

Learning and Knowledge Transfer of Professionals within the Building Services Sector

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Abstract. Buildings need to be carefully operated and maintained for optimum health, comfort, energy performance, and utility costs. The increasing use of Machine Learning combined with Big Data in the building services sector has shown the potential to bring energy efficiency and cost-effectiveness. Therefore, upskilling and reskilling the current workforce is required to realize new possibilities. In addition, sharing and preserving knowledge are also required for the sustainable growth of professionals and companies. This formed the basis for the Dutch Research Council funded TransAct project.

To increase access to education on the job, online learning is experiencing phenomenal growth. A study was conducted with two focus groups - professionals of a building service company and university researchers - to understand the existing challenges and the ways to improve knowledge sharing and upskilling through learning on the job. This study introduced an Enterprise Social Network platform that connects members and may facilitate knowledge sharing. As a community forum, Yammer from office 365 was used. For hosting project files, a SharePoint page was created. For online courses, the company's online learning site was utilized.

The log data from the online tools were analysed, semi-structured interviews and webinars were conducted and feedback was collected with google forms. Incentive models like social recognition and innovative project results were used to motivate the professionals for online activities. This paper distinguishes the impacts of initiatives on the behaviour of university researchers vs company employees.

Keywords. Lifelong learning, knowledge sharing, building services professionals, learning communities.

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1. Introduction

For a comfortable healthy indoor climate with an efficient amount of energy, buildings need to be carefully operated and maintained. With recent developments in sensor and communication

technologies, modern buildings accumulate 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 bring energy efficiency and cost-effectiveness [2–4]. This field 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].

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 H. [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.

The rapid change in technology use and required 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 factors and by reviewing the current literature, a lack of experimental research was identified for understanding the learning and sharing knowledge of professionals in the building services sector.

Therefore, this research aims to i) understand the obstacles and motivation of professional development in data analytics and ML applications in the building services sector and ii) develop a digital collaborative tool to explore incentives for sharing expert knowledge and experiences among professionals. The research project is called "TransAct" to research and develop a lifelong learning network model. The project will also identify the main motivation and barriers to knowledge adoption, transfer and exchange between different stakeholders ranging from producers, installers, to maintenance [13].

To achieve these aims, in this paper, the findings of a study on a group of professionals are discussed. The target group are professionals who have access to building data to optimize the energy performance and Fault Detection and Diagnosis (FDD) in building equipment. Despite the availability of different methods, FDD tools are not applied in practice, especially not when it comes to their application to energy performance diagnosis. There are two main categories of FDD methods; knowledge-driven-based methods and data-driven-based methods [14]. Zhao et al. [12] pointed out that, in reality, the combination of information (data-driven) and experience (knowledge-driven) is important for the learning processes within a company.

Russell and Ginsburg [15] 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 [16] or an instructional design model for e-learning [17]. Throughout the study, a suitable method of establishing an OLC within organizations is identified. In this paper, 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 [18].

In this paper, first, the research methodology is presented followed by an introduction to the study design. Then, the key points obtained from the study are mentioned. Later the insights from the learning and knowledge sharing tools are presented. The paper ends with a discussion on the results and limitations and prospects for future works.

2. Research methodology

Professionals in the building services sector have limited or no knowledge to analyse data and apply ML techniques. Interviews have been used to understand the learning and knowledge sharing practices within and among learning communities. How technology is used in the current setting was also explored. Learning Analytics was used to understand the interactions as also the effect of the technology tooling introduced.

An intervention study was planned to identify the potential added value of technology in this context. The following sections explain the steps followed and the assessment of methodologies utilized.

2.1 Step 1: Selection of learning communities

For the study, professionals from the building installation and services sector are required. Employees, trainees, and researchers working at companies, universities, or research institutes can be considered. Moreover, professionals with a background in smart buildings and cities can also be considered for the study. All the participants should

have access to data generated from buildings and energy systems.

2.2 Step 2: Developing a learning community through digital collaborative platforms

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, at first, a directory of professionals are needed 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 28 relevant articles 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 collaborative digital tool can support a learning community within organizations for a lifelong learning experience. An E-learning platform along with the communication tools can be a good option to track the learning progress and appoint new courses to the community members.

2.3 Step 3: Assessment methodologies

To understand the ability of professionals in data analytics and ML applications, a series of interviews

acceptance and the effectiveness of the digital collaborative platforms.

3. Study design and related work

This section discusses the methodology described in Section 2 with studies conducted on professionals who are working in the building services sector.

3.1 Exploring different similar communities

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 members.
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

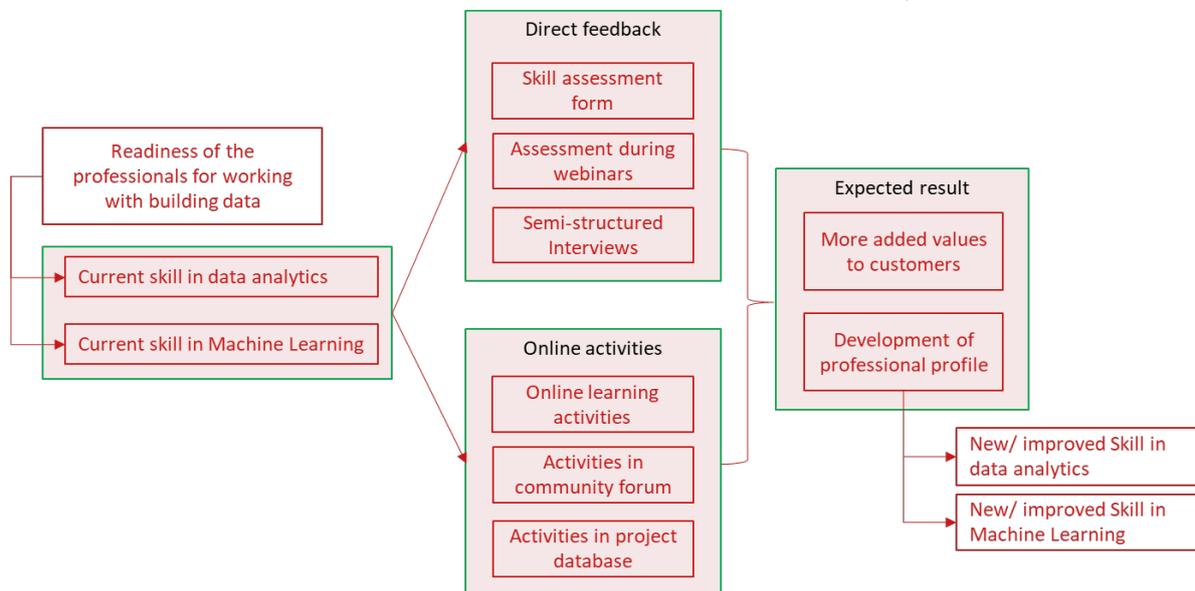


Fig. 1 - Tools used for the exploration of learning community

need to be conducted. The focus of the interviews can be the incentives and motivations behind sharing and gaining knowledge, main challenges, and future development plans. Direct feedback can also be received through webinars. Other than that, the number of new courses followed by the professionals, innovative data-driven projects delivered, and the online activities within the community-based platform can represent the

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.

One of the challenges in the growth of knowledge is the lack of innovative projects for companies. That shows the knowledge of the community can be

the professionals were tracked to assess the new competencies. The tools used to explore the communities are shown in Fig. 1.

3.4 Development of a digital collaborative platform and implementation

In order to develop a collaborative platform, first, the e-learning and the communication tools of the company were explored. Accordingly, a digital collaborative environment was developed with the existing Microsoft (MS) tools of the organization. The tools altogether are named using the project name *TransAct*. To explore communication beyond the boundary of the organization, an external community of ten trainees was also introduced who

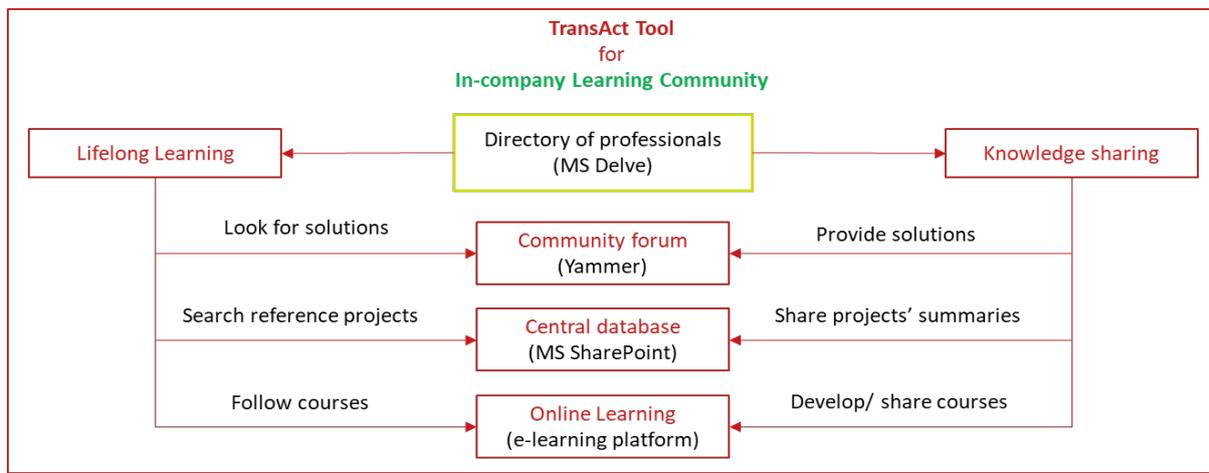


Fig. 2 - Overview of the digital collaborative learning and knowledge sharing platform

driven by customer projects.

3.2 Selection of learning community to study

A company in the Netherlands from the building services sector was selected for the study. Nineteen employees attended from different departments. Nine employees were from the building automation department, six employees were from the design and engineering department, and four employees were from the ICT department.

A group of trainees and researchers joined the study from the built environment department of a technical university in the Netherlands. All the trainees are working on projects from the same company of the study to ensure data privacy and smooth access to the company database.

3.3 Developing the learning community

To get insights into the company culture of learning and knowledge sharing, a series of semi-structured interviews were conducted. In addition, google survey forms were used to assess the level of data analytics and ML skills of the participants. Then, a series of webinars were conducted according to the requirements of the learning community. Before and after webinars, the preference for learning media, the skills level of the participants on the topic and feedback on the webinars were asked to improve the experience of the professionals. Learning activities of

are working on different projects of the company. Therefore, data privacy was maintained without any conflict of interest. The overall structure of the digital environment is shown in Fig. 2.

The community members have individual profiles in the *MS Delve* environment which is the directory of professionals. In this environment, current projects, existing skills, expertise on which others can inquire can be recorded by making an individual profile. As a result, other professionals can search for skilled colleagues and can approach them for support.

The two main focuses of the community are learning and sharing knowledge. Both are interconnected to the community forum at *Yammer* where employees will look 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 parts and locations of the company. Yammer at a foundational level is gamified with basic game elements. i.e., 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 with different functionality to look into the contents within files made this tool convenient to look for

necessary information. In addition, the version control made this location suitable for sustainable knowledgebase with the possibility of integrating the latest information on the old data. Finally, the online learning platform of the company was used where employees will follow courses and experts can develop or recommend courses for their colleagues. The admin can appoint courses to employees or keep courses optional for self-development during personal time. Some of the mandatory courses can be followed during office hours. The methodology was followed to identify the motivation for learning and incentives for sharing knowledge.

At the beginning of the study, a SharePoint page was introduced on the existing intranet of the company. The page hosts the Yammer community page, the company's e-learning platform, a news board and the directory of the professionals. The page can be accessed from the homepage of the intranet environment. 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.

4. Results

To measure the effectiveness of the learning community, the digital platform was introduced among the professionals to stimulate community building and knowledge exchange. The usage was analysed to find the added value and presented below.

4.1 Community forum - Yammer

The purpose of an in-company learning community discussion board is to find solutions to problems that are new or have been faced by others earlier. Networking with peers is another purpose of the community. The selected group of employees were added to a Yammer community. The focus of the community discussion forum was data analytics and ML applications in the building services sector. Initially, several posts were shared among the employees about the purpose of the discussion forum. It was found that employees mostly read messages posted by others. Very few messages (monthly overall average posts) and reactions to messages (monthly overall average likes) were found. Posts from employees attract more responses than posts from external trainees. The result shows the activities based on six consecutive months.

Within the community page of researchers, the activities are comparatively higher than in the community of employees. As learning and gathering information is part of the job for researchers, it is important to have responses from team members and supervisors. The community platform in that case is a convenient place to preserve information

for newcomers and existing researchers. The data was collected based on activities over four months. The overall status is shown in **Tab. 1**.

Tab. 1 - Usage of the discussion forum

Title	Usage	Company	University
Average total	Read	268	762
monthly use by members	Posts	8	15.67
	Reactions to messages	3.63	18.33

4.2 Central database - SharePoint

For the analysed period of 6 months, in the company case, the total data stored is 10.8 GB. That means much of the project data was stored in the personal drives or the personal folders in the central server which is now accessible by other employees who are working on similar projects.

Within the community of the university, around 600 MB of reports and presentations were shared among the trainees and researchers to support their research and project activities. As the community members work in the same field, there are a lot of similarities among them. The summary of the usage is shown in **Tab. 2**.

Tab. 2 - Usage of the database

Title	Usage	Company	University
Average total	Total data shared	10.8 GB	600 MB
monthly use of Sharepoint	Site visit	189.17	111
	Unique viewers	51.17	32.67

4.3 Company's e-learning platform

An external e-learning platform provider along with more than two hundred online courses on different competencies was contracted by the company. In addition, expert employees of the company can produce and share online courses within the platform. It was found from the number of participants that, short videos of less than fifteen minutes have a better chance to be followed by the employees. Long videos or articles have a lower or no participation rate. 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 learning materials. In addition, the courses are free to follow and can be a part of the annual assessment session for the employees.

4.4 Directory of professionals - MS Delve Environment

During the study, all the participants were informed about the existence and benefits of the MS delve directory. The tool supports searching for experts within the community. It was found that not all the employees updated their information. Only the basic data are available from the human resources department. However, based on practices from other communities, considering the profile update during the annual review session may realize updated professional information in the central directory. As a result, newcomers will be able to find experts to approach for solutions.

4.5 Knowledge sharing media

In addition to the online tools, live webinars were conducted for the interested participants both the company employees and the researchers from the university. Before and after webinars, survey forms were circulated and feedback from five participants was analysed. On the Likert chart, the satisfaction level of the professionals on the content of the webinar was 3.3 on a scale of 4 with a standard error of 0.119. The satisfaction score on the delivery method was found 3.4 on the same scale with a standard error of 0.114. Therefore, it was found satisfactory and promising to continue hosting webinars on the topics of data analytics and applications of ML. The skill level of the participants was also asked and the mean value that we found was 2.3 on a scale of 4 (from no experience at 0 to an expert at 4) for the overall proficiency with a standard error of 0.019. The level of skill on the webinar topic was also measured and found a mean value of 2.33 with a standard error of 0.35. Short videos and live webinars were found as the preferred learning media from the feedback of participants. On the other hand, text files were found as the least preferred media for learning. In addition, some recommendations were also received from the respondents with a high impact on improving the upcoming webinars. Some of the key points were, brief and to the point discussion, demonstrating the practical implementations of the use cases, connecting with the daily activities of the professionals.

5. Discussion and limitations

During the study, some key points were observed and identified. These findings are discussed below.

5.1 Exploring in-company learning and knowledge-sharing culture

At first, the company culture was explored through semi-structured interviews. The key findings on learning barriers are as follows:

1. Project documentation is a challenge, because;
 - 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.
 - To ensure the data privacy of a customer, the company limits access to some project folders in the central server only for the respective project employees.
 - 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.
2. In case of any problem, employees generally know, whom to communicate with for what kind of information. Accordingly, they send emails and speak over the phone. As a result, the solution remains with individuals and is not preserved within the organization.
3. Several senior employees are working for more than ten years. They are highly experienced and knowledgeable and intended to share their project's experiences through personal interaction. Because they believe most of the experiences are hard to explain through a written document. Webinars or short videos could be a solution which is an additional job on top of their regular responsibilities. Therefore, it is a challenge to document the knowledge of experts.
4. Except for some young employees, most of the employees still prefer physical training or workshop. They find it as an opportunity to interact with other colleagues and learn effectively. During those training, employees do not work on their projects. On the other hand, most of the online courses need to be followed outside of office time. Therefore, online courses became less of a motivating for them. However, management is promoting online learning through the company-owned e-learning platform. Some mandatory courses can be followed during office hours.
5. Generally, supervisors or managers suggest employees for physical training or online courses. During the annual assessment, the course plan can be defined for developing different skills and competencies. In some cases, professionals take online courses of their interest for personal development.

5.2 Handling projects with data analytics and ML applications

For any requirements related to data analytics or ML, experts from the building automation department support the project's engineers. Sometimes, trainees

are employed by universities to work on specific projects. Hence, existing employees are not gaining the skills to work with new tools for data analytics apart from MS excel. Employees also do not need to code ML algorithms. Instead, they depend on the software developed by the company to collect data from buildings and create graphs for analysis. This data analytics tool can perform some predictions based on historical data. By integrating advanced ML algorithms, the tool is getting upgraded from time to time. Hence, all the existing employees don't need to learn how the software works. Instead, what can be done is more interesting for them.

5.3 Limitations

There are several limitations to this study worth noting. First, the small group size greatly hinders the generalizability of the results. Second, the company-owned data analytics tool enables employees to generate results. So, they don't need to understand the underneath mechanism in the analytical tools and hence, limiting the courage to learn to code, algorithms for predicting the building energy demand or other ML applications. However, instead of how ML works, focusing on what can be done with ML can bring more benefits to the learning communities. This study did not consider the final state of the competence level of the participants. Future studies may address new competencies added to the profiles of the professionals and might look for different motivations and challenges in addition to the current study.

6. Conclusion and Recommendations

This research identified that, for the in-company learning community, the main motivation for learning was personal interest and the possibility to satisfy customers with new skills. In addition, the incentives discovered for sharing knowledge was the appreciation by colleagues and implementation of the knowledge in the regular project work.

Developing a sustainable knowledge base will facilitate the project participants to build on their existing knowledge and expertise [21]. Information can be stored and it can be prevented from becoming outdated. Onboarding of new professionals will then be efficient and effective. The shared documents should not contain any confidential content of specific clients. Standard templates are beneficial to make information better findable and can be used for project reports. Large projects should have project documentation as a mandatory task. Learnings from multiple small projects can be gathered through short collaborative sessions. During the study, a SharePoint location for storing project data according to the project type was introduced. Managers can continue storing project information as per project categories. Yammer was introduced as

a community discussion forum. Employees can continue discussing problems/ ideas with multiple expert employees on this platform.

Annual review sessions can include learning and knowledge sharing goals for the following year by the managers. Assessment of the learning can also be done to follow up on progress.

For the future, three key performance indicators 1) the number of innovative projects delivered by the community, 2) the skills developed by the professionals in data analytics, and 3) ML applications can be used as a measure of the success of the TransAct tool. In addition, the amount of information shared among professionals can also be used for measuring the growth of community knowledge.

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Data access statement

The datasets generated during the current study are not publicly available because of data privacy.