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Article

Learnings Networks and Professional Development in Building Energy Management Systems Industry

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Abstract: The energy management systems industry in the built environment is currently an important topic. Buildings use about 40% of the total global energy worldwide. Therefore, the energy management system's sector is one of the most influential sectors to realize changes and transformation of energy use. New data science technologies used in building energy management systems might not only bring many technical challenges, but also they raise significant educational challenges for professionals who work in the field of energy management systems. Learning and educational issues are mainly due to the transformation of professional practices and networks, emerging technologies, and a big shift in how people work, communicate, and share their knowledge across the professional and academic sectors. In this study, we have investigated three different companies active in the building services sector to identify the main motivation and barriers to knowledge adoption, transfer, and exchange between different professionals in the energy management sector and explore the technologies that have been used in this field using the boundary-crossing framework. The results of our study show the importance of understanding professional learning networks in the building services sector. Additionally, the role of learning culture, incentive structure, and technologies behind the educational system of each organization are explained. Boundary-crossing helps to analyze the barriers and challenges in the educational setting and how new educational technologies can be embedded. Based on our results, future studies with a bigger sample and deeper analysis of technologies are needed to have a better understanding of current educational problems.



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Keywords: learning networks; professional development; energy transition

1. Introduction

In 2020, the TransAct project was launched, with a focus on researching technologies and innovations that can improve learning networks in the area of building energy management systems (BEMS) within the heating, ventilation, and air conditioning (HVAC) sectors. A building energy management system (BEMS) is a computer-based system that monitors and controls a building's electrical and mechanical equipment such as lighting, power systems, heating, and ventilation. This specific topic is chosen because the building services are responsible for the majority of a building's energy use. Building services are becoming increasingly complex, and optimal use is not always guaranteed. BEMS are increasingly installed and generate a significant amount of data that could be used for predictive maintenance, commissioning, fault detection and diagnosis of the systems. The sector is facing significant challenges related to the energy transition, which is the

suitable learning educational infrastructure for professionals. Strict energy performance regulations and higher comfort expectations make those buildings more heavily equipped with complex systems that often generate data. Because of those developments in the sector, only knowledge of HVAC systems is no longer enough. HVAC consultants, contractors, and maintenance companies are suddenly expected to have knowledge of data management and data analytics techniques [1]. Transition skills, such as problem-solving, critical thinking, creativity, and collaboration [2,3], and technical skills, such as data analytics and machine learning are becoming increasingly important. These challenges can only be solved if the government, market, educational institutes, and knowledge providers in dialogue with the environment join forces and start working together. The future picture is more innovative, more digital, more integral, more efficient, more productive, with more quality and attractive to new generations [4]. In the context of such changes in the sector, there is an urgent need for continuous lifelong development.

Lifelong learning can be considered as “all learning activities that are undertaken throughout life, with the aim of improving knowledge, skills, and competencies within a personal, civic, social and/or employment-related perspective” [5] (p.33). It concerns adult learning, whether in formal and informal learning pathways or concluded with a diploma or certificate [6]. To enhance lifelong development, people must have the opportunity to participate in learning and be willing to learn [7]. The possibility to participate in learning activities is related to the ability to learn, the type of profession, the work environment, financial resources, available time to learn, information provision, and the connection to the demands of both the employer and the employee. As a consequence of more dynamic job profiles and the distribution of jobs between humans and robots, more focus on professional development came to learning at the workplace [7].

The use of learning communities and learning networks can strengthen the learning capacity of individuals and organizations [8]. As Lave and Wenger [9] describe, learning communities have been used to describe a group of people who interact regularly, share the same concern or passion for something, and aim to improve. Networks of practice (NoP) or learning networks have been used to describe a more informal and developing social network that encourages and supports the sharing of knowledge and information between a group of people who gather around the same practice and profession. There are a few differences between learning networks and learning communities [9]. First, in networks, the relationship between network members is more informal compared with communities. Second, powerful interpersonal relationships and group unity are shaping the fundamentals of communities, while networks are more widespread, and the relationships can be weak or strong. Finally, relationships in networks can be temporary, but in communities, people tend to form more permanent and lifelong connections. Additionally, as mentioned in “Networked Learning: Inviting Redefinition” [10], “Networked Learning involves processes of collaborative, co-operative and collective inquiry, knowledge-creation, and knowledgeable action, underpinned by trusting relationships, motivated by a sense of shared challenge, and enabled by convivial technologies. Networked learning promotes connections: between people, between sites of learning and action, between ideas, resources, and solutions, across time, space, and media” [10] (p. 319). In this article, we combine theories and principles from networked learning with challenges and transition in lifelong development. Learning communities are hybrid. There may be both formal and informal learning, facilitating better collaboration between companies, knowledge institutions, social organizations, governments, and more flexible training systems using information communications technology (ICT) possibilities, etc. Learning communities related to informal learning exist in various network forms, such as field labs, e.g., [11], living labs, e.g., [12,13], collaborative innovation networks, e.g., [14] centers of expertise at universities of applied sciences, e.g., [4] and centers for Innovatief vakmanschap (English translation: innovative craftsmanship) at vocational schools, e.g., [15]. Learning communities related to formal learning are, for example, employees who take a course together to be informed about developments in their field. Additionally, in all of these different

learning processes, emerging technologies can help in both facilitating access to educational resources and communication between learners.

Although knowledge management technologies (e.g., knowledge portals and collaborative workspaces) and learning networks seem to be completely distinctive issues, for effective learning networks, knowledge management is an essential process for creating, documenting, and utilizing knowledge in the networks [16]. Knowledge management has been defined as a systematic process for gathering, organizing, and communicating both the implicit and explicit knowledge of employees that can be used in their daily work [17–19]. One of the factors that ensures the success of an organization and the continuity of its businesses is its knowledge management strategy. In that sense, companies must implement technologies that can make internal knowledge and implicit knowledge shareable and build on existing resources in the company, as they also develop new competencies and knowledge in multi-stakeholder cooperation and networks.

Knowledge has to be used in the organizational process to achieve sustainable competitive advantages [20]. Additionally, knowledge management is a fundamental aspect of professional development in organizations. Companies worry about the stability and accessibility of knowledge in their organization. Usually, multiple generations of employees have to cooperate and share internally and, in some cases, this also means a change away from possessing knowledge as an individual competitive advantage to sharing in companies towards an organizational competitive advantage. In the current situation, there are often highly skilled and experienced experts in organizations, and many other employees depend on them to support them in solving their problems. They are the core or hub of the network, and other team members only rely on their connection with them to solve their problems or gain the needed knowledge. Sometimes these employees are not available, and there is no alternative information source accessible. Additionally, they frequently leave the company, and their knowledge disappears when they move. As a result, this raises the significant role of knowledge management technologies that can uptake integrated knowledge.

In addition to exploring the role of organizational learning culture, learning networks, and the boundary-crossing framework in our case study, one of the questions that we try to answer in this study is how emerging technologies have been used in the energy management system industry to increase and improve the uptake of knowledge inside the company, from senior to junior and vice versa; cross-specialism, for example, from electrical to mechanical engineering, and from design departments to maintenance departments. Specifically, we are investigating how emerging technologies have been used to support and raise awareness about learning networks in our target organizations.

Considering the educational trends from the formal and individual learning processes to more collective and informal learning, it seems that high-demand sectors (e.g., energy) dismissed the importance of this new educational opportunity. In addition, in the HVAC sector, many new people join the field every day. Due to the increase in data availability in this sector, also the required skills are changing, and different people are being hired. For example, in the past, mainly HVAC engineers were hired; nowadays, data scientists and machine learning specialists are working in the sector and HVAC engineers are expected to be able to interpret, analyze, and use data more actively in their work. This means that people from different backgrounds have to collaborate and communicate together, and employees from the sector have to gain new skills. As a result, a need for new and updated educational resources, networking, and communication technologies between the professionals in the field to facilitate knowledge-sharing is obvious.

In the following, we will first present different theoretical approaches and types of learning communities and networks. Then, we will use the approach of boundary-crossing to analyze and identify opportunities in learning networks to help the growth and sustainability of the networks in different maturity phases using boundary objects. Based on these components, we will describe three cases that this project is working on

and describe the technologies in the learning networks that this project will evaluate in the coming phase.

2. Theoretical Framework

2.1. Learning Communities and Learning Networks for Professional Development

Networked learning is considered as learning in which ICT is used to foster connections between learners and their peers, learners and tutors, and learners and learning resources [21,22]. These connections or ties result in learning networks. Goodyear and Carvalho's [23] defined learning networks as "providing educational contexts (formal, or informal, including learning in the wild) where certain pedagogical interactions take place and where people are exchanging views and experiences related to knowledge and knowing" [23] (p. 264). Additionally, learning networks are understood as a collection of ties between people, or between people and learning objects [24]. Learning networks can appear as ad hoc or long-term in teams, groups, and communities, or as ego networks in education, organizations, and society. By social networks we mean the configurations of connectivity that exist when people interact with each other by communicating, sharing resources, working, learning, or playing together, supported through face-to-face interaction, as well as through the use of information and communication technology [25].

Haythornthwaite and De Laat point out that the key to a social network approach to learning is attention to relations [25]. A relational approach emphasizes the interaction between people for commerce, work, play, or, in this case, learning and professional development. They describe several relationships between learning and networks: learning can be seen as a relationship that connects people. A student learns from a teacher, a teacher instructs students, and novices learn collaboratively from one another. It can be a direct relationship, with a child learning from a parent, a novice from an expert, or an apprentice from a master craftsman. It can also be a technology-based relationship, e.g., information exchange via databases, knowledge exchange via listservs, and communication via several computing applications.

Pahor et al. [26] highlight the networked learning perspective because it helps to develop an organizational learning culture. In their approach to networked learning, the individual is recognized as the primary source and destination of learning, while acknowledging that learning takes place primarily through social interaction. This approach stresses the individual drive for people to engage in networks to solve personal needs. They also found out that networks are a way to facilitate organizational learning. Additionally, knowledge of the structures and patterns of these learning networks provides managers with the useful tools for improving organizational performance. They argue that network visualizations, as well as the identification of key players and their characteristics should become part of a standard managerial toolkit. Most of this research still describes what networks have to offer in general terms, and not so much the specifics of what people's activities within a network and the strategies they develop to maintain their relationships. What is lacking is a grounded empirical approach to describe the networked learning behavior, detailing with the qualities involved (see also Skerlavaj, Dimovski & Desouze [27] Skerlavaj, Dimovski, Mrvar & Pahor [28]).

Learning networks and networked learning are central concepts in professional development and growth [29–31], and we need to consider that working, innovation, and learning are interconnected [32,33]. A better understanding of professional development in networks linked to working practices without considering or analyzing how informal learning happens, and how knowledge is created and shared in communities is not possible. By reviewing the current literature, we identified a lack of experimental research for understanding informal learning in professional development [34] and these informal learning networks are often implicit, ad hoc, spontaneous, and invisible to others [29]. Studying all the above-mentioned educational challenges, organizations also mostly focus on formal learning, such as official courses given by experts, in-service training, and other personalized learning trajectories (e.g., coaching). Formal education is only a small portion

of the learning processes, considering all the challenges and problems professionals or employees of companies face in everyday job-related assignments. The role or effect of informal learning has been ignored or not considered properly by organizations for professional development. Moreover, there is a large body of research that shows the benefits of such learning activities, e.g., [35,36]. Informal learning helps them to know how to interpret, adapt, share, organize, contextualize, and sustain new knowledge [37]. Furthermore, it is known as a better, more productive way to make professional development happen. Although networks have shown extensive benefits for professional development, still the behavior of learners in the networks and the strategies that they use to maintain their interaction within the networks are not clear yet.

2.2. Boundary-Crossing as an Intervention and Approach to Analyze Learning Communities and Networks in Transact

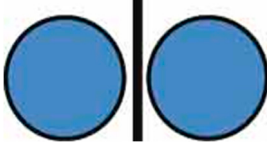
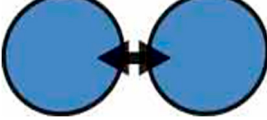

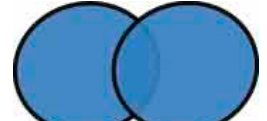
In this study, we use boundary-crossing theory as a framework to analyze and improve the learning of individuals and organizations in learning communities across boundaries. We do this by mapping gaps related to goals that stakeholders want to achieve [38]. This theory assumes that boundaries between different practices show learning potential [39]. In the boundary-crossing theory, boundaries are not so much seen as physical borders, for example, between buildings, but as social-cultural differences between practices leading to a discontinuity in actions or interactions [40]. Professionals can face boundaries when they work together with people from other organizations and disciplines. There is discontinuity when actions or interactions, such as collaboration and communication, do not progress as desired or require effort that is not self-evident. By boundary-crossing we mean processes that take place at boundaries to ensure or restore continuity in actions and interactions [41]. Boundary objects can help bridge different practices. These are objects that allow people to work together [40]. Table 1 summarizes the boundary-crossing theory mentioned in [42] (p. 246).

Here, we use the multilevel boundary-crossing approach as described by Akkerman and Bruining [42]. They suggest that boundary-crossing can occur at an institutional, interpersonal, and intrapersonal level. At an institutional level, boundary-crossing occurs “when actions and interactions are initiated between multiple organizations or organizations units” [42] (p. 247), e.g., between HVAC organizations and educational institutes. At the interpersonal level, it involves “actions and interactions between specific groups of people from different practices” [42] (p. 247). It does not concern the level of, e.g., the mentioned HVAC organizations and educational institutes, but of people from these organizations who work together. One can speak of boundary-crossing at the intrapersonal level when a person participates in two or more practices and brings elements of one practice into the other. These can be people who, in addition to their work, also participate in a learning community. These people are also called boundary crossers, brokers, or boundary workers. On the one hand, they have a rich and valuable position since they are the ones who can introduce elements of one practice into the other [39]. On the other hand, they face a difficult position because they are easily seen as being on the periphery, with the risk of never fully belonging to or being acknowledged as a participant in any one practice.

Within the multilevel boundary-crossing approach, we use four learning mechanisms that boundary-crossing can involve: (1) Identification; (2) Coordination; (3) Reflection; and (4) Transformation [40]. Boundary-crossing can first involve identification, which means a renewed understanding of how different practices or roles are distinct from or complementary to each other [41]. Within this research project, at the institutional level, it is about how organizations see themselves and their role in the learning community. At the interpersonal level, it is about the (groups of) people who participate in the learning community. How do they see their different and complementary roles and tasks? At the intrapersonal level, an individual defines his own simultaneous but distinctive participatory positions in the daily work context and the learning community [42]. We use the identification level to identify different kinds of gaps related to learning mechanisms at the

levels of coordination, reflection, and transformation [38]. At the coordination level, partner organizations and (groups of) people in the learning community seek means or procedures for exchange and cooperative work. At the intrapersonal level, a person searches for means or procedures to align his own positions in multiple practices [42]. Often, boundary objects are used to enable effective collaboration between different practices [43]. These must then be flexible to use, but also robust enough to maintain a distinct identity across practices.

Table 1. Multilevel boundary-crossing framework.

Learning Mechanism	At the Institutional Level (Action and Interaction between Organizations or Organizational Units)	At the Interpersonal Level (Action and Interaction between Actors from Different (Institutionalized) Practices)	At the Intrapersonal Level (Participation of a Person in Two or More (Institutionalized) Practices)
<p>Identification</p> 	<p>Organizations or units come to (re)define their different and complementary nature.</p>	<p>People come to (re)define their different and complementary roles and tasks.</p>	<p>A person comes to define his or her own simultaneous but distinctive participatory positions.</p>
<p>Coordination</p> 	<p>Organizations or units seek means or procedures for institutional exchange and cooperation.</p>	<p>People seek shared means or procedures for exchange and cooperative work.</p>	<p>A person seeks means or procedures to distribute or align his or her own participatory positions in multiple practices.</p>
<p>Reflection</p> 	<p>Organizations or units come to value and take up another’s perspective to look at their own practice.</p>	<p>People come to value and take up another’s perspective.</p>	<p>A person comes to look differently at his or her own participatory position because of the other participatory position.</p>
<p>Transformation</p> 	<p>Units face a shared problem space and start collaborative work or merge institutionally.</p>	<p>People face a shared problem, start collaborative work, and may build group identity.</p>	<p>A person develops a hybridized position in which previously distinctive ways of thinking, doing, communicating, and feeling are integrated.</p>

In this research, we use technological boundary objects (e.g., messenger systems, live conferences, collaboration systems, and online and real-time collaboration documents) that can help create online opportunities for different audiences, needs, and content across organizational boundaries. Technology can be motivating, but it must be accessible and effective. It should also be considered that technology calls for digital skills, which are not equally well-developed by everyone. New technologies can also be used for more personalized learning, tailored to learning needs and prior knowledge [7]. In addition, it can facilitate the monitoring of the learning process [3]. This research wants to use technology not only for coordination but also for the other levels. Boundary-crossing at the level of reflection is about learning one’s own and other practices by making differences between them explicit. Two processes that can be distinguished are ‘perspective making’, which refers to the effort of articulating one’s perspective, and ‘perspective taking’, which refers to taking the perspective of another practice [40]. From the multilevel boundary-crossing approach within this research, at the institutional level, it is about reflection between partner organizations; at the interpersonal level, it is about reflection between (a group of) people within the learning community, and at the intrapersonal level, it is about the reflection of an individual on his/her distinctive participatory positions in the daily work context and the learning community.

Transformation refers to the effort to form new practices, sometimes called boundary practices, or a new identity. At the institutional level, organizations face a shared problem space and start collaboration. Previous research pointed to changes in companies and professions and more flexibility in the labor market, and an increased focus on learning in the workplace [7]. These factors can be the start of transformation into, for example, a new learning community. At the interpersonal level, groups of people face a shared concern, such as a lack of knowledge regarding the energy transition in the building sector and optimization of operation of HVAC systems and start collaboration. At the intrapersonal level, a person develops a hybridized position in which previously distinctive ways of thinking, doing, communicating, and feeling are integrated [42]. Transformation seems to come closest to proactive learning, which is seen by the top sectors as a critical factor for economic growth. Yet, transformation need not be the highest achievable way of learning. It depends on the purpose and context of learning which learning mechanism is emphasized [44].

As indicated, we will look for gaps related to the learning mechanisms at different levels from the boundary-crossing theory. Enochsson et al. [38] identify five different gaps concerning coordination: geographical, attitude, technological, competence, and administration gaps [38]. A relational gap has been termed a gap about reflection, sometimes involving an emotional aspect. With transformation, they also mention a dichotomy gap and a perspective gap [38]. We look at the technological boundary objects that are deployed, and what people at different levels want to aim to achieve with regard to the learning mechanisms of coordination, reflection, and transformation by crossing boundaries.

Finally, considering the above-mentioned issues, we developed the following research questions:

1. RQ1: How the organizational culture and incentive structure of the studied companies can influence their point of view toward learning networks?
2. RQ2: If there is any learning network in these companies, how have they been supported using emerging technologies?
3. RQ3: Considering the learning networks' role, what are the main challenges and future direction of our target companies?
4. RQ4: How does boundary-crossing take place, what boundary objects are used, and which gaps can be identified in the companies studied?

3. Materials and Methods

To answer our research questions, a series of semi-structured online interviews were conducted with three different companies (educational, constructional, and both educational and constructional companies). Those three companies were chosen because they all reflect a specific part of the community and studying these companies can be considered as an example of how the current status of this field is performing. Two of the interviews were with the educational manager/representative of each company and one with the main board member/adviser of the organization. In all of these interviews, three researchers interviewed one of the members of each company. All participants received the same set of questions, and these questions were developed by the authors to address the concerns and challenges mentioned earlier based on the research, which we already discussed in the introduction. This questionnaire has 15 questions in 5 sections. The first part of the questions was descriptive of the companies, their activities, and number of employees (e.g., Can you please tell us a bit about (name of the company) and your role?). The second part investigated the organizational learning culture of the company. The third part focuses on learning networks. The fourth section on incentive structure and motivational factors, and the last part focuses on their main challenges and their future direction. It was essential to set up these questions with the entire team since the team members have very different backgrounds (psychology, educational science, and engineering), which makes it possible to shed light on different aspects. The interviews were recorded and then transcribed using Otter.ai. Emergent coding was used for the transcribed interviews because our

questions were mostly broad and exploratory. Additionally, the researchers defined these codes to investigate the organizational culture, educational networks, incentive structures, main problems and challenges, companies' future direction, and the most crucial aim of interviews, exploring the technologies used for educational purposes.

4. Results

Here, we present the results of these interviews with three different organizations. Our results were divided into five different sections for each of our cases. You can find the summary of the first three sections (organization culture, learning network, and incentive structures) in Table 2 and the summary of the second section (challenges, future direction, and boundary-crossing) in Table 3.

Table 2. Summary of organizational culture, learning networks, and incentive structure.

Case	Organization Culture	Learning Networks	Incentive Structure
1.	<ul style="list-style-type: none"> - Online learning platform managed by an external course provider. - The company provides several offline training, workshops and courses. - Experts share knowledge over the phone, meetings, email, or a central server with colleagues. - Project report to customers. 	<ul style="list-style-type: none"> - Online platform has access to all the employees. Experts can develop courses for their team members. - Senior employees prefer offline courses, which are an opportunity to meet peers physically for informal networking. 	<ul style="list-style-type: none"> - Some courses are mandatory for employees. - Free online courses. - Professional development programs. - Appreciation from colleagues. - Implementation in projects.
2.	<ul style="list-style-type: none"> - Most of the educational programs, courses, and workshops are provided offline and traditionally. - Course contents are updated based on audience requests and market demands. 	<ul style="list-style-type: none"> - Online environment with a discussion forum for document-sharing and assignment submissions. - Course-based community. 	<ul style="list-style-type: none"> - Professional development. - Certificate for career growth. - No program in place.
3.	<ul style="list-style-type: none"> - Collaboration with other educational organizations. - Monthly internal presentation. 	<ul style="list-style-type: none"> - Networking with external learning content providers. - Within the organization and external experts. 	<ul style="list-style-type: none"> - Personal coaching plan

4.1. Case One: Building Services' Company with an Existing Learning Platform

This organization is a building service company in design, realization, maintenance, and exploitation of buildings' technical installations in the Netherlands. They are specialized in building energy management systems and have an online learning platform for their employees.

4.1.1. Organization Culture

In this company with around 900 employees in 13 different locations, the education and professional development of experts are highly appreciated. They have an agreement with an online course provider with more than 200 online courses. These courses include soft skills and technical expertise. On the platform, they can add online courses, which can be developed by their expert employees. Knowledge-sharing is one of the main fundamental ideas of the organization, but still knowledge transfer has not reached its full potential. Employees prefer to have personal connections with other employees to solve their problems and use phone calls or emails. Therefore, there are several separate informal learning networks that are not visible to other employees with similar problems and the management team. This shows the importance of informal networks and their role in the professional education of employees.

Table 3. Summary of challenges, future direction, and boundary-crossing.

Case	Challenges	Future Direction	Boundary-Crossing
1.	<ul style="list-style-type: none"> - Employees working on-site are not interested in online learning. - Physical distance. - Knowledge is scattered. - Annually, project documents are archived and become hard to find. 	<ul style="list-style-type: none"> - MS Yammer community forum. - Single central database for project summaries. - Tracking personal development in MS delve and online learning platform. 	<ul style="list-style-type: none"> - From 13 locations, boundary-crossing mainly takes place between organizational units. - Online learning platform. - Employees prefer boundary objects telephone and email, rather than formal courses for learning.
2.	<ul style="list-style-type: none"> - Lack of incentive structure. 	<ul style="list-style-type: none"> - Strategies to increase the engagement of participants in the educational networking platform. - Advanced behavioral change approaches and gamification. 	<ul style="list-style-type: none"> - Coordination takes place at the institutional level about courses. - Online network platform with a discussion forum.
3.	<ul style="list-style-type: none"> - Knowledge-sharing with project partners is limited and lacks proper execution. 	<ul style="list-style-type: none"> - Accessible knowledge database for experts. - Investing in learning networks. 	<ul style="list-style-type: none"> - The personal coaching plan can be seen as a boundary object for employers at the intrapersonal level.

4.1.2. Learning Networks

The learning network of this company consists of both informal and formal learning networks. An online learning platform is organized by an external provider to cover formal education. This platform provides more than 200 different courses on a wide range of topics. A fraction of these courses are obligatory courses that every employee needs to participate in every few years. Besides this online platform, this company provides several offline trainings, workshops, and courses. Still, there is a big challenge in motivating the experts in the company to use the online educational platform as they mostly prefer offline courses that are followed by communication and informal networking with other peers. This is more obvious for senior employees, who often have less interest in using digital tools.

4.1.3. Incentive Structure

Employees can join the mandatory educational programs (physical or online) during office hours. Educational courses and programs designed for career development are free to join outside working hours. There is no other promotion or external benefit from the company to motivate employees to join the educational networks. Considering the knowledge management strategy, this company is struggling in preserving the lessons learned from their running or completed projects. Currently, all the project documents are saved on a central server that is archived annually. As a result, finding information becomes difficult because it is spread across all different kinds of documents from a particular project in the archive. In addition, special approval is needed from the IT department to access the archive. Therefore, there is a big need for a convenient location to organize the knowledge in a structured way and provide easy access for all professionals from different departments and locations. However, that requires additional effort and time by the project employees for the documentation of the learning points and the preparation of the summary of the whole project. At this moment, small projects do not keep enough budget for the time required for documentation, which makes this task optional for employees. To make it happen, the company is looking for an incentive model for their employees to be active in sharing their knowledge. The knowledge can be exchanged through project summaries in a database with a smart search engine or at a discussion board where solutions will be shared by experts against discussions or queries.

4.1.4. Main Problems and Future Direction

Physical distance is one of the main challenges for this company. Thirteen different locations can make sharing knowledge, communication, and networking for experts more difficult. In this situation, several unconnected networks of professionals can be seen, who work in the same field and face similar problems and challenges every day, but they are not properly connected with each other. Therefore, they cannot effectively share their knowledge and learn from each other's experiences. Additionally, the difficulty in removing the boundaries between experts who work on construction sites and experts who work in the design and maintenance department is another main challenge in such an organization. This company starts to not only make policies to encourage their employees to share their knowledge and start networking with their fellow professionals but also, try to develop knowledge-sharing and sustainable communication infrastructure. They believe, detecting informal learning networks, recognizing their power, and facilitating their functions can help the professional development of employees.

4.1.5. Boundary-Crossing Perspective

If we analyze the above in the context of the boundary-crossing theory, the following can be observed. Because the company has 13 locations, boundary crossing mainly takes place between organizational units. At the institutional level, a platform has been arranged with more than 200 courses. This can be seen as a technological boundary object with regard to coordination. However, there is a gap at the interpersonal level. Employees prefer to acquire knowledge through informal networks using the boundary objects telephone and email, rather than through formal courses. Furthermore, few of the courses are compulsory, which creates an attitude gap. Because older employees do not want to and cannot deal with technology, there is a competence gap at the intrapersonal level. However, in the future, the organization wants to focus more on informal learning. Another gap has been found in relation to administration. Information is difficult to find because it is spread over several documents. One goal is to organize knowledge and provide easy access for all professionals in different departments. The last one that is indicated is a geographical gap, which is experienced by the distance between locations, challenges, companies' future direction, and the most important aim of interviews is exploring the technologies used for educational purposes.

4.2. Case 2: Networking and Professional Education Provider

This case is a professional education and networking platform for experts in the field of installation technology. Professionals can collaborate with fellow people who work in the same field, gain knowledge, and share. This association consists of more than 1700 individual members and 500 Dutch companies in building services. Knowledge is shared through educational programs, workshops, an online knowledge data bank, magazines, congresses, regional meetings, and expert groups. In order to share knowledge more actively and encourage collaboration within the sector, they initiated an online networking platform, which is open to all professionals in the building services sector.

4.2.1. Organization Culture

Considering the delivery form of knowledge and the educational program format, this is a traditional professional education provider. Most of the educational programs, courses, and workshops are provided offline and traditionally. The company tries to provide updated content based on audience requests and market demands.

4.2.2. Learning Network

Initially, the company started an online environment for document-sharing and doing assignments, but then they added new features such as a discussion forum that facilitates communication and networking between experts in the field.

4.2.3. Incentive Structure

The main motivation for joining the community is professional development and networking. By successfully completing the educational program, participants will receive a diploma or certificate that can boost their careers. Even some companies in the installation industry ask their employees to gain some specific certificate provided by this educational program. The online networking facility is a great opportunity for experts to connect, solve their problems, and share their knowledge. There is no specific motivational program to keep participants active in the network or increase their engagement.

4.2.4. Main Problems and Future Direction

Besides the enormous educational potential that such an association can unlock, there are a few key educational challenges that need to be solved. One of these challenges is the lack of incentive structure in the learning network. The association will follow different strategies to increase the engagement of participants in the educational networking platform. Again, as also discussed in case one, learning networks, detecting their informal activities, and recognizing their existence can facilitate professional development. In addition, advanced behavioral change approaches and gamification can be used in educational programs to increase the motivation of the participant and help career development.

4.2.5. Boundary-Crossing Perspective

The association consists of more than 1700 individual members and 500 Dutch companies in building services. As a result, boundary-crossing activities frequently take place at different levels. For example, coordination takes place at the organizational level about courses that must be followed. Most workshops, educational programs, and courses are traditional and offline. However, an online network platform is used as a technological boundary object to stimulate active knowledge-sharing, promote collaboration, and do assignments. There is also a discussion forum linked to this. The organization would like to increase the involvement of participants in the educational network platform, as it is recognized that informal learning contributes to professional development. Gamification is referred to as a technological boundary object to increase the motivation of employees.

4.3. Case 3: MEP (Mechanical, Electrical, Plumbing) Consultancy Company with No Independent Learning Platform

This case is an independent consultancy company with extensive expertise in the field of building services (e.g., mechanical, electrical, and plumbing installations for buildings). This company provides a wide range of services, mainly focusing on designing the energy systems in the building.

4.3.1. Organization Culture

This company, with around 20 employees, is a small organization. They not only try to provide the best services for their customers but also highly appreciate the education and professional development of their employees. They do not have a formal active and independent learning platform like Case 1, but they collaborate with other educational organizations to gain and spread updated knowledge and educate their employees. Likewise, they also organize monthly internal presentations to share knowledge. Because of their highly qualified employees, they are often able to educate each other within the company, but if needed, employees are also allowed to follow a formal education from external education providers.

4.3.2. Learning Network

Although this company has no formal independent learning platform, they cross organizational boundaries by networking with other learning content providers. This helps them to always have access to updated knowledge in the field, and even share their

experiences and knowledge with other experts and service providers in the field. Some employees also act as educators in those formal learning content providers.

4.3.3. Incentive Structure

A personal coaching plan is one of the main supports that they provide for their employees to help them with their career development and professional growth. Employees are highly encouraged to take part in educational programs and study if it is needed.

4.3.4. Main Problems and Future Direction

This company mentioned that they have very up-to-date knowledge, but the companies they work with (contractors, maintenance engineers, etc.) do not have the knowledge, which means that their building services designs are not executed well.

4.3.5. Boundary-Crossing Perspective

Case 3 describes a small organization that depends on other knowledge and skills providing organizations the professionalization of employees. Boundary-crossing is, therefore, a necessity. It has ensured that the learning potential is well utilized; an exchange of current knowledge takes place. Employees are strongly motivated to develop. No gaps are mentioned aimed at attitude. The personal coaching plan can be seen as a boundary object for employers at the intrapersonal level to take part in educational programs elsewhere.

4.3.6. Main Problems and Future Direction

Lack of communication between different departments of the big building services companies might be one of the main boundaries in the field. As also discussed earlier, different groups of professionals in different locations or different companies face similar problems in their everyday work, but lack of communication and no access to a sustainable source of knowledge can interrupt professionalization and career progress. Following this problem, we can claim that this problem is not only because of unsuitable networking facilities but that the knowledge gap for experts in the field can cause serious problems. Knowledge grows very fast, and it raises the importance of learning networks, which may help to cover the knowledge gap in the field. There are a few companies in the installation industry that have created a knowledge database for experts, but unfortunately, they are not accessible to all professionals, and even if they are, they often do not know about their existence.

5. Discussion

This research project focuses on one of the most critical educational challenges in the field of building energy management systems within the heating, ventilation, and air conditioning area, which is the importance of networked learning as a form of social learning and supported technologies. Due to the energy transition, more data have been generated from HVAC systems and demands for data management and data analytics techniques have increased [1]. Therefore, there is a growing need for continuous lifelong professional development and the design of effective professional networks by emerging technologies. One of our aims was to investigate the learning networks in our target organizations and explore emerging technologies that they use to support learning networks and communities in the field, and the challenges, barriers, and problems that they have experienced in embedding these technologies.

In this research, we conducted a series of semi-structured interviews with three different organizations (educational, constructional, and both educational and constructional) in the Netherlands. In these interviews, organizational culture, learning networks, incentive structures, technologies used for educational purposes, the main problems and challenges, and their future direction were investigated. In addition, these interviews can give us a clear insight into the current state of educational technologies that have been used in the field to foster communication between professionals and facilitate knowledge transfer.

Back to our research questions (What types of learning communities and networks exist in the studied companies? How do these networks and communities perform in regard to knowledge management? What type of educational technologies have been used to promote communication and facilitate knowledge-sharing in the field of the building service sector? How does boundary-crossing take place, what boundary objects are used, and which gaps can be identified in the companies studied?). The first case, which is a building services company with an existing learning platform, has an excessive emphasis on educational culture and professionalization of employees. This company provides formal education for employees, but the main challenge in this section is motivation. Professionals, especially senior experts, prefer to have face-to-face connections, informal communication, and networking, and obtain their knowledge through phone calls, emails, and messaging apps. Employees prefer to have their informal networks in the organization to access knowledge, learn, and solve their everyday challenges and difficulties. We understand how essential it is to pay attention to the fundamental role of informal learning networks in professional education. This can bring the challenges to the next level in such companies. Knowledge management and a solution to make knowledge stable and accessible for all can be a huge issue. In this case, technologies such as social network analysis can be used to raise awareness about the existence of these informal learning networks and make communication between professionals easier. The second case is a professional education and networking platform that provides a networking opportunity for experts in the field of installation technologies. Besides the networking technologies emerging on their platform, knowledge is shared through educational programs, workshops, an online knowledge data bank, magazines, congresses, regional meetings, and expert groups. However, the main challenge in this company is adapting the new technologies with current traditional, and mostly offline forms of education. Like in previous cases, experts are interested in face-to-face communications and networking with their trusted networks and motivating them to use the new technologies is hard and frustrating. Again, as also discussed in case one, informal learning networks, detecting their informal activities, and recognizing their existence can facilitate professional development. Therefore, not only is the existence of technologies important, but also adapting these educational technologies can be a significant concern of companies for professional development. Our third case is an MEP (mechanical, electrical, and plumbing) consultancy company with no independent learning platform. They have to connect with other educational institutes to gain the knowledge and skills needed for their work. However, it is not only a one-way connection, but they also share their experiences and knowledge with other organizations in the form of informal or formal education.

6. Conclusions

In this qualitative study, although we did our best to select three companies that properly reflect our target sample, this does not necessarily provide us with a complete picture of current statutes in the field. Only focusing on these three companies provided us with this opportunity to go deeper inside each company and investigate their learning networks in-depth, and we believe this insight can be helpful and valuable for all experts, researchers, and policymakers in this field.

Within the large building services company from Case 1, boundary-crossing mainly takes place between the organizational units, while in the small MEP consultancy company from Case 3, boundary-crossing takes place between this organization and other organizations. Boundary-crossing with other organizations is also encouraged here through the use of a personal coaching plan. Technological boundary objects are used by all three companies but seem to be mainly focused on the coordination level. We see the same when we map the gaps. We looked for gaps related to learning mechanisms at different levels. Furthermore, we used the identification level to detect different kinds of gaps related to learning mechanisms at the levels of coordination, reflection, and transformation [38]. It is striking that all the gaps that have been identified relate to learning mechanism coor-

dination: geographical, attitude, technological, competence, and administration gaps. In the continuation of the TransAct project, we want to stimulate the use of technological boundary objects for coordination, reflection, and transformation levels. It will also be examined how perceived gaps can be reduced.

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