Delft	Series of videos totalling 30 hours and 25 hours	Not interested by the employees due to long time requirement
3	Certificate course from Pluralsight	17 hours required to complete the video course at the provider's website	No participants for this course due to the length of the course. In addition, a digital certificate is not a motivating factor for most employees.
4	Short videos on sustainable building components by TU Delft	YouTube videos (5 to 15 minutes long)	Short videos are interesting for employees and have a higher completion rate.
5	Recorded webinars are available to check	Sharing cases by experts in data analytics	Interested participants join live sessions instead of checking the recorded session later.

To explore the overall performance of the Kropman Academy, a survey was conducted among the employees by the communication department. In total 216 employees participated in the survey. The key results are as follows:

1. The number one requirement of 70% of respondents for personal development is time.
2. Out of 174 employees, 24% prefer online learning. Still, 57% of participants prefer learning with experienced colleagues and 49% prefer learning through performing challenging works.
3. 86% of employees followed courses in Kropman academy because they were assigned to them.

4. The most important reason for further development for 77% of employees is to keep up with the position. The second most important reason found for 56% of the participants is to further specialization in the current position.

Based on the internal survey results, a few recommendations to increase online learning could be as follows:

- The participation rate increases by the employees if courses are appointed from the platform by the admin with a deadline. This helps the employees to decide on more relevant courses among more than two hundred available learning materials in Kropman Academy.
- As the courses are free to follow, they can be a part of the annual assessment session for the employees with a learning goal for the following year.
- Some of the job-related courses could be considered from the working hours.
- Mandatory training creates a ‘must’ feeling instead of having employees follow training on their own.
- Diversify the learning materials according to the convenience and preference of the individual employees. Webinars, articles, conferences, tutorials, short videos and other mediums of learning should be available for the personal growth of employees.

4.2 Community of TVVL

Among the participants of four webinars, the preference of learning media was asked. Figure 9 shows the top learning preference of the participants through live webinars and the least preferred media for learning are text files. The response can be considered biased as the participants are already interested in online webinars and attended the webinars.

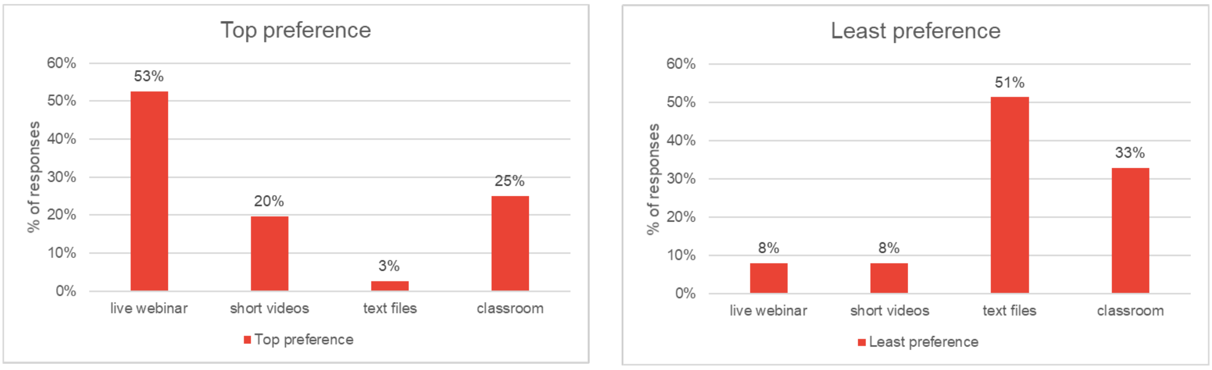

Figure 9: Preference for learning media

From the responses in skills assessment rubrics which were circulated among the TVVL webinar participants, we see the requirement to upskill the existing workforce. Figure 10 shows the proficiency of 57 respondents in data analytics and ML applications. The proficiency of ML application is below 2 on a scale of 4 which represents the status is lower than the proficiency of data analytics which has an average score of just above 2. However, the community is regularly arranging webinars by expert professionals to disseminate knowledge among its members. A few recommendations for a useful webinar are as follows:

- Brief and to-the-point discussion
- More practical examples and fewer theories
- Added value to the participants should be highlighted from the knowledge shared in webinars
- A structured and well-prepared presentation will improve the connection to the audience

- Interaction with the participants before, during and after a webinar
- The topic and learning goal of the webinar should be communicated earlier to the target group of professionals

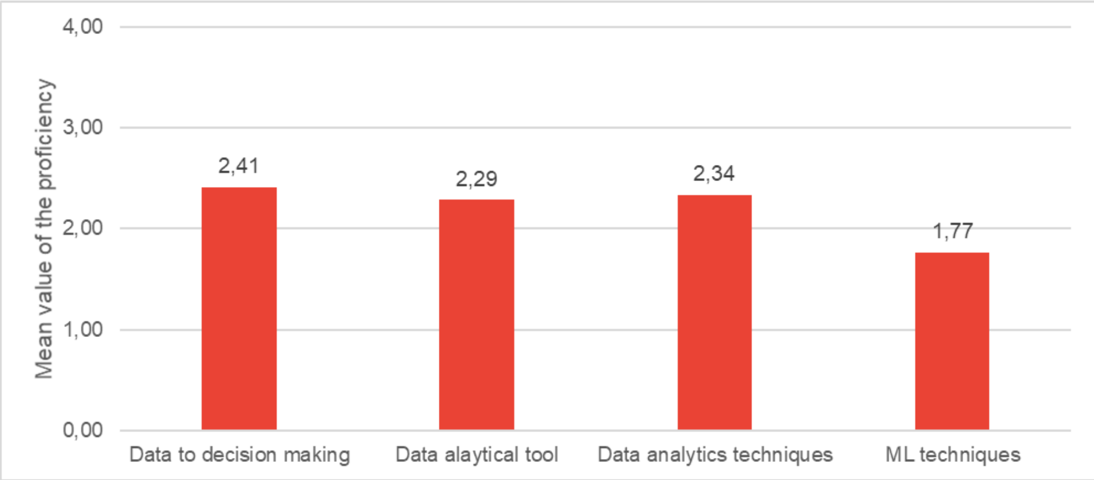

Figure 10: Average proficiency of 57 participants

4.3 Communitiy of Eindhoven Engine

Within two months, only 15 community activities were found in the community forum. The usage of the tool is not remarkable and the information shared by the project partners is not satisfactory. Therefore, the management decided to freeze the pilot program. However, from the interviews with different project members it was found that an online community platform should contain the following three features:

- A member directory (with contact details/ expertise/ team role)
- A search engine (to search for people with expertise)
- A forum (to put questions)

The Eindhoven engine management realized the importance and necessity of having a community platform. Therefore, they are in search of a suitable tool to introduce to the professionals. However, different project members are not yet sure about how they can be benefited from professionals of other projects. Therefore, some social events will be held for professional interactions in an informal way. Hackathon was also arranged to bring young talents to the community. To have a central database and interaction among different project members, the following recommendations could be followed:

- All project partners should agree officially about a central location to share project documents.
- As all the projects extensively use MS tools, the members can have profiles at MS Delve and look for experts from other projects.
- Eindhoven Engine has its website with details of all its running projects. A forum can be introduced to have an open conversation within the community.
- MS Teams channels can be used for individual project communication which will keep the privacy and accountability among the professionals.

4.4 Community of B4B project

Seven innovative learning communities within the Netherlands that are working on projects related to data analytics and ML were contacted. Some of the key findings are as follows:

1. Regular group meetings are the most common form of knowledge dissemination.
2. Annual assessment of employees includes learning goals for the following year and assessment of the last year's learning and development activities.
3. The skills matrix is maintained for employees.
4. Some companies have an internal learning management system to track the learning progress of employees on company-specific knowledge and new competencies.
5. Maintain formal and informal communication through MS Teams channels or WhatsApp groups.
6. Get recommendations from peers about courses on data analytics and ML applications.
7. Attend conferences, conduct literature reviews and follow blogs to remain updated with the latest development in the field.
8. One community rewards points to its members for sharing their knowledge gained from projects. The annual target of points is regularly fulfilled which is a part of the annual assessment meeting.
9. A central location for data depending on the type of information (i.e., MS SharePoint, OneDrive etc.) is maintained where project summaries, meeting minutes and other learning points are preserved.
10. At the age of 66, one engineer wants to learn ML applications. The purpose is to get an overview of the latest possibilities and to lead engineers who can code. The motivation is not to get outdated in the field as an old-fashioned old grumpy man.

Table 3 shows details of two of the communities for learning on the job culture and knowledge-sharing practices within the in-company learning community consisting of the employees. Some of their practices can be followed by other companies for having a better culture of learning and knowledge-sharing.

Table 3: Learning and knowledge-sharing culture

Sl	Community	Learning culture	Knowledge sharing
1	Consultation on building construction and services with data analytics and ML	- Supervisors and peers recommend courses and tips to follow - Online courses (internal and external platforms) - Communicate through MS teams with channels for different topics - Setup personal development goals with the manager	- Newsletters with data science case files - A central database at MS SharePoint (ML cases, ML discoveries, notes from 2 weekly stand-up meetings) - The annual target for earning points through sharing knowledge in the database
2	Consulting on supply chain, business, building automation with data and ML	- Interesting articles via MS teams chat - Courses from Coursera and Udemy - Skill matrix is maintained on data engineering (Python, SQL etc.) and data science (algorithms) - Skill assessment is connected with yearend bonus	- Small whitepapers on completed projects are uploaded in SharePoint - Monthly project presentation with a discussion on challenges - Lack of challenging projects is a challenge to adding new knowledge and skills

4.5 Community of Building services at TU/e

The members of the community have a common interest in learning on-the-job and there are similar learning goals for multiple professionals. Therefore, the community forum and the SharePoint page had regular activities. In addition, the chair of the department was active which inspired most of the researchers and trainees to participate in the discussion and share their reports in the database. Some of the trainees provided presentations in webinars arranged by TVVL and at Kropman. This way, the exchange of knowledge occurred within communities. The response of the participants proved webinars as a potential medium of knowledge dissemination among different communities. New members of the community found necessary administrative and academic information without much effort due to the knowledge base that has been developed during the experiment.

5. Product Design: Visualizing data for different users

The remote services team of Kropman was explored to identify different tools in use and understand their work culture. Figure 11 shows how data flows among different stakeholders. From the customer's locations, notifications of different errors arrive at the remote service team of Kropman. In most cases they are automatic. Sometimes, they are informed over the phone or by email. The service team then tries to solve the issue remotely. If they succeed, they update the customer portal. Otherwise, they communicate with internal departments to solve the problem. Employees of the ICT department, Building automation department or mechanics (if a physical visit is required) then solve the issue and update in MS Navision. It is then updated in the customer portal. Employees of Kropman can inspect different locations of customers via InsiteReport, an in-house built software to monitor and report operations of installed systems. Some of the customers have a subscription to this platform and can monitor the operation. However, the tool is not thoroughly checked by the customers. Too many graphs, excess indicators than the available data, and scattered information on multiple pages for each location made the tool unattractive to the users. Customers can see the status of their complaints at the customer portal.

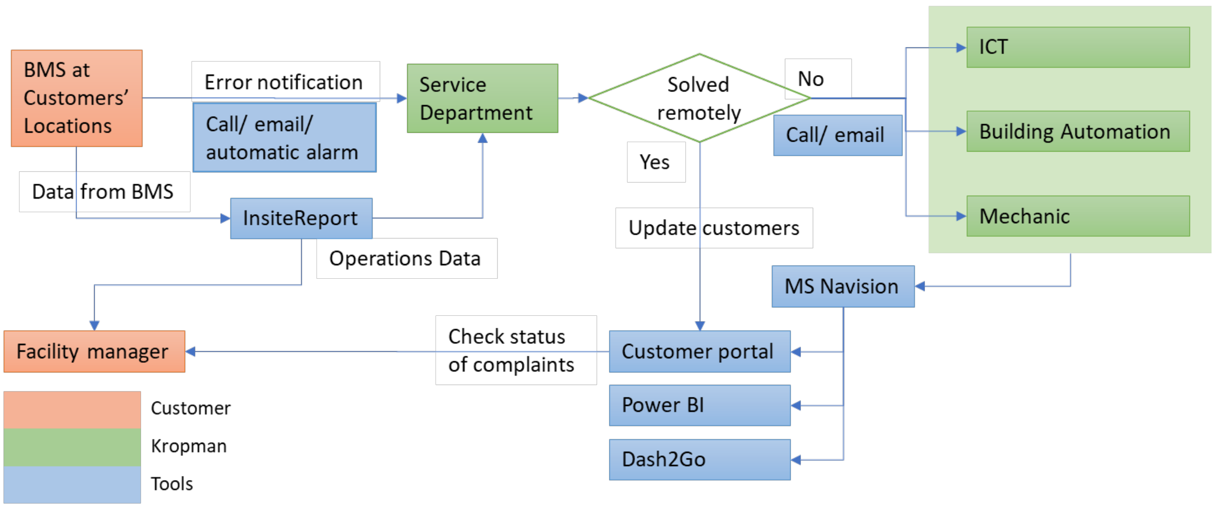

Figure 11: Tools in use by the remote services team of Kropman

Within Kropman, MS Power BI and Dash2Go are used to visualize some of the data from MS Navision. They also visualize operations of different locations at InsiteReport. However, they do not have a common platform where they can see errors, activities of service engineers, mechanics and the operation status of buildings. Therefore, some valuable insights are missing. Also, the locations requiring higher attention are not always clear to the service team. All these situations led the project to develop a common platform where data can be visualized in the most effective way for facilitating a data-driven decision-making process by the employees of Kropman.

5.1 Prototype of a dashboard

In the beginning, the current status and the expectations of customers, engineers and managers were explored. Customers can be better served through a closer collaboration of engineers and managers of Kropman. Table 4 shows the perspectives of different users.

Table 4: Current practices and future expectations on the dashboard of different users

User	Role	Current situation	Goal
Customer	Facility manager	Have Building Management System (BMS) from Priva, johnson controls or Siemens to see different information about the installed systems. InsiteReport is available to some customers.	- Auto alarms should inform the service provider about any possible issues to avoid system failure - Assess the performance of the installations, cost reduction and sustainability - Assess the performance of the service provider
Engineer	Remote services	BMS of customers can be checked remotely. Internal communication is made with the mechanics to visit the customer.	- Installation and energy performance with underlying data and analysis - Implement data analytics to correlation and corrections to get better (derived) results and insights. Ambient conditions can be used to justify some situations. - Combine continuously measured data with incidental alarms and malfunctioning - How can the historical data of alarms and utility be used to improve performance?
	Mechanic	Receive communication from remote service team with relevant information and move to the location for fixing problems - FSA (field service application) represents information of MS Navision. Regular errors are solved physically.	- The specific information of the error. - Recommend tasks to solve a problem. - Reduce the work.
Manager	Contract manager, Remote services manager	Can check the overview of the service orders with a timeframe at a dashboard made in MS Power BI.	- Key Performance Indicators (KPIs) represent Installation and operation performance - Planned activities at that location - Number of faults detected and solved

User	Role	Current situation	Goal
		The response time of the service engineers can be checked at MS Navision.	- Costs and time spend, trend? - % of one-time-fix, trends? - Monitor time required by engineers/technicians and compare, and analyse to help develop knowledge and skills.

To understand the goal of individual users further, user stories were developed and shown in Table 5.

Table 5: User stories

Persona	As a [Role]	I want to [Action]	So that [Benefit]
Customer	Facility manager	See the **number** of errors for individual components/ systems	I can assess the performance of the components/ systems
		Assess the **response time** of the service provider	I can assess the performance of the service provider
		Know the **utility consumption reduction** in the last month	I know the cost saved
		Compare the **energy consumption** per m^2 compared to the sustainability standards	I know how sustainable the building is
		See the recent maintenance activities	I know how active the service provider is
Engineer	Remote service engineer	See **alarms** from any system immediately	I can inform service engineers to take the necessary actions
		I want to see relevant information **about errors** (Last visited mechanic and time of visit)	Who should act on the error
	Mechanic	See the **measures** taken against previous alarms	I can decide on actions to be taken for similar alarms
		See the **details of the mechanic** who solved a similar problem earlier	I can ask for suggestions if required
Management	Remote service manager	See the **number of alarms** on a time scale	I can assess the performance of the service team
	Contract manager	See the **cost** of services	I can assess profit growth
		Correlation between errors and different parameters	I can identify the major causes of errors
		The concentration of the number of errors within a certain period	I can identify problematic locations to focus
		See the **performance** indicators against the agreed KPIs	I can satisfy the customers
		Feedback from the customers	I know the expectations and complaints of the customer

Based on the above stories, a convenient tool to visualize data from different platforms was searched. Some mandatory criteria were as follows:

1. Accessible with a user ID and password for security reasons.
2. Open-source framework. So that the tool can be shared with other project partners.

3. The tool should be usable without the requirement of installing new software.
4. The tool should be able to be added to an existing platform in companies.

After searching for a suitable tool, 'Dash' was found the most suitable which is a Python-based framework for developing dashboards. A prototype of a dashboard was built. It was then deployed to Heroku, a free web-based platform to host web apps with a size below 500 MB [31]. With the help of python code, user ID and password were introduced for the users. To develop a prototype and collect data, Eigenhaard was chosen as a customer of Kropman. Data for two locations of Eigenhaard was gathered from different platforms and visualised in the dashboard. Introduced features for the customer dashboard are as follows:

A. At-a-glance overview of different locations
B. Communication channel with the relevant person
C. Introduced KPIs on energy performance and service activities
D. Relationship between service orders and alarms
E. Consumption record of electricity
F. Consumption record of gas

A. **At-a-glance overview of different locations**:

In the beginning, a tabular representation of all the locations with relevant information from the past two months is presented. The locations which may need special attention can be highlighted. The reason for attention could be the highest number of service orders or the number of urgent cases. Issues according to the individual components like pumps or boilers can also be a reason. According to the interest, customers can sort the table based on different criteria. Moreover, the use of colour can drive the attention of the user to the most vulnerable locations and can support taking immediate actions.

B. **Communication with the relevant person:**

The last visited mechanic to a location is visible with the date and time. The details of the service order are also visible. The user may report any issue to Kropman or ask for support on any issue. Therefore, an MS Teams channel for the customer is available with a link in a button. The user can click the button and share his/ her concern. He can also communicate with the last visited employee from Kropman if the customer has any particular interest in that location.

C. **Introduced KPIs on energy performance and service activities:**

After having an overview of all the locations by the customer, the user might inspect deeper into any particular location. KPIs in this case will provide an overview of that location in terms of service quality, the comfort of occupants and the performance of utility consumption. Normally KPIs depend on the service contracts between Kropman and the respective customers. For standardizing a dashboard, the following KPIs were introduced with the most reasonable calculation methods. The location-wise KPIs are visible according to the selection of the user in the dashboard. The data used are filtered for the last 30 days to represent the most recent status of the location.

a) KPI-Electricity: It is the percentage of the electricity consumed last month compared with the average same month's electricity consumption for the past years in the same location. The electricity consumption is not dependent on the weather condition. Instead, the type of building and the occupants' behaviour are the defining factors. Therefore, to assess the performance of the electricity consumption, it was compared with the past years' monthly consumption and not with the consumption from other locations.

b) KPI-Heating: The heating performance of a location depends on whether the occupants received enough hot water supply with the required temperature. As the hourly temperature of the hot water from the central boiler is available, it was used to represent the performance. The KPI shows the percentage of hours in the last 30 days that the supply water temperature was above 65^{o}C.
c) KPI-Response: for any urgent cases, Kropman engineers need to respond within one hour according to the service agreement. Therefore, it will represent the percentage of times Kropman complied with the responses of urgent cases.
d) KPI-Legionella: The Drinking Water Act regulations of the Netherlands require in terms of temperature control, the hot water temperature should be above 60^{o}C and cold water temperature should be below 25^{o}C for at least 20 minutes per day [32]. This will maintain the level of legionella bacteria in buildings below 100 CFU/L.

D. **Relationship between service orders and alarms:**

To represent the connections between the service orders and the complaints, a graph is available with a timeline. Therefore, the trend of work orders and alarms can be inspected by the users. Also, the actions by the service provider against alarms can be related with the help of this graph within the previous two months' time.

E. **Consumption record of electricity:**

Monthly electricity consumption for different years is plotted to compare the usage for a month with previous months. Based on the difference in consumption, customer can plan their actions.

F. **Consumption record of gas:**

Gas usage is dependent on the heating demand. Therefore, the outside temperature was considered with the gas consumption to represent reasonable consumption of gas based on heating demand. As the building should have a base load of heating, the maximum gas consumption of the location in June was taken to deduct from the monthly gas consumption in other months. Therefore, the gas consumption for space heating is represented. Then the value is divided by the monthly total heating degree days. It is a measure of how cold the temperature was in a given period. This shows the gas consumption in m^3 per month per heating degree day. In the summer months, there might have some peaks which can be ignored, because the number of heating degree days is less which is used to divide the amount of gas consumed.

Based on the overview of different locations, users can explore deeper for a particular location in this layout. While developing the layout, an effort was made to follow the best practices. On a dashboard, the priority of information starts from the top-left corner [33]. A dashboard design competition was found relevant to follow. The competition was organized by Stephen Few [34], a recognized international leader in the realm of dashboard design. He is a teacher, consultant, and innovator in the fields of business intelligence and information design. The tabular layout of the competition for at-a-glance monitoring of 30 students by a school teacher can be similar to a customer who wants to have an at-a-glance overview of all the locations. The prototype contains some of the concepts from the competition. In addition, the font and colour code from InsiteReport have also complied. The layout of the dashboard is available at ANNEX VII.

Prototype for remote services engineers

A prototype of another dashboard was designed for remote service engineers. The service-related data and performance of the engineers were highlighted. A remote service engineer handles a lot of data every day. The dashboard will provide a summary of all the latest status of service activities by the mechanics. Based on the interviews and responsibilities of the engineers, the following KPIs were identified as important to visualize on the dashboard:

A. **KPI-Responses**: the response time requirement is different for service engineers based on the type of request they receive from customers. Table 6 shows the details of the time requirement.

Table 6: Recommended response time of service engineers

Type of request	State change from 'received' to 'in treatment'	State change from 'in treatment' to 'completed'
Wishes	Maximum 5 days	Maximum 10 days
Complaints	Maximum 5 days	Maximum 10 days
Information	Maximum 2 days	Maximum 4 days
Defects	Depends on the type of customers. For police, it is <4 hours to complete. Whereas for residential buildings it can be delayed a bit. On the other hand, for urgent cases, the response time should be less than one hour according to the agreed terms in some service contracts.	

B. **KPI-fixing problems**: 1st-time fix is always preferred which saves cost and time for the service department. Three fixing categories are available which were considered in ratios to represent the performance.
   - Fixed remotely: The remote service engineer fixes the problem the same day it was received without communicating with mechanics.
   - Fixed by mechanics: The mechanic fixes the problem on the first visit without issuing a request for another visit.
   - Fixed by 3rd party: the 3rd party supplier fixes the problem in a single visit within the same day.

   As the dashboard represents the performance of the remote service engineers, the performance of the mechanics can be ignored.

In addition to the KPIs, the number of problems solved remotely per month can represent the activities and performance of the team.

5.2 Methodology for assessing and improving the dashboard

Existing options for data analytics have been described in section 5. Most of the shortcomings have been addressed through the prototype dashboard. To understand the experience of different users, a Google survey form was circulated among the employees of Kropman. According to responses, the dashboard can be developed further with new information and visualization techniques. Over time, integration of all the feedback will standardize dashboards for different stakeholders. The key focus points of the survey form on a scale of seven were as follows:

a. Can this dashboard with visualized data support you in getting an at-a-glance overview of different locations?
b. How the data represented in the dashboard can initiate communication among different departments and stakeholders?

c. Do you see it as a medium to build trust between different stakeholders?
d. Can it be a medium to educate different stakeholders on KPIs and assessment methodology of operational performance?

5.3 Value added by dashboards

According to the findings from the experiments described in section 4.1, employees and customers are not gaining the required knowledge for data analytics. As a result, their daily activities are not getting the advantage of machine learning and data visualization techniques. Moreover, the communication between the stakeholders remained inaccessible and not preserved due to the conversation over the phone or MS Teams. The lack of awareness of a central location for project documents also remained a challenge for preserving data analytics-related project documents. In addition, the data analytics tool of the company 'InsiteReport' with huge potential is still lacking in usage by the users. All these limitations were addressed by the newly developed dashboards. Opinions were collected with Google forms, through meetings and personal discussions. The findings from the responses are available in ANNEX VIII. Although the number of responses is only 4, they represent the majority of the employees due to their long-term service with the organization and huge amount of experience. The key observation is that there is a positive feeling about all the indicators mentioned in the previous section 5.2. The following sections describe the added values by different dashboards.

5.3.1 Dashboard for customers

- Customers can have an at-a-glance overview of the recent operation status of all the locations within a short time.
- Customers can easily identify locations which require attention based on the number of work orders or the number of errors generated recently.
- It will become easy to focus on important and relevant parameters to focus on among hundreds of other information. As a result, it will be possible to make data-driven decisions for efficient building operations.
- The communication portal connected with the dashboard will facilitate the users to communicate with the service provider in the most effective way. In that case, segregating the type of requests is possible into complaints, wishes, information requests and defects.
- The facility manager or the building owner can see the name of the technician who last visited the location and when. So the mechanic can be reached for any queries without searching for names.
- The current status of the major equipment like boilers and pumps can be monitored closely based on the trend of errors coming from those components.
- The performance of the service provider can be monitored based on KPIs. As a result, trust and reliability in the service can be built.
- Customers can learn different parameters of the building operation performance by going through the details of individual indicators. This was the knowledge of the service provider which can be transferred to the customer. As a result, customers can make better service-related decisions.

5.3.2 Dashboard for remote service engineers

- The cost saved by the remote service engineers can be measured by avoiding the physical visit of mechanics to the customers' locations.
- Customer-wise performance of the engineers can be assessed which can be used to satisfy different customers according to their preferences.
- The overview of all the customers' locations will facilitate the service engineers to put priority on locations which require more attention.

- Visualizing the type of requests from customers will facilitate the engineers to put more attention on defects than other minor requests.

6. Discussion

The initial phase of the project focused on developing a learning community around the knowledge of data analytics techniques. The tools used are owned by the company. Therefore, the community developing tool had no commercial prospect. Instead, it will support the employees to communicate internally more effectively. In addition, employees will be able to preserve and share their knowledge more efficiently which will have a long-term commercial benefit through delivering innovative projects with better quality. However, the company culture was found a strong driver for employees to adopt new communication practices and knowledge-sharing activities. In addition, the culture of learning on the job by professionals plays a big role in gaining new skills. That means, it can be a barrier as well which should be addressed by the higher management of organizations. Team leaders or managers can start the practice and follow up on the progress of their team members to bring change in the company culture. Based on the observations of five communities, a paper was published at the CLIMA 2022 conference titled 'Learning and Knowledge Transfer of Professionals within the Building Services Sector' [35].

The prototype was cross-checked with the user stories developed in section 5.1 and assessed whether the expectations of individual users can be met. In addition, a survey form was circulated to verify the technical viability of the dashboard. The findings of the survey are described in section 5.3. For assessing the financial viability, the efficiency of remote services was considered. The potential of cost savings from reduced time spent to solve a problem by remote service engineers and avoiding the physical visit by a mechanic show the financial benefit of the tool.

Since the beginning of the project, some limitations were there which can be addressed in the future project. Key findings are mentioned below:

- A large number of professionals in the building services sector are mechanics. However, in this study, communication with mechanics was not made. Instead, the engineers supporting mechanics were involved in the study to increase their efficiency in supporting through better data analytics techniques.
- A data visualization tool for customers was developed. For remote service engineers, only a concept of a dashboard was designed. Future work can include developing prototypes for remote service engineers, mechanics, and contract managers.
- The commercial advantage was not visualized on the dashboard due to the limited access to financial data from the company and the customer.

The current status of the market, existing problem analysis of the employees, a business model canvas for the dashboard, analysis of Strengths Weaknesses Opportunities and Threats (SWOT), scalability, deployment strategy and revenue streams can be found at ANNEX IX. In addition, assumptions made for the financials of the business plan and the balance sheet developed for the designed dashboard were developed and included in the same ANNEX section.

7. Conclusion and prospects for future work

The goal of TransAct project is to identify elements that help to build a learning network. In addition to that, the PDEng program aimed to demonstrate the benefits of data analytics among professionals in the building services sector. As a result, the prototype of a dashboard was developed to visualize different concepts and collect feedback from the users.

The project started with exploring different communities. The community members are getting oriented with the latest analytics techniques, communication tools, online learning platforms and knowledge-sharing strategies. However, they are interested to get the full advantage in their day-to-day activities. The outcome of the interactions with different communities shows this common motivation. The quote from Henry Ford can be mentioned here, “If I had asked people what they wanted, they would have said faster horses”. Therefore, a community with an effective combination of different tools can be a role model for other communities to follow and experience the underlying benefits that were not clear to them earlier.

During the experiment, a platform with different tools for communication, online learning, and knowledge sharing was introduced to the professionals. The experiment identified some approaches which are not effective for motivating learning on the job and some smart approaches which inspire professionals to gain knowledge about the latest analytics techniques. The appreciation by the colleagues and implementation of the shared knowledge were found as motivating factors for professionals for sharing knowledge within the organization.

Finally, to demonstrate the benefits of the data-driven decision-making process, a prototype of a dashboard was introduced to the professionals. Instead of programming and pre-processing data from different sources, with the help of this tool, professionals will find insights into data from different customers’ locations and service activities. As a result, the benefits of data visualization can be realised immediately. The integration of communication platforms into the dashboard will facilitate exchanging thoughts and knowledge among different stakeholders. Therefore, future tasks can include developing the dashboard further with new features based on the feedback and expectations from different users.

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ANNEX

I. Queries to Kropman employees and explored challenges

The queries to the employees of Kropman are as follows:

a) How does knowledge development proceed
b) E-Learning platform experiences
c) Desired extensions in the online platform
d) What kind of tools are used for communication and knowledge transfer
e) Informal networks for knowledge sharing
f) Current skills and plan to develop in future
g) Motivation to learn on the job
h) Expected incentives to share knowledge with colleagues

The initial challenges for learning and sharing knowledge were found as follows:

1. Project details are not accessible to all the employees
   Due to the data privacy of respective customers, project information has limited access to the project members only. Therefore, other employees working on similar projects have no scope of getting the benefit except having some conversation over the phone or communicating by email. On top of that, Project managers don't update regularly relevant departments about the progress due to their busy schedules and for avoiding criticism from colleagues.
2. Information/ knowledge is transferred mostly through direct contacts
   In case of any problem, employees generally know, whom to contact for what kind of information. Accordingly, they have some email communication and some conversations over the phone. As a result, the solution remains with individuals and is not documented at a central location.
3. Documentation of the knowledge of experts
   Several senior employees are working for more than 10 years. They have a huge amount of project experience and knowledge that can only be gained through personal interaction. Due to a busy project schedule, documentation of the entire knowledge gained throughout the project was not done. Many of the experiences are hard to explain through a written document. Webinars or short videos could be a solution which is an extra job on top of the regular responsibilities.
4. Most employees are not interested in online courses
   Excluding some young employees, many of the company professionals still prefer physical training or workshop. They find it an occasion to interact with other colleagues and learn effectively. During those training, employees can get a break from their ongoing projects. On the other hand, most of the online courses need to be followed outside of office time during personal time. Therefore, online courses became less motivating for them.
5. Top-down approach
   Normally, supervisors or managers suggest employees for training or online courses. Through the annual assessment, the course plan is defined for developing different skills and competence. In some cases (i.e., IT professionals) take online courses of their interest for personal development.
6. Customers are increasingly showing interest in predictive maintenance and FDD
   In some tender documents, customers ask for predictive maintenance and FDD. In that case, experts in ML and data analytics from other departments support the sales team. Sometimes, students are employed as trainees to work on some predictive modelling according to different project requirements. As a result, existing employees don't feel the demand to gain the skill.
7. Project documentation is a challenge

- For smaller projects (project cost below Euro 500,000), no budget is appointed for the hours required to document learning points and project summaries.
- No central location to preserve summaries of different projects.
- Summarizing project results is not a mandatory task in most projects.
- The regular project documents are saved on the central server. Annually the folders are archived. To access the old project files, permission is required from the ICT department.

II. Helpful features for a learning community-building platform

Table 7: Features to support learning community development

No	Features	Details
1	Knowledge base	- Company-specific knowledge of different categories - A smart search engine which can search the content of the files
2	Discussion forum	- Discussion on a course or topic by the employees - Upvote on good answers and questions.
3	User database	An individual profile should have the following information: - Name of skills with a level of expertise - Endorsed skills by colleagues and managers (similar to LinkedIn) - Years of experiences - Number of completed courses - Infographic of learning activities, progress and rewards on a daily/ weekly/ monthly/ yearly basis - Status of e-learning activities on other platforms (i.e., Pluralsight, Coursera, EdX, Udemy etc.) - Personal course plan integrated with outlook calendar
4	Users' directory	- Learners should be able to search for experts and send messages
5	In-depth analytics	- Usage of the platform on an individual and organizational level
6	Authoring functionality	- Expert learners can improve or create learning content, lessons or quizzes.
7	Gamification	- Points to be awarded based on different learning activities - A leaderboard based on monthly/ quarterly activities

III. Assessment rubrics

Table 8: Assessment rubric on Data analytics and ML applications

Criteria	**Poor** **No knowledge**	**Fair** **Basic knowledge**	**Good** **Sufficient knowledge**	**Excellent** **Expert**
From data to decision making	☐ **I cannot** assign meaning to data for making a decision	☐ **Occasionally** relate statistical methods with data types for making an impactful decision.	☐ **Most of the time** relate statistical methods with data for making an impactful decision	☐ **Consistently** relate statistical methods with data for making an impactful decision.
Proficiency in data analysis tools	☐ I am **not able** to operate data analytical tools (i.e., excel, python, Power BI etc.)	☐ **Familiar** with data analytical tools (only excel). Can analyze a **small dataset** with **standard** techniques	☐ **Good** with standard tools (i.e., excel, python, Power BI etc.). Can analyze a **big dataset** with standard techniques	☐ **Good** with standard tools (i.e., excel, python, R etc.). Can analyze a big dataset with standard techniques through **reasonable alternative approaches**

Criteria	Poor No knowledge	Fair Basic knowledge	Good Sufficient knowledge	Excellent Expert
***Explore & evaluate data analytical techniques* (regression, cluster, time series etc.)**	☐ **I cannot** identify the trend and behaviour of the data.	☐ **Occasionally** identify the trend and behaviour of the data with suitable analytical techniques by exploring a **few** of the possible alternatives.	☐ **Most of the time** identify the trend and behaviour of the data with suitable analytical techniques by exploring **some** of the possible alternatives.	☐ **Consistently** identify the trend and behaviour of the data with suitable analytical techniques by exploring **most** of the possible alternatives.
Explore & evaluate machine learning (ML) techniques (Decision trees, artificial neural networks etc.)	☐ **I cannot** explore and clean data to implement ML models. Not know about assessing prediction accuracy.	☐ **Occasionally** explore and clean data to implement ML models. Can get a prediction accuracy with an ML model **without** exploring possible alternatives.	☐ **Most of the time explore** and clean data to implement ML models. Can improve prediction accuracy with a suitable ML model by exploring **some** of the possible alternatives.	☐ **Consistently explore** and clean data to implement ML models. Can get the best fit ML model with high prediction accuracy by exploring **most** of the possible alternatives.

IV. Overview of different learning communities

Sl no	**Name of the organization**	**organization culture**			**Education network**	
		Internal & external communication	Learning culture	Knowledge sharing (Internal/ External)	Online and physical learning	Learning the tool for ML
1	Kropman	MS Teams, phone calls, Email, MS Intranet page	Annual review of skills with the development plan for the following year	*Experts share knowledge with colleagues over the phone, in meetings, by email or at the central server *Project report to customers	Third-party online course provider with a platform where the company-owned courses are also available	Company-owned software for data analytics with simple ML applications. Employees use excel
2	Industrial Design department, TU/e	*Bi-weekly internal project meeting *3 weekly meetings with project partners *WhatsApp group for PhD researchers *MS Teams for project communication	*Training and Supervision plan is developed along with the supervisors.	*Dropbox for internal use *For the project, a shared drive is used for partners. Publications are another way of knowledge dissemination	*Courses from TU/e and TU Delft. *Online courses on YouTube and Coursera *Attending conferences	Python is used by data scientists. Others use **Gamebus**, a tool developed by the department.
3	The built environment department, TU/e	MS Teams, phone calls, Email, WhatsApp group	Supervisors and peers recommend courses and tips to follow. Training and supervision plans need to be developed.	MS teams, emails, publications, presentations, meetings	University courses, online courses, learning from peers	Python and excel for data analytics

Sl no	Name of the organization	organization culture			Education network	
		Internal & external communication	Learning culture	Knowledge sharing (Internal/ External)	Online and physical learning	Learning the tool for ML
4	BAM Energy Systems BV	MS Teams with specific channels for particular topics. Total 5 team members with electrical, mechanical and data science backgrounds. Monthly lunch meetings. Two weekly standup discussions (1) **process**: what and how is one doing (2) **technical challenges**: What one learnt, how problems were solved. Notes from the standups are shared in the SharePoint database.	Supervisors and peers recommend courses and tips to follow.	A central database at SharePoint for project summaries and learning points (findings of cases, ML discoveries, useful ML applications). Large projects have a budget for documentation. The summary of small projects is in form of notes from the weekly standup discussions. Newsletters with data science case files are circulated.	BAM learning (online platform) Online courses on ML from other online platforms. Attend conferences to network with other companies and learn from them. Individual budget for personal development.	BAM developed analytical tools. Team members are using python. 'ubiOps' software provider regularly shares interesting courses in the field of ML.
5	EFESO	Work on an agile basis. Have weekly scrum meetings. Brainstorming with team members on problems and ideas. Total of 12 members in the team. Some are MSc in the supply chain, installation techniques, EE, physics, math etc. Data scientists and engineers work closely with each other. MS Teams is used for communication. Customers can have specific access to the relevant SharePoint page.	The monthly session for a presentation of 1.5 hours on clients' projects. Then a discussion on challenges. Self-learning on programming. Interesting articles are shared via group chats in MS Teams.	Small whitepapers are uploaded into the toolkit after projects are completed. Standardized dashboard to show model performance, standardized pipelines for data cleaning on time series.	combination of platforms. (Coursera, Udemy). Subscribed Medium blog website for updates. ResearchGate is checked for updates on use cases. An Analytics network is an MS teams group where questions can be dropped for solutions.	Developed Toolkit based on SharePoint is available for data science matters. Quickly apply repetitive tasks and faster delivery to customers. The skill matrix is maintained on several subjects. skill level from 1 to 5 for data engineering. (SQL, Python etc.) and data scientist (algorithms) based on the number of cases. Individuals fill the skill matrix.

Sl no	Name of the organization	organization culture			Education network	
		Internal & external communication	Learning culture	Knowledge sharing (Internal/ External)	Online and physical learning	Learning the tool for ML
6	Avans hogeschool	MS Teams, BlackBoard. SharePoint is used for sharing documents. BrightSpace as LMS system. MS Team channels are used for discussion among the course participants. Good students ask the most. There is space to use materials in the presence of lecturers.	Projects with different institutes. There is an Ai minor for 3 years within the engineering department. Students learn from what is the building automation system, and what has been done in other research projects. End of the minor, a mini-conference is organized. Students learn from project activities and lectures. They try out challenges and continue learning.	Meeting and doing things together is the most common way of sharing knowledge in applied science-based institutes like Avans. Knowledge is developed along with the product which is delivered in projects. Github repository is used. Technical articles are shared on LinkedIn or within the Avans environment (i.e., newsletters). Avans+ is responsible for giving training to professionals. Avans focuses only the academic learning.	The 1st-year course is conducted together with MOOCs from Finland. Most of the time practical lesson is conducted. Some courses from Udemy are advised to the students. Some mathematical online resources are recommended while conducting lectures. A Digital Copy of the writings during the lecture is shared through Brightspace.	Developed an application where all the students can program together interactively. The teacher can immediately correct students on a large screen. Anaconda and Python 3.0, TensorFlow, Pytorch, Artificial Neural Network (ANN), all the frameworks that can be applied to the convolutional space, vision, CNN, RCNN, Yellow, reinforcement learning with agents, LSTM, generative advisory networks, and eventually all the fundamentals of Neural Nets. In one semester (20 weeks) through project works, students learn these.
7	POWErFITTing project, Eindhoven Engine, TU/e	Regular online meetings and communication through email. Prof. Steven Vos (scientific lead) and Marieke van Beurden (business lead) are the project's leads. There are PhDs and short-term students (BSc and MSc). The workplace vitality hub is the most important learning community.	self-learning according to the project requirement. A development plan was submitted with courses and workshops.	Has shared one drive and shared SharePoint location to preserve documents for internal use. Online talk shows for knowledge dissemination during the Dutch design week. Regular meeting with Eindhoven engine and a report is shared with a presentation every 6 weeks. There was a podcast last year when other projects of Eindhoven Engine were learnt. Their social media and newsletters are also good sources to know their activities.		PhD researchers worked on **SPSS** and excel during their masters.

Sl no	Name of the organization	organization culture			Education network	
		Internal & external communication	Learning culture	Knowledge sharing (Internal/ External)	Online and physical learning	Learning the tool for ML
8	ChessWise	Small software team (10 people). Hardware team (2 people). Including management of 30-40 people to develop and maintain products. Using MS Teams for 1.5 years. Physical meetings. For bookkeeping, Github is used.	Walk around and learn from peers and supervisors. Sometimes online courses are arranged for team members.	Several central systems are in place depending on the type of tasks. Central issue tracker (used to do all planning). Redmine is used. Assana for the manufacturing side. Central file server for all project documents. Central continuous built environment (building all the releases of software) Central test environment (testing all the releases) Technotes are used when someone describes the research phase of his product engineering. Then a meeting can be arranged on the topic.	design work is mainly experience. Craftmanship can only learn by doing. Coffee machines facilitate discussion within the community.	At this moment not focused on data analytics and ML. Within the building, a small closed-loop control system will be implemented. The company will support the long loop where cloud data can be utilised to optimise the building operation with the help of ML and Ai.
9	Art Energy	Working alone. Regular meetings with partner companies.	Follow overall literature to see recent developments.	advises on the company board meetings, attend project meetings, involved with the new energy performance standard in Netherlands NTN8800 which was developed last year. Chairman of a committee for the installation sector where installers need to show compliance. The committee assessed the compliances (i.e., standard for legionella in a building). Support 2/3 small companies for development.	New innovative projects.	a simple software was developed based on the 80/20 rule where major parameters were taken into account to predict the energy demand for the next day. Accordingly, the set-point temperature is controlled and brings significant energy savings.

Sl no	Name of the organization	organization culture			Education network	
		Internal & external communication	Learning culture	Knowledge sharing (Internal/ External)	Online and physical learning	Learning the tool for ML
10	Renor	3 Former Royal Haskoning employees. Fast lane platform. Building construction and mechanical engineering. BPS MSc. Tiun, Construction manaement. Familiar with asset management. 3rd Roland. IT development. Internal meetings and plan is managed in Miro. ORA is used (advanced Trello). for task management Google workstation is used.	Work on a project together. Expanding knowledge of other domains. Use templates for presentation, and energy calculations. Not everything is organized yet. As soon as new employees are hired, new templates should be standardized.	Provide consultancy to clients. Energy calculation. Google workspace (Sheets, Docs, forms). 75% via google slides. As clear and easy as possible. Course developed on Performance monitoring of HVAC installations at TVVL together with Werner Vink. Develop online tools for TVVL, and provide workshops to encourage on building industry. The courses are followed by diverse professionals including the building owners to have an idea of the building operation and optimization.	Searching on the internet. MOOCs. Coursera. Asking people from the industry. Reading in LinkedIn. Multiple topics: energy transition, data analytics, building services.	Python learnt. Jupyter notebook is used for projects.
11	Deerns	MS Teams, outlook. Groups are made in MS teams for internal discussion on different topics.	employees give presentations and webinars are recorded. Lunch lectures are also provided	MS SharePoint through MS teams	Groups in MS Teams for discussion on topics.	Excel is mostly used.

V. Questionnaire for exploring learning communities

Current job details (20 min)

1. General questions, Learning
   2.1. Job description & personal background
   2.2. Work-related to data-driven maintenance and services with big data analytics and machine learning
   2.3. Where do you preserve final project reports and data from clients
   2.4. How do you get support from your colleagues while analysing data?

Learning and sharing knowledge (15 min)

2. Learning and sharing knowledge
   2.1. What do you expect to have in the central knowledge base? (i.e., previous project reports, project data from the clients, how the project was done etc.)
   2.2. Now have a look at the Data analytics page, Study tube, database and Yammer forum. What do you expect to get from each of these locations?
   2.3. Do you feel that you need a better tool for data analysis? In that case, python is a great tool to work with. What kind of courses do you prefer to learn python? (i.e., long course with more details, short videos on simple data sets)
   2.4. Which other sources do you prefer/ used to learn Data Analytics?

2.5. Which skills would you like to develop further and why?

Towards TransAct (15 mins)

3. Towards TRANSACT
   3.1. What are the main problems and challenges you see in learning and sharing knowledge within Kropman?
   3.2. What questions did you ask your colleagues that you could ask in the forum?
   3.3. What questions did you receive from your colleagues recently that you think could be answered in the forum?
   3.4. Can you please respond to the following questions in Yammer?
      - If you were asked to dedicate around an hour for personal development on the weekdays, which day would you prefer and when (morning/ afternoon)?
      - There is a database for projects on data analytics. Which motivating factor will inspire you to share your previous and ongoing project reports as per the template provided?

VI. Questionnaire for Mentorjam experience

a. What kind of Eindhoven Engine related information have you been looking for during the past weeks? Should this be on the platform?
b. How do you currently find and reach out to other members of the Eindhoven Engine community?
c. What would make you come to the Eindhoven Engine community platform more often?
d. Rate potential feature (on a scale of 1 to 10):
   i. Overview of profiles and direct access to all members part of the Eindhoven Engine community
   ii. Direct access to all running projects
   iii. Direct access to project team members
   iv. Direct access to all partner organizations part of the Eindhoven Engine community
   v. Events calendar (showing all events, seminars and webinars and offering registration)
   vi. Library with all relevant information on Eindhoven Engine: processes/training/ …
   vii. Discussions forum where the entire community can be involved in topics or asked for support
   viii. Job board showing available jobs in the projects and at the partner organizations
   ix. Mentoring program for (members of) project teams

VII. The layout of the dashboard

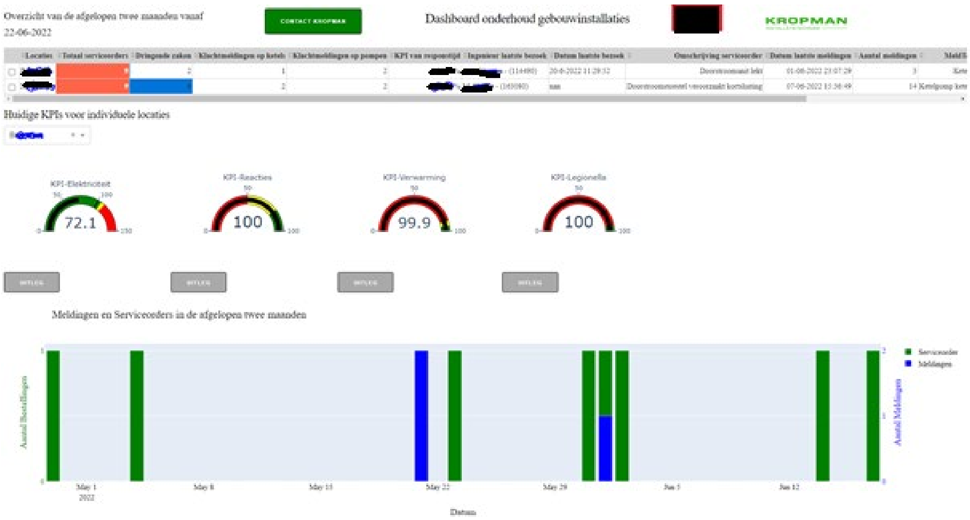

Figure 12: Overview of different locations and KPIs of selected location

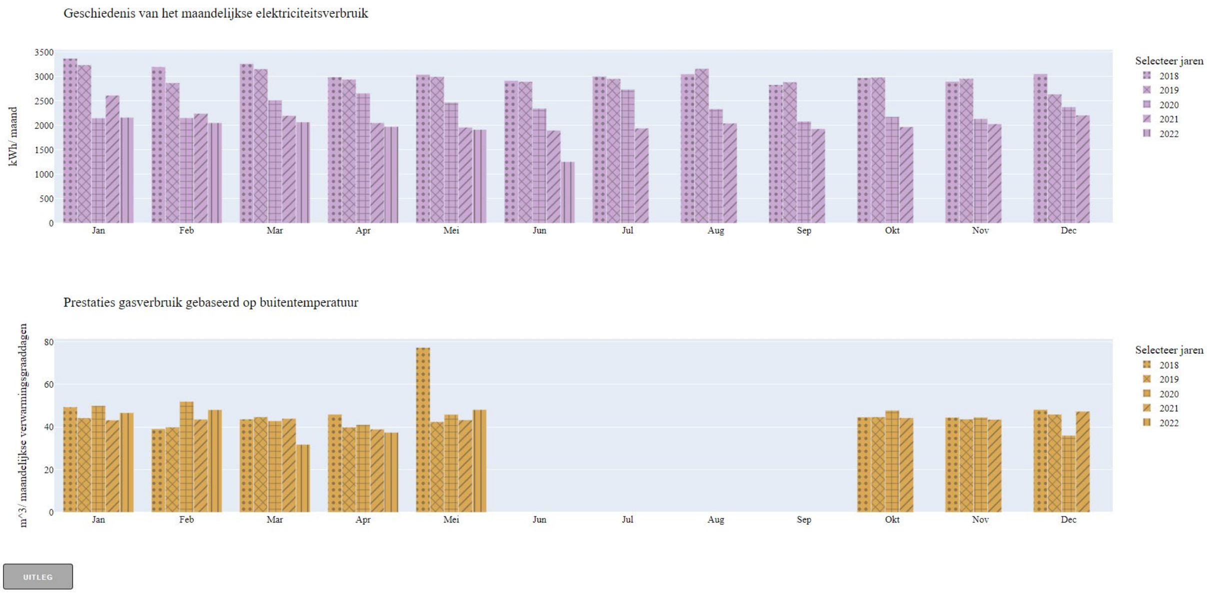

Figure 13: Electricity and gas consumption record visualization of a selected location

VIII. Findings from the survey on customer's dashboard

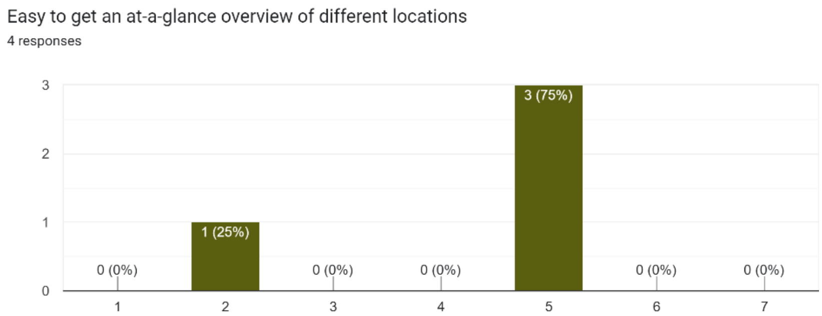

Figure 14: Responses on the convenience of the at-a-glace overview of different locations

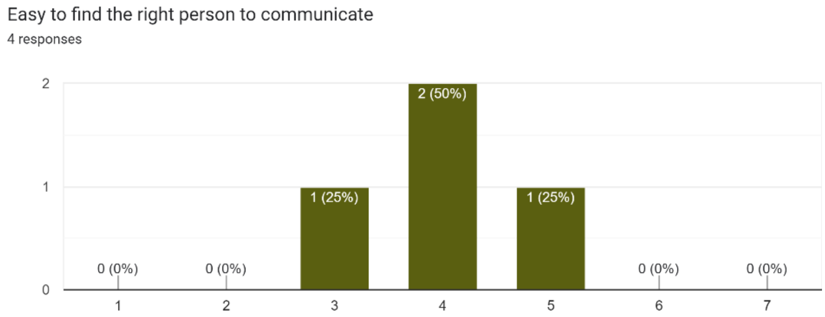

Figure 15: responses about finding the right person for a particular purpose

Figure 16: Possibility to build trust through visualizing data in a transparent way

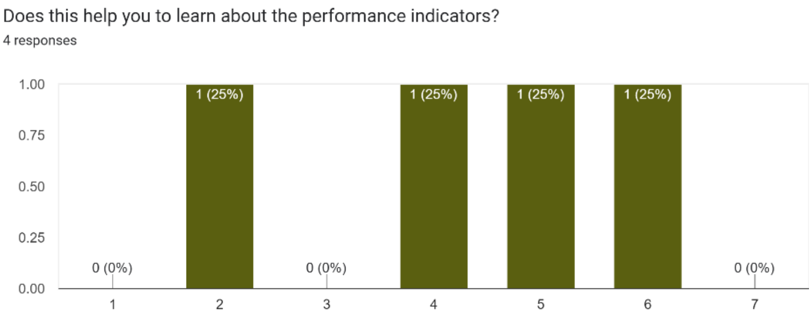

Figure 17: Potential of learning about the key performance indicators

IX. Business model

The data visualizing tool is considered for the business plan development in this study. The developed prototype represents the Kropman perspective which can be a role model for other organizations who are involved or willing to start with a data-driven decision-making process. A detailed business model was developed with technical and financial feasibility. Considering the ongoing market demand for more data-oriented products, the designed tool can have a high market potential to introduce among interested customers considering a software-as-a-service (SaaS) business model [36].

a. Current status

Currently, the data is collected and analysed by the software InsiteSuit which was built in-house by the ICT department. There are other data visualization tools available like MS Power BI and Dash2Go. Data from the customers' locations are received and analysed in InsiteReport, a part of InsiteSuite. For internal management, MS Navision is used with all the service activities. There is an SQL server to save data from locations and service activities. Therefore, there are some limitations in facilitating the data-driven decision-making process in the service team and for the customers.

b. Problem analysis

- Reports and dashboards of the tool have all categories of data visualized. As a result, some locations have available data and some locations have missing data. That creates confusion about whether to check with the customer for the missing data or if there is some trouble in receiving the data from the locations.
- Not all the information is interesting for all kinds of users of the tool. But the reports or dashboards are not aligned with one's background and responsibilities. As a result, from the users' perspective, it is not always clear where to concentrate.
- Different types of data are scattered on different platforms. Therefore, the interrelation is difficult to make between different service activities and data from customers' locations.
- Data from different locations are available on different pages of the application. Therefore, to check the status of all the locations, users need to enter every page which is time-consuming and tiresome.
- To make a data-driven decision, it is crucial to make key information visible on the same screen. In the current situation, useful data is scattered on different pages and even on different platforms.
- All kinds of communications are visualized together. As a result, important notifications might not be receiving the required attention they deserve.

c. Business model canvas

Based on the above description, a business model canvas was made as follows.

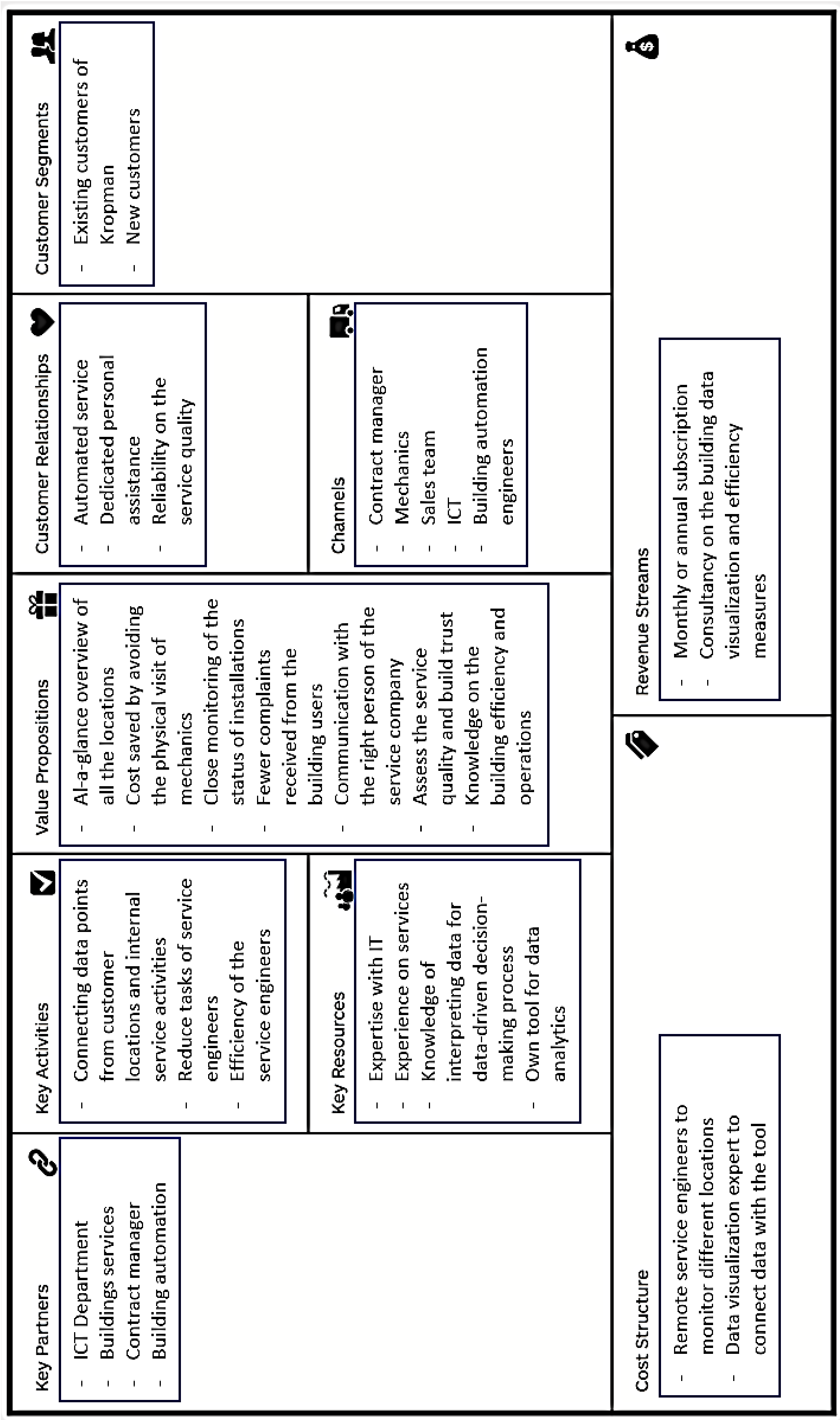

Figure 18: The business model canvas

d. SWOT analysis

Strengths, weaknesses, opportunities and threats are analysed as follows based on the different features offered by the tools to the customer, engineers and managers.

Strengths

- Does not require an expert or additional training to use it.
- Bridge the gap between different user communities
- Able to focus on locations and issues. Accordingly, guide in the best way for solving the issue.
- Customer-specific dashboard supports engineers to meet agreed KPIs
- Educate users on how different parameters affect different KPIs

Weaknesses

- Data can be missing from different locations due to unavailable sensors or malfunctioning. In that case, confusion will raise among the users.
- The dashboard is a prototype and not yet visually appealing to the users.

Opportunities

- A comparison of the performance among different locations will represent the rank of that location on a sustainability scale.
- Financial data has not been included in the dashboard. The cost savings and other financial information will make the dashboard more appealing to the users.
- Machine learning models can be introduced to predict the energy demand. However, the proper use case and benefits to the users should be clearly explained. Otherwise, that would be excess information on top of what is more important.

Threats

There are multiple data visualization tools available in the market. i.e., MS Power BI can produce visually attractive dashboards without the requirement of coding or learning a new programming language. Therefore, the developed tool might not be used further. Instead, the selective information and the visualization techniques might be useful for the companies as a knowledge resource.

e. Scalability

The prototype visualises data from only two locations. However, the major focus was to demonstrate the benefits of data visualization to the employees of Kropman. Whatever the tool they use, suitable data visualization techniques can play an important role to support the right decision-making process. With the current Dash tool, data from different locations can be connected and the dashboard can be scaled up to visualize all locations of individual customers. A paid version of Heroku can host a dashboard sized more than 500MB. Although the dashboard aims to represent the most current status of a location, some predictive models might need more data to analyse and may exceed the data limit for a free version of a dashboard. The methodology can be used to represent all the locations of all the customers for an overall overview of the operation that is going on within the organization.

f. Deployment strategy

After making sure the dashboard is complete, all the locations of a customer should be added to the dashboard. The missing data should be handled and make sure all the sensors and connections with

BMS systems are working properly. The introduction to the first customer will gain the real experience of the user's perspective. As an expert, it will be standardized by the service company about which information is shared with the customer and how. If the customer has specific concerns and interests, they should explain with justification. Accordingly, the dashboard will be adjusted and shared with other customers for their convenience.

Within Kropman, the service engineers will be the first users of the dashboard. Later the mechanics and managers will have their version of dashboards with relevant information.

g. Revenue streams

The cost for service engineers is 75€/hr and the cost for mechanics is 70€/hr. In a normal case, when there is trouble at any customer's location, one mechanic visits the location and solves the problem. For each visit, the charge is 65€ to the customer. The time for exploring and solving the problem also costs money per hour. If the remote service engineer can remotely inspect the installation systems and solve the problem, then the cost of the travelling can be avoided by the mechanic. As a result, the cost of customers and also Kropman will be reduced.

The designed dashboard in this case will support the service engineers to monitor different customer locations more effectively. Preventive activities can also be possible by analysing data from different locations. The remote service engineer can introduce mechanics who have solved similar problems to the appointed mechanics. Therefore, the quality of customer support will improve and the time required by mechanics for solving a problem will reduce. The number of remotely solved problems will also increase. All these activities will generate revenue for the company. In addition, a monthly subscription to the platform will bring profit through software as a service (SAAS). The number of locations will define the basic cost for the platform. Additional features will come with an additional subscription cost.

h. The financials of the business plan

Assumptions and comments

Due to the limited access to the company's finances and high uncertainty on the early adoption of the dashboard with the data from different locations, the financial model can be considered conceptual and simplified. A base case was assumed with ideal operations in customers' locations.

The initial investment was covered for the concept development, proof of concept, and designing of the dashboard through the PDEng program. During the first year of implementation, operation and fine-tuning of the dashboard for the proof of market phase, two employees were considered. Their responsibility will be to make collaboration with different stakeholders, collect feedback and adopt the new expectations. Part-time employment of trainees from reputed universities can also be considered to introduce different machine learning techniques and if possible, deep learning or genetic algorithms depending on the type of data available over time from customers. The cost saved due to the visualization tool was not considered within the financial model.

The current customer base of Kropman was considered for the market entry. As less than 5% of the total customers are managed by the remote services team, it was assumed to gradually introduce a larger share of customers of Kropman with the visualization tool. Not only connecting data, but understanding the data type, required pre-processing, and requirements of additional sensors need to be assessed before adding a new location to the dashboard. Therefore, the time required to cover the whole customer base of Kropan was assumed to be three years. To support and satisfy more customers, in the second year one additional employee and in the third year another employee was assumed to join the team to support the data processing and visualization. Figure 19 shows the relationship of the revenue with cash flow and the technology rink. Over time, when the dashboard will be optimized and standardized, the risk of failure will reduce. With a higher number of customers with subscriptions, the revenue will increase. Some financial assumptions of the financial model are as follows:

- Tax over gross earning: 25%
- The weighted average cost of capital: 15%

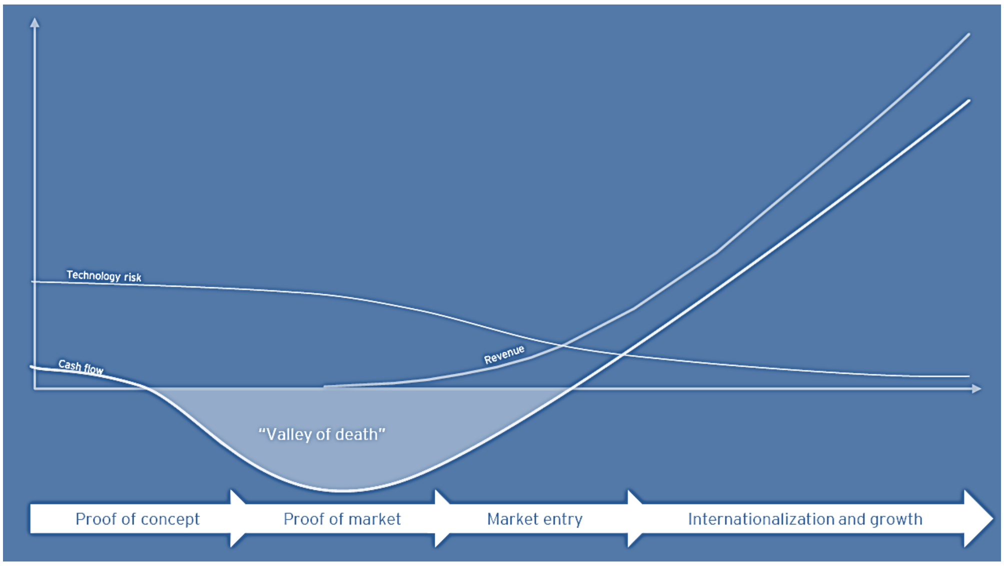

Figure 19: Cashflow and revenue relationship layout

Balance sheet P-L

The monthly subscription was considered the only revenue stream for the dashboard. Initially, the number of locations will be 10 with a subscription cost of 20€ per month/location. After the first month, the number of locations will raise to 50. By the end of six months, the number of locations will raise to 100. By the end of the first year, the total number of locations will be 150. Over the following years, each year 150 locations will be added to this service. From the second year, the subscription cost will raise to 30€ per month/location.

shows that in the first three years, there is no profit from the subscription cost. The market is the existing customers of Kropman which is a conservative assumption. The introduction of new locations with customised requirements and with higher subscription costs will bring additional revenues for the organization. The cost-saving for individual remote services is 65€ which is the cost of travelling by the mechanic. The average monthly remote services are not known at this moment which will bring much financial benefit to both Kropman and customers.

Table 9: Profit and loss calculation for the dashboard subscription

Profit & Loss	31/09/23	31/09/24	31/09/25	31/09/26	31/09/27

Profit & Loss	31/09/23	31/09/24	31/09/25	31/09/26	31/09/27
Sales	29.000	108.000	162.000	216.000	270.000
Cost of goods sold	-	-	-	-	-
Gross Margin	**29.000**	**108.000**	**162.000**	**216.000**	**270.000**
Personnel cost	(84.000)	(126.000)	(168.000)	(168.000)	(168.000)
Sales & Marketing	(10.000)	(10.000)	(5.000)	(5.000)	(5.000)
General Administration	(500)	(500)	(500)	(500)	(500)
Research & development					
Other costs	(100)	(100)	(100)	(100)	(100)
Total cost	**(94.600)**	**(136.600)**	**(173.600)**	**(173.600)**	**(173.600)**
Earnings before interest tax depreciation and amortisation (EBITDA)	**(65.600)**	**(28.600)**	**(11.600)**	**42.400**	**96.400**
Depreciation and amortisation	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)
Earnings before interest and tax (EBIT)	**(66.600)**	**(29.600)**	**(12.600)**	**41.400**	**95.400**
Interest	-	(2.913)	(4.499)	(5.292)	(3.874)
Financial cost	**-**	**(2.913)**	**(4.499)**	**(5.292)**	**(3.874)**
Earnings before tax (EBT)	**(66.600)**	**(32.513)**	**(17.099)**	**36.108**	**91.526**
Tax	16.650	8.128	4.275	(9.027)	(22.882)
Net result	**(49.950)**	**(24.385)**	**(12.824)**	**27.081**	**68.645**