Gamification, Interdisciplinarity, and Learning Networks

A Holistic Approach to Professional Development

Soleymani, A.

DOI
10.4233/uuid:95eafc9f-3b60-4090-845e-867b8bb4bccb

Publication date
2025

Document Version
Final published version

Citation (APA)
Soleymani, A. (2025). *Gamification, Interdisciplinarity, and Learning Networks: A Holistic Approach to Professional Development*. [Dissertation (TU Delft), Delft University of Technology]. https://doi.org/10.4233/uuid:95eafc9f-3b60-4090-845e-867b8bb4bccb

Important note
To cite this publication, please use the final published version (if applicable).
Please check the document version above.

Gamification, Interdisciplinarity, and Learning Networks: A Holistic Approach to Professional Development

Dissertation

for the purpose of obtaining the degree of doctor
at Delft University of Technology

by the authority of the Rector Magnificus Prof.dr.ir.T.H.J.J.van der Hagen
Chair of the Board for Doctorates
to be defended publicly on

Thursday, 01 May 2025 at 12:30 o'clock

By

Ali SOLEYMANI

This Dissertation has been approved by the promotors.

Composition of the doctoral committee:

Rector Magnificus,	chairperson
Prof. Dr. M.M. Specht	Delft University of Technology, promotor
Prof. Dr. L.C.M. Itard	Delft University of Technology, promotor
Prof. Dr. M. De Laat	University of South Australia, promotor

Independent members:

Prof. dr.ir.AH.M. Smets	Delft University of Technology, Netherlands
Prof. dr. T. Ryberg	Aalborg University, Denmark
Prof. dr. J. Jaldemark	Mid Sweden University, Sweden
Prof. dr. E. Ventura-Medina	Eindhoven University of Technology, Netherlands

The work described in this thesis was carried out at the Leiden-Erasmus-Delft Center of Education and Learning (LDE CEL), Faculty of Electrical Engineering, Mathematics and Computer Science, Delft University of Technology. This work is part of the TransAct project funded by the Dutch Research Council (NWO).

Keywords:
Educational Technology, Networked Learning, Professional Development, Gamification, Interdisciplinary Learning, Knowledge Networks, Learning Analytics, Personalized Learning, Value Creation Framework, Learning Communities, Lifelong Learning, Career Advancement, Technology-Enhanced Learning, MOOCs (Massive Open Online Courses), Case Studies, Boundary-Crossing Framework, Collaboration and Innovation, Knowledge Sharing, Incentive Structures, Digital Learning Environments, Skill Development, Learning Culture.

ISBN 978-94-6384-783-4

Printed by Proefschrifmaken.nl
Cover Design: Ali Soleymani
An electronic version of this dissertation is available at https://repository.tudelft.nl

Contents

Appendices

Chapter 1.

General Introduction

In today's dynamic and knowledge-driven world, continuous professional development is crucial for individuals across various sectors and industries. The rapid evolution of technology, changing professional practices, and the necessity for interdisciplinary collaboration have led to a growing emphasis on learning networks to enhance professional growth. The ability to connect, share knowledge, and collaborate within these networks can shape the future of education and professional development.

High-tech companies thrive on innovation and rapid adaptation, especially in the energy industry (MIT Technology Review Insights, 2024). To maintain their competitive edge, organizations must prioritize maximizing the capacity and capabilities of their human capital (De Waal & Linthorst, 2020). This translates to empowering employees to reach their full potential and contribute meaningfully to the company's success. There is a considerable demand for a fast-growing professional workforce. Many companies need a more skilled workforce. They need to address this through continuous professional development of the current workforce and educating their new employees (van Kappen et al., 2020; Li, 2022).

However, the proposed networked learning idea comes with a fundamental pitfall: the sustainability and motivation of employees and professionals. Therefore, maintaining employees' engagement in this professional networked learning remains a challenge (Chow & Yeh, 2022; Rus-Casas et al., 2020). This implies a crucial pedagogical challenge: How can we design engaging and effective learning experiences for professional development?

In this dissertation, it is crucial to distinguish between the terms students and professionals as these two terms represent two distinct groups of learners with different needs, objectives, and contexts. While Higher Education Institutions (HEI) traditionally focused on educating students enrolled in degree programs, they have increasingly expanded their scope to support a broader audience

(Chankseliani et al., 2021). More specifically, courses in HEI's formal programs primarily serve students early in their professional careers. However, universities have reached students and professionals with the rise of digital learning environments and Massive Open Online Courses (MOOCs) in the last few years (Guerrero et al., 2021). Higher education institutions in the Netherlands, such as TU Delft, have recognized the importance of professional training and lifelong learning. TU Delft Extension School, for example, offers a wide range of programs aimed at professionals and students worldwide seeking to develop or refresh skills in technology, engineering, management, and so on (Extension School, n.d.).

To design an engaging and effective learning experience for a professional learning network, we need to understand the foundation of the problem and its current status. Therefore, the first part of this dissertation tries to delve into and provide a comprehensive exploration of the existing literature on networked learning for professional development. The second chapter critically examines the context, function, and scale of networked learning by positioning it to be an essential force in professional development. Through an in-depth analysis of various studies, we emphasize the importance of networked learning not only in formal educational environments but also in informal professional activities. Bringing this collection of literature together, we emphasize the growth of professional learning and demonstrate how networked learning can drive growth across all sectors. The third chapter of this dissertation tries to extend our understanding of networked learning in professional learning by focusing on the complexity of value creation cycles. Our findings emphasize how these values contribute to professional development on an individual and collective level. The value creation framework (Wenger et al., 2011) provides a foundation for understanding networked learning in different contexts, and it also helps us develop our intervention and assessment in the final chapters.

This PhD project is supported by NWO (De Nederlandse Organisatie voor Wetenschappelijk Onderzoek) and multiple universities and industry partners, and it is part of a bigger project called TransAct (Human Capital: Learning in Learning communities with the dossier number 055.19.002). This project explores the role of networked learning and professional development in the energy industry, and its ultimate goal is to help energy transition. Therefore, after reviewing the literature in the field of networked learning and professional development and creating a strong

foundation for our future research, this project aimed to investigate the current status and our TransAct partner's needs. In part two of this dissertation, we conducted two studies to explore the pedagogical challenges of implementing networked learning in the context of a series of MOOCs in the field of Energy Management Systems Industry (EMSI) (Chapter Four) and challenges, problems, and networked learning in EMSI (Chapter Five).

In Chapter Four, by analyzing learners' key behaviors and interaction patterns within MOOCs, we tried to provide insight into how to optimize the networked structure to improve the learning experience. In Chapter Five, by qualitatively analyzing professional learning networks in EMSI, we tried to clarify the unique needs and challenges professional learners face. The results also address the gap between theoretical networked learning models and their practical application in professional development.

Integrating online learning environments into education has highlighted a significant gap in the availability of suitable assessment and evaluation tools to track the quality of online interactions and learning outcomes effectively. This issue is compounded by the challenge of quantitatively and qualitatively assessing online learning interactions, which are critical for effective education delivery and learners' engagement (Kent et al., 2019). In light of the problems and limitations discussed, this dissertation aims to contribute to the advancement of networked learning in professional development by addressing several key areas:

1. Enhancing Pedagogical Practice: Our research aims to explore and identify effective pedagogical practices for designing engaging and impactful online learning experiences in networked environments. This includes investigating and evaluating these networks' characteristics from value creation perspectives (Part One).

2. Understanding the current status and challenges in implementing networked learning: Recognizing the importance of networked learning in professional development, we must explore the challenges and problems that professional learners face in everyday practice (Part Two).

3. Developing Robust Assessment Methods: Traditional assessment methods often fail to capture networked learning complexities in online environments. Our research aims to develop and validate robust assessment methods using the value creation framework that can effectively evaluate the quality and impact of professional learning occurring within networked learning platforms. Recognizing the importance of sustained engagement and motivation in professional learning, this dissertation aims to explore and implement innovative strategies, such as value creation-based gamification elements, to create more engaging and motivating networked learning experiences for professional development (Part Three).

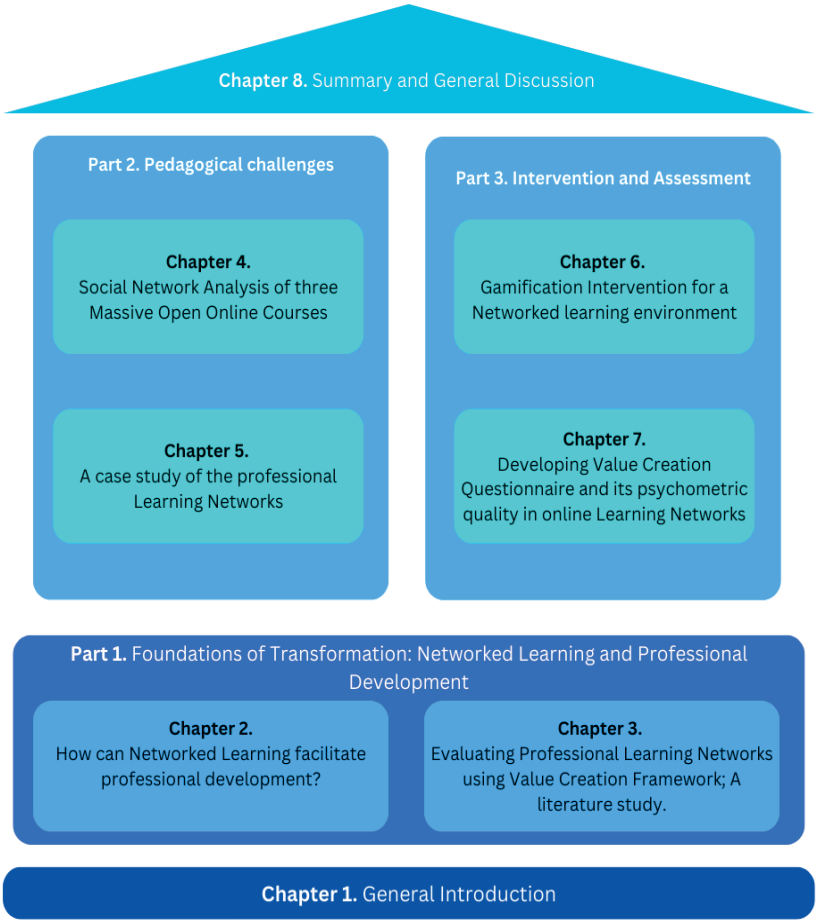
By pursuing these aims, this research aims to contribute a comprehensive understanding of effective practices and innovative approaches to enhancing professional development through networked learning, ultimately impacting the field by promoting high-quality, engaging, and accessible learning experiences for all.

Methodology

To address these issues comprehensively, we adopted a multifaceted methodology consisting of literature reviews, case studies, and experimental interventions. Our approach aimed to provide a well-rounded perspective on the complex dynamics of learning networks and their role in professional development. Figure 1.1 represents an outline of this dissertation.

Figure 1.1

Dissertation outline



In Part One, we embarked on a journey through existing literature to grasp the foundations of networked learning, professional development, and the interconnectedness between the two. The findings from these studies laid the groundwork for our subsequent investigations, emphasizing the significance of networking, knowledge sharing, and collaboration within learning networks.

We conducted two case studies in EMSI in Part Two to explore real-world scenarios and challenges. This study delved into the motivations and barriers for knowledge adoption, transfer, and exchange among professionals, emphasizing the role of learning culture, incentives, and

technologies. The boundary-crossing framework facilitated the analysis of educational challenges and opportunities. We backed up these findings by investigating the learners' online interaction in the context of MOOCs in EMSI.

Two major challenges identified in our literature studies and case studies were A) learners' motivation and B) lack of sufficient assessment tools to investigate professional learning networks. Therefore, in the last part of the dissertation, we designed gamification interventions inspired by the value creation theory (Wenger et al., 2011) to investigate if we could tackle one of the major issues identified in our previous finding, which was the lack of proper incentive structure in the professional learning networks. This intervention was implemented within an online learning network. We also developed a questionnaire based on the different cycles of the value creation framework to facilitate the evaluation of networked learning users. This newly developed questionnaire evaluated our gamification intervention in online learning environments like MOOC users.

The seamless connection between these studies lies in our pursuit of understanding how learning networks can be harnessed to push professional development forward. Each research component adds a layer of comprehension to the detailed procedure of networked learning, shedding light on the strategies, technologies, and incentives that facilitate knowledge exchange and collaboration within these networks. The following chapters will delve deeper into the specific findings, implications, and lessons learned from each study. Through this comprehensive exploration, we aim to contribute valuable insights to educational psychology and professional development. We offer guidance for practitioners and policymakers striving to enhance professionals' learning experiences and opportunities in the ever-evolving knowledge landscape.

References

Chankseliani, M., Qoraboyev, I., & Gimranova, D. (2021). Higher education contributing to local, national, and global development: New empirical and conceptual insights. *Higher Education, 81*(1), 109–127. https://doi.org/10.1007/s10734-020-00565-8

Chow, N. C.-H., & Yeh, I.-J. (2022). Correlation Between Learning Motivation and Satisfaction in Synchronous On-the-Job Online Training in the Public Sector. *Frontiers in Psychology, 13*. https://doi.org/10.3389/fpsyg.2022.789252

Guerrero, M., Heaton, S., & Urbano, D. (2021). Building universities' intrapreneurial capabilities in the digital era: The role and impacts of Massive Open Online Courses (MOOCs). *Technovation, 99*. https://doi.org/10.1016/j.technovation.2020.102139

Kent, C., Rechavi, A., & Rafaeli, S. (2019). Networked Learning Analytics: A Theoretically Informed Methodology for Analytics of Collaborative Learning. In Y. Kali, A. Baram-Tsabari, & A. M. Schejter (Eds.) Learning In a Networked Society. Computer-Supported Collaborative Learning Series, vol 17. Springer International Publishing. https://doi.org/10.1007/978-3-030-14610-8_9

Li, L. (2022). Reskilling and Upskilling the Future-ready Workforce for Industry 4.0 and Beyond. *Information Systems Frontiers, 26*, 1679-1712. https://doi.org/10.1007/s10796-022-10308-y

MIT Technology Review (2024) 'Transforming the energy industry through disruptive innovation,' *MIT Technology Review*. Retrieved on 18 July 2024 from:. https://www.technologyreview.com/2024/07/17/1095012/transforming-the-energy-industry-through-disruptive-innovation/.

van Kappen, P., van Bree, T., Stolwijk, C., Yagafarova, A., & van Der Horst, T. (2020). High-tech industry in 2040 New challenges for achieving long-term earning power and impact for the Netherlands. TNO. Retrieved on 18 July 2024 from:https://publications.tno.nl/publication/34640945/W2sLVo/kappen-2023-hightechindustry.pdf

Rus-Casas, C., Eliche-Quesada, D., Aguilar-Peña, J. D., Jiménez-Castillo, G., & La Rubia, M. D. (2020). The Impact of the Entrepreneurship Promotion Programs and the Social Networks on the Sustainability Entrepreneurial Motivation of Engineering Students. *Sustainability, 12*(12). https://doi.org/10.3390/su12124935

Waal, A. de, & Linthorst, J. (2020). Future-Proofing the High-Performance Organization. *Sustainability, 12*(20), 8507. https://doi.org/10.3390/su12208507

Part 1.

Foundations of Transformation:

Networked Learning and Professional Development

This part is based on:

Soleymani, A., De Laat, M., Itard, L., & Specht, M. (2024). How Networked learning can facilitate professional development? In Proceedings of the International Conference on Networked Learning, 13. https://doi.org/10.54337/nlc.v13.8543

&

Soleymani, A., De Laat, M., & Specht, M. (2024). Evaluating Professional Learning Networks using Value Creation Framework; A literature study. *SSRN*. http://dx.doi.org/10.2139/ssrn.4870033

Introduction

Technology is evolving every day. It changes how we think, work, and communicate. Continuous advancements in information and communication technology (ICT) significantly transform the education and professional development landscape. This transformation has been driven by the emergence of networked learning—a dynamic form of education that harnesses the power of digital connectivity to foster connections between learners, tutors, and learning resources. The implications of this paradigm shift extend far beyond traditional classrooms, encompassing a diverse range of sectors, from high-tech industries to established businesses.

Chapter Two explores the multifaceted nature of networked learning for professional development. Our exploration begins by delving into the networked learning contexts, domains, and scales investigated by existing academic literature. This extensive review highlights the diverse ways networked learning is practiced and underscores its crucial role in equipping professionals with the skills, knowledge, and connections essential for thriving in today's evolving workforce.

In Chapter Three, we explore value creation cycles in networked learning. The significance of our investigation becomes evident as we uncover the role of different value-creation cycles embedded within learning networks. The value creation cycles we determine serve as a dynamic framework that enables us to evaluate and understand the multifaceted benefits and challenges networked learning brings to stakeholders engaged in professional development.

Chapter 2.

How Can Networked Learning Facilitate Professional Development?

Abstract

In this review article, our primary goal is to understand the networked learnings used for professional development. Networked learning can be defined as a form of learning where information and communication technology (ICT) can be used to promote connections between learners and their peers, learners and tutors, and learners and learning resources. Such networks play an essential role in employees' professional development in different sectors, from high-tech industries to traditional businesses, and in formal teaching, educational programs, and informal learning activities. This review explores how networked learning contexts, domains, and scale levels are practiced and reported in the academic literature. Finally, we will investigate support technologies used to facilitate networked learning for professional development.

Keywords

Networked learning, professional development, value creation, technology-enhanced learning

1. Introduction

We live in an era of constant change and transition, which, for example, is experienced at work, by global challenges, and through transforming technologies (Jakupec & Garrick, 2000). These changes and challenges bring us many growth opportunities and require us to tackle many work-related and professional issues. These issues, more often than not, involve learning and development and require continued or lifelong professional learning to support capability development. The Building Energy Management System (BEMS) within the Heating, Ventilation, and Air Conditioning (HVAC) sector is one of the professional sectors significantly affected by transition at work. This sector is becoming increasingly complex and facing significant challenges related to the energy transition. For example, stricter energy performance regulations and higher comfort expectations make the buildings more heavily equipped with complex (intelligent and digital) systems, often generating large volumes of data. Because of those developments in the sector, more than knowledge about HVAC systems is required. HVAC consultants, contractors, and maintenance companies are suddenly expected to know about data management and analytics techniques (Ligtvoet et al., 2016; Radar 2020, 2014). Transition skills such as problem-solving, critical thinking, creativity, and the ability to collaborate (Topsectoren, 2019), as well as technical skills like data analytics and machine learning, are becoming increasingly important. In the context of such changes in the sector, there is an urgent need to reflect on lifelong learning and practices.

Lifelong development is “all learning activities that are undertaken throughout life, to improve knowledge, skills, and competencies within a personal, civic, social and employment-related perspective” (Commission of the European Communities, 2001, p. 9). It concerns adult learning in formal and informal learning pathways and whether it is concluded with a diploma or certificate (Gielen et al., 2017). To enhance lifelong development, people must have the opportunity to participate in learning and be willing to learn (Topsectoren, 2019). The possibility to participate in learning 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. Because of more dynamic job profiles and the distribution of jobs between humans and robots, there is a noticeable focus on learning and professional

development in the workplace (Topsectoren, 2019). The use of learning communities and learning networks can strengthen the capacity of individuals and organizations to learn (Topsectoren, 2019). As Lave and Wenger (1991) describe, learning communities have been used for people who interact regularly, share the same concern or passion for something, and aim to improve their knowledge and practice. Networks of Practice (NoP) or learning networks (Seely et al., 2001) have been used to describe a more informal and developing social network that encourages and supports sharing knowledge and information between a group of people who gather around the same practice and profession. Seely Brown and Duguid (2001) and Wenger et al. (2011) claimed a few differences between learning in networks and learning in communities of practice. First, in Networks, the relationship between network members is more informal and intimate than communities. Second, powerful interpersonal relationships and group unity shape the fundamentals of communities, while networks are more widespread, and the relationships can be weak or strong. Finally, network relationships can be temporary, but people tend to form more permanent and lifelong community connections. Also, as mentioned in "Networked Learning: Inviting Redefinition" (2021), "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" (p. 319).

This research combines theories and principles from networked learning with challenges and transitions in lifelong development. Within networked learning, forms of social learning related to informal learning can exist in various configurations, such as field labs (e.g., Stolwijk & Seiffert, 2016), living labs (e.g., Maas et al., 2017; Nyström et al., 2014), Collaborative Innovation Networks (e.g. Xie et al., 2016), and Centers for Innovatief Vakmanschap (English translation: Innovative Craftsmanship) at vocational schools (e.g. SBB, 2020). Examples of learning communities related to formal learning are employees who take a course together or with their peers to be informed about developments in their field. In all these different learning processes, emerging technologies can help facilitate access to educational resources and communication between learners. However, in this research project, we mainly focused on the networked learning

framework because how HVAC is currently organized is more similar to network principles than community organization. Therefore, this review article investigates current developments in networked learning and continued professional development to explore how this can support emerging needs for lifelong learning in the HVAC sector.

2. Methodology

In this study, we conducted a systematic literature review following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Page et al., 2021) to ensure transparency and rigor in reporting our findings. The review aimed to explore the role of networked learning in professional development, focusing on how professionals engage in learning networks to enhance their skills and competencies.

2.1 Search Strategy and Data Sources

This research systematically searched three major academic databases: Web of Science, Scopus, and PubMed. These databases were selected due to their comprehensive coverage of high-quality peer-reviewed journal articles in education, professional development, and interdisciplinary research. The search was conducted using the keywords:“networked learning” and “professional development.” The search was restricted to peer-reviewed journal articles published between 1998 and 2021 to ensure a comprehensive and focused scope of review.

2.2 Inclusion and Exclusion Criteria

The selection of studies was based on the following criteria: Inclusion Criteria: Studies that explicitly examined networked learning in professional development contexts. Research focusing on employees, professionals, and workplace learning networks. Studies employing experimental, quasi-experimental, or mixed-method approaches to analyze networked learning. Peer-reviewed journal articles published in English.

Exclusion Criteria: Studies that focused only on primary education or K-12 settings, as the focus is on professional learning. Research that primarily discussed technical aspects of network analysis

(e.g., neural networks, machine learning in computer science) without application to networked learning or professional development. Conference papers, book chapters, and grey literature, as we aimed to focus on high-quality, peer-reviewed empirical studies.

2.3 Screening and Selection Process

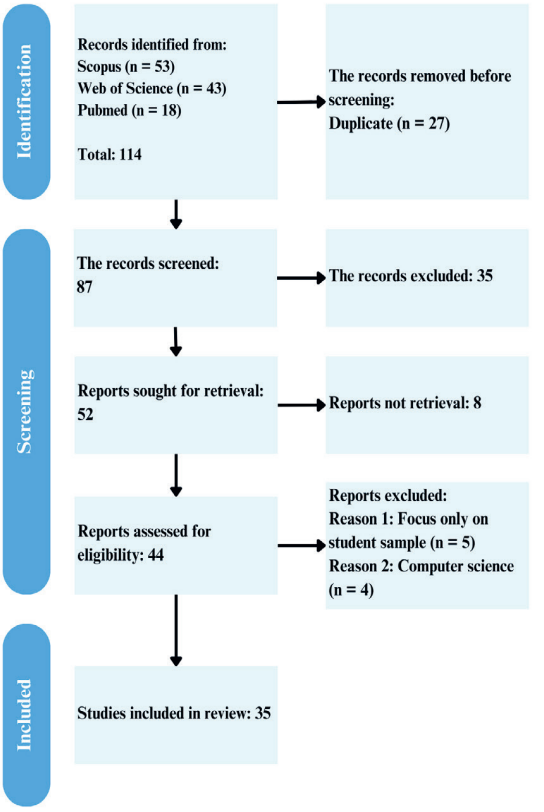
Following the database searches, all retrieved articles were first screened by title and abstract to determine their relevance. After this initial screening, the full texts of the remaining articles were reviewed based on the inclusion and exclusion criteria. The complete selection process is illustrated in Figure 2.1 (PRISMA Flowchart).

2.4 Data Extraction and Analysis

A structured data extraction sheet was used to systematically collect relevant information from each selected study, including study design (experimental, qualitative, mixed-methods), sample characteristics (industry, profession, country, participant demographics), networked learning approach (formal/informal networks, online/hybrid, workplace settings), key findings and contributions to professional development, Methodological rigor and limitations. The extracted data were synthesized using thematic analysis, allowing for the identification of recurring patterns and key themes related to how networked learning contributes to professional growth.

Figure 2.1

PRISMA Chart of Literature Review



3. Results

We categorize our findings to understand how the literature can support emerging needs for lifelong learning in the HVAC sector. First, we describe networked learning contexts, followed by social and individual attributes of networked learning, the domain, and mechanisms and design features that support productive networked learning practices.

3.1 Networked Learning Context

The literature we reviewed shows that professional learning can occur not only through formal settings, like organized workshops, conferences, and classrooms, but also might be a part of the everyday working of professionals (Eraut, 2004, 2007, 2011). Such informal learning can happen during the face-to-face communication of employees, observation of more experienced colleagues, or any other form of unintentional learning besides working (Felstead et al., 2009; Tynjälä, 2008). These informal learnings are mainly invisible to managers, organizations, and professionals as a form of professional development (Milligan et al., 2014). It is considered as a "huge mass of iceberg" (Vaessen, 2014) because mostly such informal activities are invisible and spontaneous (De Caluwe & Vermaak, 2003; De Laat, 2012). Although it is unknown primarily for organizations, often it is at least as influential as the other forms of formal education (De Caluwe & Vermaak, 2003; De Laat, 2012).

In general, formal and informal learning forms can be essential for professional development. For example, Bautista et al. (2021) have shown that for art specialists and music teachers, both formal and informal education needs to be seriously considered by policymakers. Vaessen et al. (2014) also explored the relationship between formal and informal professional learning of teachers. Moreover, finally, instead of conflicting formal with informal learning, we should highlight the need to develop a "hybrid form of learning." With this approach, formal and informal activities are recognized, respected, and promoted (McGuire & Gubbins, 2010; Vaessen et al., 2014) and formally supported/implemented by organizations as forms of learning and professional development (De Laat, 2012).

3.2 Networked Learning Social and Individual Attributes

According to Vaessen et al. (2014), networked learning can promote different social and individual attributes. For example, by providing networking and communication opportunities for people to connect and learn with other professionals, networked learning can provide more professional autonomy, freedom of choice, commitment, responsibility, accountability, power, control, trust, communicative openness, and interest to share and provide feedback. On the other hand, it can also offer a collaborative atmosphere in the organization and increase the chance of success of networked learning activities (Vaessen et al., 2014). In addition, networks can also create an

opportunity to link to other professionals outside of the direct working environment by having the freedom of choice (cf. Büchel & Raub, 2002). This option, which enables you to choose what you want to learn, can improve a person's performance (Akkerman et al., 2008) because it is believed that such freedom can bring a feeling of responsibility and increase personal motivation (Varga-Atkins et al., 2010). Oddone et al. (2019) explored the role of autonomy within teachers' professional learning networks. They claimed that teachers experience autonomy in learning networks as linking (choice and control), stretching (an expression of self as teacher and learner), and finally amplifying (an expression of self as individual). Also, investigating networked learning in continuing medical education shows that educational networking and communication between professionals can encourage learner engagement and commitment to practice improvement (Margolis et al., 2015). Significantly, "interactivity conducive to learning and behavior change" in professional learning networks can be facilitated with trusted relationships and freedom to express their concern or dissatisfaction with peers (Parboosingh et al., 2011).

3.3 Networked Learning domain

Networked learning has been used in various domains like higher education, management and organizational learning, workplace, and continuing professional development. However, one of the main domains of networked learning applications is in the professional development of teachers, where they can expand their relationships in and outside of their school's network to learn, solve their everyday problems, and innovate in their teaching (De Laat, 2012). In the last few years, more digital technologies have been used for teachers' professional learning that can cross the boundaries of school's limitations. ICT can enable teachers to remain connected with their professional learning network regardless of geographical limitations (McGregor et al. 2004, 2006). For example, we can mention the TeachConnect platform, which provides community support for teachers (Kelly, 2018).

3.4 Mechanisms and design features that support productive networked learning practices

Different mechanisms and design features can support network learning and its value creation. The recent progress in networked learning has mainly been influenced by the understanding and

development of technologies to support networked learning and moving from traditional learning to more innovative, technology-based learning. Reviewing empirical research, Lee et al. (2020) revealed a few essential factors that can influence member's engagement in knowledge creation in online learning communities and networks. A structured approach (for example, Bedford, 2019) argues that incorporating structure and having a timeframe for online professional learning networks can be beneficial. We already observed the importance of organizational support in our interviews with different companies involved in the TransAct project. Our interview revealed that imagining success for online learning networks in organizations without managers' or leaders' support is out of reach. As we also discussed earlier in the social and individual attribute section, the psychological characteristics of professional network members can highly influence the success of learning networks (Owston et al., 2008). A culture of sharing is a feature of online learning networks that professionals actively engage with sharing, which is also appreciated by the organization and can promote network learning between professionals. Shared ownership: It can have a significant effect and explore whether there is a sense of personal value in the online learning networks and co-ownership of common goals such that members find value and perseverance in engaging in online knowledge construction. Besides that, there is a wide range of web technologies that have been used for facilitating networked professional learning, from a local website where professionals can communicate with each other using email messaging, chat, or discussion forums to more national or international platforms that they provide video cases, lesson plans, and many different teaching and learning activities (Lock, 2006; Powell & Bodur, 2019).

4. Discussion

Professional networked learning is situated within a broad economic, societal, and educational context. Answering whether and how networked learning can be considered and developed in the professional working environment of experts in high-tech industries like the energy management sector can be challenging. By critically reviewing the literature and exploring what has been achieved in networked learning, we can take the following steps: fill in the research gaps and implement new ideas.

Now, the energy transition is at its fast speed. Distributing technical knowledge and experience is needed, and continuous professional development of the current workforce and educating the new

employees is crucial. We have conducted this research mainly to develop a conceptual networked learning model that can help tackle these educational challenges. These days, many educational and research institutes in the Netherlands have tried to create a formal form of learning communities and networks to help the energy transition (Topsectoren, 2019). We discussed the importance of formal and informal networked learning activities (Brown et al., 1989). Organizations that only focus on formal education and ignore informal learning may miss a significant and vital aspect of professional development. On the other hand, considering only informal learning for professional development can be misleading. Therefore, as McGuire and Gubbins (2010) suggest, we recommend a hybrid form of learning where both formal and informal are recognized and respected. High-tech industries, like HVAC, cannot unlock their potential by focusing on one form of networked learning and ignoring the others.

In both formal and informal learning networks, different social and individual attributes can be substantial and affect the productivity of such networks. Various aspects like level of control over the learning process and autonomy, self-directedness, and independent decision-making can change the direction of networks (Vaessen, 2014). We see that the freedom for professionals to choose the areas to explore can improve their performance (Akkerman et al., 2008). Also, research on the professional development of teachers shows how important the role of organizational culture is in providing the opportunity to develop (De Laat, 2012). Organizations with hierarchy and a more centralized culture can negatively affect the possibility of learning from more senior experts (Pahor et al., 2008). Hence, policymakers and strategists in energy management must consider these critical social and individual attributes in their future decisions and consider designing a professional learning network.

Professional learning networks in the HVAC sector can inspire and learn from other domains. Professional learning networks have been used in the field of professional development of teachers (e.g., Pettersson & Olofsson, 2019; Spante et al., 2019; Oddone et al., 2019; Bautista et al., 2021) ZooCamp educators (Khalil et al., 2017) and continuing medical education (Margolis et al., 2015). Each of these networks has its specific features, but the fundamental idea behind all of them is the same and is generalizable to the other networks. Therefore, reviewing these different professional

learning networks in various domains, we can explore and implement the current initiatives, barriers, and opportunities of network learning designs in the HVAC sector.

Finally, this literature review not only provides a comprehensive overview of the current status of networked learning research but can also help us develop a conceptual model that can help the energy management system experts in the HVAC sector. Our practical model focuses on a hybrid form of network learning where the freedom of choice and trust between the network participants is respected, and organizational culture facilitates this type of learning.

References

Akkerman, S., Petter, C., & de Laat, M. (2008). Organising communities-of-practice: Facilitating emergence. *Journal of Workplace Learning*, *20*(6), 383–399. https://doi.org/10.1108/13665620810892067

Bautista, A., Stanley, A. M., & Candusso, F. (2021). Policy Strategies to Remedy Isolation of Specialist Arts and Music Teachers. *Arts Education Policy Review*, *122*(1), 42–53. https://doi.org/10.1080/10632913.2020.1746713

Bedford, L. (2019). Using Social Media as a Platform for a Virtual Professional Learning Community. *Online Learning*, *23*(3). https://doi.org/10.24059/olj.v23i3.1538

Brown, J. S., & Collins, A. (1989). Situated Cognition and the Culture of Learning. *Educational Researcher*, *18*(1), 32–42.

Brown, J. S., & Duguid, P. (2001). Knowledge and Organization: A Social-Practice Perspective. *Organization Science*, *12*(2), 198–213. https://doi.org/10.1287/orsc.12.2.198.10116

Büchel, B., & Raub, S. (2002). Building Knowledge-creating Value Networks. *European Management Journal*, *20*(6), 587–596.

de Caluwé, L., & Vermaak, H. (2003). *Learning to Change: A Guide for Organization Change Agents*. https://doi.org/10.4135/9781452229584

De Laat, M. (2012). *Enabling professional development networks: How connected are you?* https://www.ou.nl/documents/40554/111664/Inaugurele_rede_Maarten_de_Laat_def_2012.pdf/af2ce77e-2169-46fb-9b81-ea7fdd5ff588

Eraut, M. (2004). Informal Learning in the Workplace. *Studies in Continuing Education*, *26*, 247–273. https://doi.org/10.1080/158037042000225245

Eraut, M. (2007). Learning from other people in the workplace. *Oxford Review of Education*, *33*(4), 403–422. https://doi.org/10.1080/03054980701425706

Eraut, M. (2011). Informal learning in the workplace: Evidence on the real value of work-based learning (WBL). *Development and Learning in Organizations: An International Journal*, *25*(5), 8–12. https://doi.org/10.1108/14777281111159375

European Commission. (2001). *Making a European area of lifelong learning a reality* (TD/TNC 77.521). European Commission. https://www.voced.edu.au/content/ngv%3A33722

Felstead, A., Fuller, A., Jewson, N., & Unwin, L. (2009). *Improving Working as Learning*. Routledge. https://doi.org/10.4324/9780203877951

Garrick, J., & Jakupec, V. (Eds.). (1999). *Flexible Learning, Human Resource and Organisational Development: Putting Theory to Work*. Routledge. https://doi.org/10.4324/9780203991817

Gielen, P., Moerman, P., & Bobeldijk, M. (2017). *Inspireren voor leven lang leren. Hoe (de samenwerking met) beroepsonderwijs er (ook) uit kan zien*. Kata Pult. https://www.wijzijnkatapult.nl/files/downloads/Kennisbank/Publicatie_Leven_lang_leren.pdf

Kelly, N., Russell, N., Kickbusch, S., Barros, A., Dawes, L., & Rasmussen, R. (2018). Online communities of teachers to support situational knowledge: A design-based study. *Australasian Journal of Educational Technology*, *34*(5), Article 5. https://doi.org/10.14742/ajet.3867

Khalil, K., Ardoin, N. M., & Wojcik, D. (2017). Social learning within a community of practice: Investigating interactions about evaluation among zoo education professionals. *Evaluation and Program Planning*, *61*, 45–54. https://doi.org/10.1016/j.evalprogplan.2016.12.001

Lave, J., & Wenger, E. (1991, September 27). *Situated Learning: Legitimate Peripheral Participation*. Higher Education from Cambridge University Press; Cambridge University Press. https://doi.org/10.1017/CBO9780511815355

Lee, L. H. J., Rahmat, R. B., Lin, L., Lim, P. H., & Tan, T. H. (2023). The development of an implementation framework to support knowledge construction in online networked learning. *Professional Development in Education*, *49*(1), 69–90. https://doi.org/10.1080/19415257.2020.1763430

Ligtvoet, A., Cuppen, E., Ruggero, O., Hemmes, K., Pesch, U., Quist, J., & Mehos, D. C. (2016). New future perspectives through constructive conflict: Exploring the future of gas in the Netherlands. *Futures*, *78*. https://doi.org/10.1016/j.futures.2016.03.008

Lock, J. V. (2006). A New Image: Online Communities to Facilitate Teacher Professional Development. *Journal of Technology and Teacher Education*, *14*(4), 663–678.

Maas, T, J. van den Broek, & J. Deuten. (2017). *Living labs in Nederland, Van open testfaciliteit tot levend lab*. Rathenau Instituut. https://www.rathenau.nl/nl/werking-van-het-wetenschapssysteem/living-labs-nederland

Macgregor, G., & McCulloch, E. (2006). Collaborative tagging as a knowledge organisation and resource discovery tool. *Library Review*, *55*(5), 291–300. https://doi.org/10.1108/00242530610667558

Margolis, A., & Parboosingh, J. (2015). Networked Learning and Network Science: Potential Applications to Health Professionals' Continuing Education and Development. *The Journal of*

Continuing Education in the Health Professions, *35*(3), 211–219. https://doi.org/10.1002/chp.21295

McGregor, D. (2004). Coming Full Circle: Indigenous Knowledge, Environment, and Our Future. *The American Indian Quarterly*, *28*, 385–410. https://doi.org/10.1353/aiq.2004.0101

Mcguire, D., & Gubbins, C. (2010). The Slow Death of Formal Learning: A Polemic. *Human Resource Development Review*, *9*, 249–265. https://doi.org/10.1177/1534484310371444

Milligan, C., Littlejohn, A., & Margaryan, A. (2014). Workplace Learning in Informal Networks. *Journal of Interactive Media in Education*, *2014*. https://doi.org/10.5334/2014-06

Networked Learning Editorial Collective (NLEC). (2021). Networked Learning: Inviting Redefinition. *Postdigital Science and Education*, *3*(2), 312–325. https://doi.org/10.1007/s42438-020-00167-8

Nyström, A.-G., Leminen, S., Westerlund, M., & Mika, K. (2014). Actor roles and role patterns influencing innovation in living labs. *Industrial Marketing Management*, *43*. https://doi.org/10.1016/j.indmarman.2013.12.016

O'Brien, M., Burton, D., Campbell, A., & Qualter, A. (2010). The importance of interplay between school-based and networked professional development: School professionals' experiences of inter-school collaborations in learning networks. *Journal of Educational Change*, *11*, 241–272. https://doi.org/10.1007/s10833-009-9127-9

Oddone, K., Hughes, H., & Lupton, M. (2019). Teachers as Connected Professionals. *The International Review of Research in Open and Distributed Learning*, *20*. https://doi.org/10.19173/irrodl.v20i4.4082

OTIB. (2014). *Radar 2020 -editie 2014 -Verkenning van belangrijke toekomst ontwikkelingen voor installatiebedrijven.* UNETOVNI.

Owston, R., Wideman, H., Murphy, J., & Lupshenyuk, D. (2008). Blended teacher professional development: A synthesis of three program evaluations. *The Internet and Higher Education*, *11*, 201–210. https://doi.org/10.1016/j.iheduc.2008.07.003

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, *372*, n71. https://doi.org/10.1136/bmj.n71

Pahor, M., Skerlavaj, M., & Dimovski, V. (2008). Evidence for the network perspective on organizational learning. *Journal of the American Society for Information Science and Technology*, *59*, 1985–1994. https://doi.org/10.1002/asi.20912

Parboosingh, I. J., Reed, V. A., Caldwell Palmer, J., & Bernstein, H. H. (2011). Enhancing practice improvement by facilitating practitioner interactivity: New roles for providers of continuing medical education. *The Journal of Continuing Education in the Health Professions*, *31*(2), 122–127. https://doi.org/10.1002/chp.20116

Pettersson, F., & Olofsson, A. D. (2019). *Learning to Teach in a Remote School Context: Exploring the Organisation of Teachers' Professional Development of Digital Competence Through Networked Learning* (pp. 167–185). https://doi.org/10.1007/978-3-030-18030-0_10

Powell, C. G., & Bodur, Y. (2019). Teachers' perceptions of an online professional development experience: Implications for a design and implementation framework. *Teaching and Teacher Education*, *77*, 19–30. https://doi.org/10.1016/j.tate.2018.09.004

SBB. (2020). *De kracht van praktijkleren in het mbo. Impuls aan een leven lang ontwikkelen.* http://www.s-bb.nl/

Spante, M., Johansson, K., & Jaldemark, J. (2019). *MakerSpaces in Schools: Networked Learning Among Teachers to Support Curriculum-Driven Pupil Learning in Programming* (pp. 223–237). https://doi.org/10.1007/978-3-030-18030-0_13

Stolwijk, C., & Seiffert, L. (2016). *Fieldlab als aanjager van het innovatie ecosysteem*. TNO.

Topsectoren. (2019). *Samen aan de slag: Roadmap Human Capital Topsectoren 2020-2023*. https://www.topsectoren.nl/publicaties/kamerstukken/2019/november/12-11-19/roadmap-hc-topsectoren

Tynjälä, P. (2008). Perspectives into learning at the workplace. *Educational Research Review*, *3*(2), 130–154. https://doi.org/10.1016/j.edurev.2007.12.001

Vaessen, M., Van den beemt, A., & Laat, M. (2014). Networked professional learning: Relating the formal and the informal. *Frontline Learning Research*, *2*. https://doi.org/10.14786/flr.v2i2.92

Chapter 3.

Evaluating Professional Learning Networks Using Value Creation Framework; A literature study.

Abstract

This literature review seeks to identify value creation cycles in networked learning environments and understand their mechanism and implications for promoting and assessing professional development activities. Specifically, it investigates the immediate, potential, applied, realized, enabling, strategic, orienting, and transformative values professionals create when learning within their professional networks. The research adopts a systematic literature review approach based on the PRISMA guidelines. The value creation cycles uncovered the significance of professional networks in fostering social learning and facilitating value creation. Network characteristics identified include the importance of connecting with peers (networking), knowledge sharing, collaboration, and information exchange among members of these networks. The value creation cycles provide a framework for understanding the different aspects and levels of benefits that networked learning offers. These cycles shape a dynamic framework for assessing learning networks and promoting the professional development of individuals. Government policymakers, organizational leaders, trainers, those responsible for HRM* policies, and researchers can consider these factors to ensure effective implementation. Understanding the characteristics contributing to value creation within learning networks can inform the development of more effective and valuable networks for different stakeholders. The study emphasizes the importance of fostering collaboration, providing support and guidance, and creating an enabling environment for knowledge sharing and professional growth.

Keywords: Networked learning, learning networks, social learning, value creation, professional development, systematic literature review.

1. Introduction

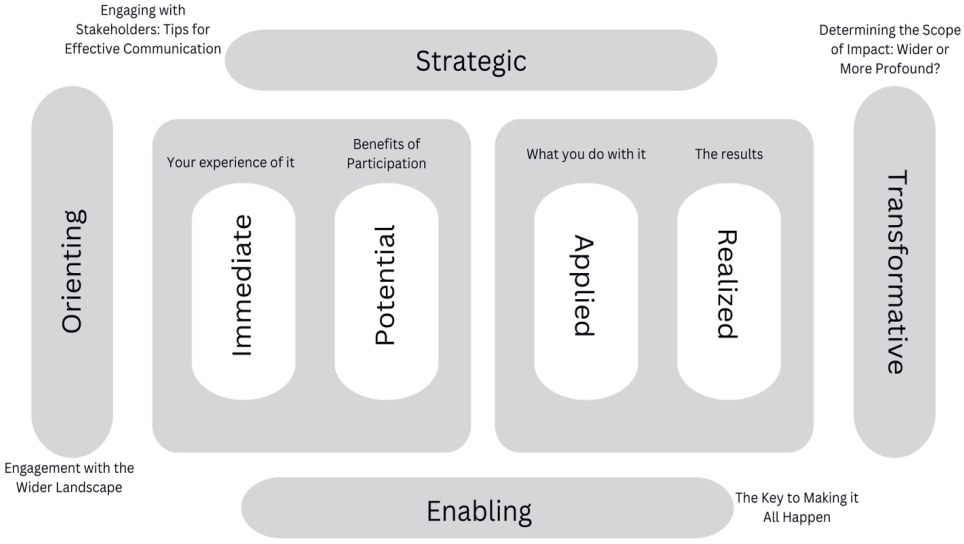
Social learning has gained traction in an era of rapid technological advancements and integration into education and professional development. Utilizing communication technologies, social learning has revolutionized collaboration, interaction, and the knowledge economy. Specifically, learning networks have emerged as pivotal in harnessing collective expertise and fostering innovation (Edwards & Romeo, 2003; Sørensen, 2005). A learning network is a developing social network that supports and promotes sharing knowledge and information between people who follow the same discipline or practice (Koper et al., 2009). We use the updated Value Creation Framework (VCF) that Wenger-Trayner and Wenger-Trayner (2020) introduced to understand the social learning processes in professional networked learning and clarify the benefits and drawbacks for different members and stakeholders. An overview of these cycles is shown in Figure 3.1. Despite the recognized potential of networked learning, there is a notable gap in comprehending the variation and depth of value creation within these networks.

Wenger et al. (2011) established the value creation framework. It has been used extensively to evaluate and assess social participation and learning in (online) networks and communities. For example, Gao et al. (2023) investigated learning value based on teaching, social, and cognitive presence in an online community of inquiry (CoI). Although their results show that CoI activities can generate immediate, potential, and applied value, their analysis did not include value creation cycles like enabling and strategic values mentioned in the updated framework (see Wenger-Trayner & Wenger-Trayner, 2020) for an updated version of the VC framework). In another recent study by Spilker et al. (2020), VCF was used to understand the impact of conference attendance on the academic development of professional competencies. This research covered the original five value creation cycles as introduced in 2011. As a result, there is a need to investigate such professional development networks using the updated framework to grab a complete picture of value creation, their process, and related challenges in professional networked learning environments. No literature review has focused on assessing professional networked learning based on the updated VCF framework.

However, the specific mechanisms that influence the value creation indicators of these networks still need to be explored. Our aims in this study are to address this gap by delving into the complications of value creation cycles within learning networks, identifying value creation cycles in professional development learning networks, and determining how networking mechanisms influence the value they create for their members. Ultimately, we want to propose a framework for a value-driven professional development learning network. We aim to systematically evaluate these networks across eight value-creation cycles to illuminate the elements that promote value generation within these collaborative environments and answer our main research question: What are the characteristics of learning networks seen from different indicators of the value creation cycles?

Figure 3.1

Value Creation Cycles (Based on Wenger and Trayner (2020)).



2. Methods

In this research, PRISMA guidelines (Page et al., 2021) for conducting systematic reviews have been used to define our inclusion and exclusion criteria and identify the relevant studies. This guideline helps us with transparent reviewing and preparing our systematic review report.

2.1. Developing the Search Strategy

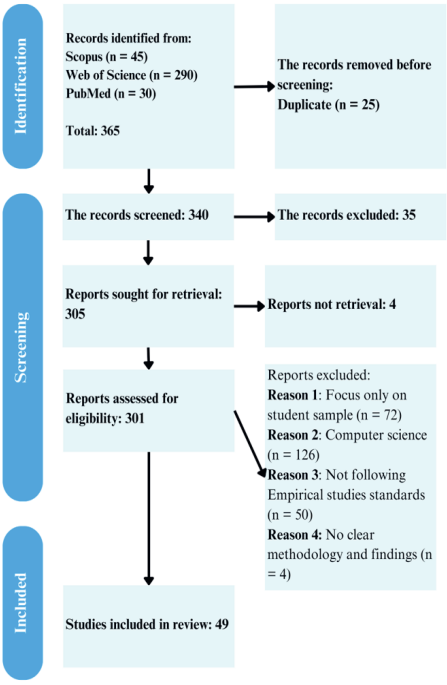
Keywords and databases are two primary components in conducting our search strategy for finding relevant studies. First, the keywords that cover the main body of our literature review are defined based on prior literature reviews in networked learning and professional development (e.g., Schreurs et al., 2019 & Soleymani et al., 2022). The keywords were ("networked learning" OR "network learning" OR "learning network") AND ("professional development" OR "professionals" OR "professional learning"). Second, we have used the three largest databases to find relevant articles: Web of Science, Scopus, and PubMed.

2.2. Defining inclusion and exclusion criteria

To develop our inclusion criteria, we initially screened the relevant studies by including only publications in English. Because the vast majority of scientific papers are in English. Then, we included all articles between 2002 and 2023. Moreover, we only included peer-reviewed papers. Therefore, we did not cover dissertations, book chapters, government reports, or author notes. After this initial screening, in the second phase, our inclusion criteria were as follows: (1) Only studies that followed empirical studies standards were included. Therefore, studies with conceptual and review nature were excluded. (2) Our study focused on professional development, professional learning, and higher education. Therefore, studies with a focus on primary education were also excluded. (3) Using learning networks and networked learning keywords resulted in several papers in our database focusing on technical computer science methods (e.g., neural network analysis), not education. These papers were excluded. To address all these criteria, the authors screened titles, abstracts, and, if needed, the full text of the study. The results of the search findings are presented in Figure 3.2.

Figure 3.2

PRISMA Chart of Literature Review



2.3. Analysis Strategy

In the next step, we developed our coding scheme based on Wenger-Trayner & Wenger-Trayner (2020) value creation framework to analyze the selected studies. A summary of the typical indicators used in this coding scheme is presented in Table 3.1.

Table 3.1

Value creation cycles and their typical indicators (Based on Wenger-Trayner & Wenger-Trayner 2020).

Cycle	Indicator	Source of data
Immediate value: Activities and interactions	-Level of participation, activity, and engagement -Quality of interaction	-Logs and website statistics -Number of queries in the network -Depth of discussion
Potential value: Knowledge capital indicators	-Inspiration -Change in perspective -Level of trust -Documentation -Quality of output	-Self-report -Number of referrals or recommendation -Archives -Frequency of downloads
Applied value: Indicators of changes in practice	-Innovation in practice -Use of social connections -Transferring learning practices	-New ways of solving problems or doing things -Collaborative arrangement -Using networks and tools provided in the network for learning in other contexts
Realized value: Performance improvement, indicators	-Personal improvement -Organizational performance	-Customer feedback, -Business metrics
Enabling values	-Evaluation of what works well to support learning in the network, including activity design, relationship, and more. -Adequate funding for activities	-Feedback forms -Back-channel conversation about the network -Budgets -Complains about technologies
Strategic value	-Frequent moments of reflection by participants on the difference they care to make and how their network can help them achieve it. -Regular conversations with stakeholders -Strategic documents -Stakeholders' perspectives mentioned in interaction among participants	-Interview with stakeholders
Orienting value	-Interest in exploring boundaries -Connections with relevant groups or institutions -Attention to external audiences	-Tracking the frequency and importance of activities oriented to the broader landscape, such as: -Web or literature searches -Invited guests -Cross-boundary activities
-Transformative value	-Changes in identity beyond the space -Changes in mindset -New cultural norms -Changes in policies or regulations	-Stories of personal transformation

3. Results

3.1. Value Creation Indicators

3.1.1. Immediate Value

Most of the reviewed research reported the immediate value of networked learning because it is the foundation of the other values (follow the summary of the indicators in Table 3.2). Creating or promoting the other cycle of value might be easier with proper activities and interaction (Katz & Earl, 2010). Similar studies (Sharimova & Wilson, 2022; De Laat & Schreurs, 2013; Shaari, 2020) showed that informal and formal learning networks (Tynjälä & Nikkanen, 2009) could connect teachers from different schools and regions. Networked learning was an excellent tool for facilitating collaboration and connection between areas with difficult access. Meijs et al. (2016) and Shaari (2020) reported that teachers appreciate connecting with other teachers and see this immediate value as a valuable source for their professional development program.

Table 3.2

Summary of Immediate Value Creation Indicators

Research	Indicators
Prenger et al., 2019	Exchanging information with other teachers from different schools.
Pataraia et al., 2015, 2014	Teachers attending workshops and conferences.
Sharimova & Wilson, 2022	Teacher's networking in a virtual community.
De Laat & Schreurs, 2013	Informal networking of teachers from different schools.
Shaari, 2020	Attending formal workshops.
Tynjälä & Nikkanen, 2009	The networking facilities for teachers from different regions.
Meijs et al., 2016	A formal professional development program for teachers.
Soetanto et al., 2017	Entrepreneurs' interactions.
Moore & Kelly., 2009 Moore & Rutherford., 2012	Primary school headteachers networking.
Sammons et al., 2007	Teachers' networking.
Dos Santos et al., 2017	Networking of companies in a formal learning network.

Melo & Beck, 2015	Formal and informal networking facility in a public teaching hospital.
Peters et al., 2010	Collaboration between business firms.
Knight, 2002	Interaction between network members in an inter-organization network learning setup.
Santo et al., 2016	A collaboration between experts in an informal learning organization.
Coghlan & Coughlan, 2015	Interaction via workshops.
De Laat, 2011	The connection among teachers in different schools.
Lefebvre et al., 2015	Social gathering of entrepreneurs.
Nieminen & Lemmetyinen, 2015	Networking in the formal workshops arranged for entrepreneurs.
Pietri et al., 2015	The connection between food industry experts and stakeholders.
Bergh et al., 2011	The formal networks to facilitate networking with entrepreneurs.
Kelliher & Reinl, 2011	Learning network in the Irish tourism industry.
Alasoini, 2014	Face-to-face and virtual forums for open dialogue.
Leung et al., 2019	IT companies met informally to discuss business problems.
Roosipold, 2012	Cooperation and communication between the network of Estonian Chefs.
Hytönen et al., 2012	Collaboration between experts in the energy efficiency field.
Abdirahman Z.-Z., & Sauvée L, 2012	Interactions between food industry experts in small and medium enterprises (SME).
McCormack et al., 2016	Interaction between higher education stakeholders.
Risien & Goldstein, 2021	Gathering of university professionals to support and share their knowledge and experience.
Del Campol et al., 2008	The closer expertise level and closer location level of employees in an industrial electronics and defense company predict forming mutual ties in their learning network.
Fu et al., 2006	Professionals in knowledge-demanding positions search more actively in their learning network for connection and learning. For example, project leaders – civil engineers learn more actively through their learning networks.

Toiviainen & Vetoshkina, 2018	Communication between the textile, clothing, and interior printing industry networked learning members.
Bayers & Leventon, 2021	Interaction between textile industry experts in the online learning platform.
Leff et al., 2022	Home-based primary care experts interact in online events.

3.1.2. Potential Value

Acquiring new skills and creating documents, tools, and methods to improve the practices are examples of potential value indicators. The online data storage environment, instruction documentation, and information and guidance (Hanraets et al., 2011; Pataraia et al., 2014) might influence potential value creation. Also, teachers believed that the professional development learning network was not only stimulating and informative, but they could acquire new pedagogical knowledge (Prenger et al., 2019). Also, the entrepreneurs built their networks to enable new exploration and expertise from external networks and receive critical reflection from other networkers (Soetanto, 2017). Moreover, the richness, diversity, and relevance of advice provided in the learning network can contribute to potential value (Tynjälä & Nikkanen, 2009; Sharimova & Wilson, 2022; De Laat & Schreurs, 2013; Haythornthwaite et al., 2014).

Table 3.3

Summary of Potential Value Creation Indicators

Research	Indicator
Hanraets et al., 2011	The online data storage environment, instruction documentation, and information and guidance.
Pataraia et al., 2014	The network resources include expertise, information, and guidance.
Prenger et al., 2019	The new pedagogical knowledge gained ideas, insight into the working methods at other schools, and subject-specific knowledge.
Tynjälä & Nikkanen, 2009	Open discussion, knowledge-sharing, and problem-solving sessions.

Sharimova & Wilson, 2022	News, information, opinions, experience, and teaching resources in a virtual professional network of teachers.
De Laat & Schreurs, 2013	Teachers gained new skills and knowledge.
Haythornthwaite et al., 2014	An accumulation of resources in a network of teachers.
Soetanto, 2017	The new exploration and expertise seeking from external networks.
Moore & Kelly, 2009	The support and insight received by working and learning from colleagues in a national learning network of headteachers.
Dirani et al., 2021	Shared vision, embedded systems, and knowledge sharing.
Santo et al., 2016	Knowledge-building activities and discussions in situ. An online space called Hive NYC listserv, blog, portfolios, and the offline spaces for meetups, pop-ups, and more informal collaboration.
De Laat, 2011	An online tool to detect, connect, and facilitate informal networked learning.
Lefebvre et al., 2015	A weekly e-newsletter. Also, participants reported that their networking activities changed their knowledge, perspectives, and reputation.
Randstad, 2009	Creation of new knowledge related to the remuneration system and thematic field.
Pietri et al., 2015	The exchanged information and the connections are established within the network.
Bergh et al., 2011	Experiencing cognitive, emotional, and social changes by participating.
Alasoini, 2014	New competence.
Keliher & Reinl, 2011	Learning new business strategies.

Leung et al., 2019	Presentation of business goals, operation, and revenue data during the meetings.
Roosipõld, 2012	Acquiring new knowledge and competencies.
McCormack et al., 2016	Gaining valuable advice. Tools and templates to document and self-assess current practices, peer review others' practices, and spread examples of good practices.
Risien & Goldstein, 2021	Tools, ideas, and experiences in experimenting with new approaches, exchanged.

3.1.3. Applied Value

Adopting or applying the knowledge and expertise learned in a specific learning space can create applied value. Assessing such value needs more information from participants. For example, networked learning can create applied value by helping the network members to execute work-related tasks and solve teaching problems (Pataraia et al., 2014, 2015; Haythornthwaite et al, 2014), increasing the number of collaboration between the participants (Tynjälä & Nikkanen, 2009), reducing the errors in the practice (De Laat & Schreurs, 2013), improving their teaching expertise (Prenger et al., 2019; Shaari, 2020), and foster changes in thinking and practice (Katz & Earl, 2010).

Table 3.4

Summary of Applied Value Creation

Research	Indicator
Pataraia et al., 2014, 2015	Improvement in executing work-related tasks and solving teaching-related problems.
Haythornthwaite et al., 2014	Improved classroom management and administrative skills.
Tynjälä & Nikkanen, 2009	Increase in regional cooperation and interaction between different fields of study.
De Laat & Schreurs, 2013	Avoiding repetitive work and time and energy saved.

Prenger et al., 2019	Improved lesson practice and experimented more with innovative teaching practices.
Shaari, 2020	Teachers integrated the proposed innovation in their classrooms.
Soetanto, 2017	The entrepreneurs made a change in their business strategy.
Sammons et al., 2007	Improved teachers' school practice.
Dos Santos et al., 2017	Implementing the new management practices in the organizations.
Melo & Beck, 2015	Adapting and filtering external knowledge.
Lefebvre et al., 2015	Starting the tangible business collaborations, such as the co-branding efforts between two corporate communication companies and their joint participation in professional trade shows.
Bergh et al., 2011	Cognitive changes improved how entrepreneurs exploit business opportunities.
Roosipõld, 2012	A network of chefs starts implementing innovative changes in their menu, dishes, and interior design.
McCormack et al., 2016	Network members improved their confidence and skills in giving feedback and advising colleagues.
Leff et al., 2022	Home-based primary care experts improved their performance in multiple work-related areas.

3.1.4. Realized Value

Realized value can be highly context-dependent, demonstrating the impact of networked learning on changes in performance. It can take place at different scales, from small accomplishments like success at solving a problem, career advancement, saving time and money, or satisfying customers, students, or patients to significant effects like student achievement and satisfaction in the education sector. For example, Teachers participating in the learning network could improve their lesson practice and try new teaching techniques, saving time and effort in their exercise (Prenger et al., 2019; De Laat & Schreurs, 2013).

Table 3.5

Summary of Realized Value Creation Indicators

Research	Indicator
Prenger et al., 2019	Improved lesson practice. The influence of networked learning on system improvement is still questionable.
De Laat & Schreurs, 2013	Avoid making mistakes in their teaching practice and save time and energy.
Tynjälä & Nikkanen, 2009	Change in work-based learning strategy and teachers' work culture.
Sammons et al., 2007	Network boosted the overall practice of teachers, pupil engagement, and motivation.
Melo & Beck, 2015	An improvement in the quality of services.
Lefebvre et al., 2015	Entrepreneurs acknowledged cognitive outcomes like improvement in the market and customers' understanding and knowledge. Also, they deepen their knowledge about financial issues and legal requirements of their businesses.
Bergh et al., 2011	Entrepreneurs experienced cognitive, emotional, and social changes.
Keliher & Reinl, 2011	Change in business strategies for entrepreneurs.
Roosipõld, 2012	Development in chefs' food-making skills, innovation, leadership, sales, and other competencies.

3.1.5. Enabling Value

To improve the effectiveness of networked learning, we need to know how to enable learning. Enabling value can come from both internal and external network sources. For example, facilitating one of the network meetings by one of the network members can be an internal enabling value, and having an external expert facilitate the meeting can be an external enabling value. This type of value has both positive and negative sides. Hanraets et al. (2011) discussed the role of

networked facilitators in teachers' professional learning networks. The results show facilitators have a critical role in starting the discussion in the network. School management's support and direct supervision can be crucial in creating enabling value and having an active network. Also, raising awareness about the existence of informal networks and an appreciation of their value using ICT technologies can create enabling value for the network (De Laat & Schreurs, 2013).
Results show that knowledgeable others (Barry, 2023) and formal and informal infrastructural support like funding, physical resources, and expertise (Shaari, 2020) can create enabling value and enhance the professional development of teachers and academics.

Table 3.6

Summary of Enabling Value Creation Indicators

Research	Indicator
Hanraets et al., 2011	Network facilitators, school management's support, and direct supervision in the teachers' professional development network.
De Laat & Schreurs, 2013	Using ICT to raise awareness about informal learning networks of teachers.
Barry, 2023	The 'knowledgeable other' is crucial for academic developers in supporting professional academic learning.
Shaari, 2020	Strong infrastructural support like funding, physical resources, organized activities from management, and expertise.
Prenger et al., 2019	Organizational aspects of network learning like time management during the meetings, the digital environment provided for information exchange, and the structure of guidance by the external coaches.
Sharimova & Wilson, 2022	Online professional development of teachers supported by the government.
Meijs et al., 2016	The guidance and support for teachers to follow their teaching path.
Tynjälä & Nikkanen, 2009	Teachers' learning networks need to be innovative, encourage knowledge-sharing, have an open and equal communication environment, and provide channels for discussion.

Moore & Kelly, 2009	The bureaucratic structures and additional workloads include meetings, minutes, and reports, reduced the quality of interactions.
Moore & Rutherford, 2012	To enable a greater degree of success and system-wide reform in education and raise the standard, teachers must be supported by ongoing funding, resources, and training.
Kubiak, 2009	Facilitators had a significant role in capturing and passing on the knowledge generated within the network.
Dos Santos, 2017	Learning design provided by the business school to promote network learning.
Melo & Beck, 2015	The organization provides clear objectives.
Dirani et al., 2021	Diverse and broad cross-sector learning facilities are needed to make changes and solve the problems in the network.
Santo et al., 2016	Companies provide network learning infrastructures to promote open-source systems.
De Laat, 2011	Informal networked learning visualization tool.
Lefebvre et al., 2015	A business support professional is arranged to manage the network coordination, communication, and organizing activities.
Randstad, 2009	Policymakers had an essential role in network activities and were able to create broader learning infrastructures.
Pietri et al., 2015	The network coordinators to arrange network activities by planning the activities and establishing connections between learners.
Alasoini, 2014	Among different learning networks, the one which received good financial support was successful in local sustainability and producing new competence.
Hytönen et al., 2014	The network members were divided based on location rather than profile similarity, expertise, or assignment, eventually making learning and communication more difficult.

Abdirahman et al., 2018	Besides providing a concrete and consistent framework for SME development, open educational resources within the network, enabled stakeholders to adopt, localize and share learning materials in different contexts.
Risien & Goldstein, 2021	Introducing a regular rhythm by the network leadership to facilitate networking opportunities through the annual summits and a listserv.
Martins & Ling, 2017	The network of creative and digital industries argued that they need a collaborative space or shared physical location to communicate, learn, and conduct different learning activities.
Bayers & Leventon, 2021	The online platform, network events, annual meetings, and expert groups forums are organized to facilitate communication and knowledge flow.

3.1.6. Strategic Value

Typical indicators of strategic value mentioned in the previous research were strategic documents to support the networked learning of teachers (Tynjälä & Nikkanen, 2009) and recognition of the contribution by the participants in the network (Prenger et al., 2019). Mejis et al. (2016), Shaari (2020), and Pataraia et al. (2014) discussed the strategic decision about the topics in the learning network. They mentioned that it is vital to keep participants' autonomy in mind because this negotiation of the objective in the network can trigger changes and improvement.

The success of networking is significantly influenced by power dynamics and power partnerships, which can be observed through three dimensions: authority (network control), micropolitics (internal influence), and legitimacy (external validity). When harnessed positively, these power dynamics generate synergy within networks, serving as a powerful trigger for change (Moore & Kelly, 2009). Furthermore, another study (Kubiak & Bertram, 2010) identified five key leadership activities that facilitate networked learning: (1) initiating partnerships and crafting network proposals, (2) fostering partner alignment and securing buy-in for network goals, (3) establishing structured collaboration opportunities, (4) institutionalizing network activities and capturing practitioner-generated knowledge, and (5) recalibrating network efforts. These activities introduce inherent tensions related to negotiating purpose, ensuring ownership of network activities,

managing time, fostering trust, and striking a balance between short-term achievements and long-term initiatives.

Table 3.7

Summary of Strategic Value Creation Indicators

Research	Indicator
Tynjälä & Nikkanen, 2009	Strategic documents to support the networked learning of teachers.
Prenger et al., 2019	Recognition of the contribution by the participants in the network.
Mejis et al., 2016	82.7% of the teachers in a professional development network believed that their autonomy must be respected in deciding what topics they are interested in.
Shaari, 2020	Negotiating the original objective of the network learning by engagement of an external consultant.
Pataraia et al., 2014	Strategic discussion between participants about establishing, maintaining, and operating learning connections.
Moore & Kelly, 2009	Power dynamics and power partnerships can be influential on the success of networked learning.
Kubiak & Bertram, 2010	Leadership in the network by negotiating purpose, securing ownership of network activities, managing time, and planning the activities.
Moore & Rutherford, 2012	Investing in participants by listing and responding to their viewpoints and concerns.
Dirani et al., 2021	The shared leadership and strategic collaboration between participants.
Lefebvre et al., 2015	Discussed with the members the strategies to improve the network and their interaction with external stakeholders.
Bergh et al., 2011	Trust was an essential part of the network, and initial dialogue about the expectation of the network members and written rule agreements helped this process.
Kelliher & Reinl, 2011	Peer interaction and reflection enabled open discussion regarding learning shortcomings, what has been learned in the network, and how they should continue to learn.

Risien & Goldstein, 2021	A guiding principle document published by the network members includes reflection on core practices.

3.1.7. Orienting Value

We should remember that orientation to the broader landscape comes from the actions in the network and the mindset. Orienting value can be seen as the attention of network members to the external audiences like students in a teachers' professional development network (De Laat & Schreurs, 2013), interest in exploring boundaries (Tynjälä & Nikkanen, 2009), and connections with relevant groups or institution (De Laat & Schreurs, 2013).

Table 3.8

Summary of Orienting Value Creation Indicators

Research	Indicator
De Laat & Schreurs, 2013	Attention to applying knowledge acquired in the network to schools' practice and students.
Tynjälä & Nikkanen, 2009	Interest among the network members to cross boundaries and connect with other networks.
Soentanto, 2017	The entrepreneurs tried to reach new networks to foster new exploration and expertise.
Sammons et al., 2007	Teachers are concerned about the effects of learning networks on schools and students' outcomes and motivation.
Kubiak, 2009	Facilitators were engaged in going beyond the boundaries and sharing the knowledge that resulted from the network with other networks and policymakers.
Melo & Beck, 2015	The hospital experts tried to reach and collaborate with external organizations and institutes.
Dirani et al., 2021	The extensive problems need cross-sector coordination, learning, and knowledge sharing.

Pietro et al., 2015	Network members tried to increase their regional and local capacity and gain access to new information by acting as brokers between networks and other national and regional networks and organizations.
Alasoini, 2014	The connection between learning networks in the industry with universities.
Risien & Goldstein, 2021	Focused on the broader impacts of the community by giving access to network knowledge to those not engaged in it.

3.1.8. Transformative Value

Considering the broad scope of transformative value, it is more complex to assess this than the other value creation cycles. Therefore, the results show that the learning network causes a change in the cultural norm or different ways of doing things. For example, the teachers' learning network changed the mindset from a competitive network to a cooperative network and generally changed teachers' work culture (Tynjälä & Nikkanen, 2009). Moreover, engaging in professional networks changed the participants' identities and reduced their professional isolation (Sharimova & Wilson, 2022).

Table 3.9

Summary of Transformative Value Creation Indicators

Research	Indicator
Sharimova & Wilson, 2022	Identity change and reduction of professional isolation feeling.
Tynjälä & Nikkanen, 2009	Teachers' working culture is influenced by networked learning.
Moore & Kelly, 2009	A fundamental transformation in the network can be facilitated by creating synergy using power dynamics and power partnerships.
Moore & Rutherford, 2012	The strategic and enabling value creation cycle could boost system-wide reform in education and raise the standards in the studied schools.
Dos Santos, 2017	A paradigm shift in executive education.

Santo et al., 2016	Improvement of "open work culture" by helping experts to connect and providing them the infrastructure to network and share their knowledge and expertise.
De Laat, 2011	A transformation of beliefs about learning and training, seeing professional development as a "continuing process of acting, reflecting, and changing day-to-day practices."
Bergh et al., 2011	A change in how entrepreneurs developed social skills and how they observed their social networks.
Kelliher & Reinl, 2011	The new learning strategies were incorporated into different networked learning settings.
McCormack et al., 2016	Reviewing and revising the current protocols in the teaching awards program.

4. Discussion

This paper reviewed the networked learning literature and evaluated 49 studies using the value creation framework. We aim to answer the following research question: What are the characteristics of learning networks, seen from different indicators of the value creation cycles? We introduce the concept of networked learning and explain why they are essential for professional development and innovation. Second, we present value creation theory as a theoretical lens to understand how learning networks generate value for their members and stakeholders. Finally, we presented the literature review results using the value-creation indicators.

4.1. An Overview of the Key Findings

Considering our research question, the characteristics of learning networks that contribute to different indicators of the value creation cycles are evident in the reviewed research. The studies highlight the significance of immediate value creation as a foundational element within networked learning environments. Table 3.2 summarizes that the immediate value is achieved through various activities and interactions. Thus, establishing meaningful connections and utilizing both formal

and informal learning networks are essential characteristics that contribute to immediate value creation.

The potential value explores indicators for creating potential value in networked learning. The characteristics of learning networks that contribute to potential value creation have been mentioned in the result section. The research emphasizes acquiring new skills, creating documents, tools, and methods for improvement, and accessing online data storage environments and instructional documentation.

Concerning the applied value cycle, which focuses on applying and implementing the knowledge gained through networked learning, the reviewed research highlights several characteristics of learning networks that contribute to the value creation cycle. These characteristics suggest that learning networks contributing to the applied value cycle are characterized by opportunities for practical implementation and utilization of knowledge and expertise acquired through networked learning.

The realized value cycle can manifest at various scales. Characteristics of this cycle in learning networks range from small accomplishments, such as problem-solving success, career advancement, and saved time and money, to significant effects, like student achievement and satisfaction in the education sector (e.g., Prenger et al., 2019; De Laat & Schreurs, 2013). Realized value reflects networked learning efforts' tangible and observable results and highlights its potential for meaningful changes in various domains.

The enabling value cycle focuses on the characteristics that contribute to the effectiveness of networked learning by enabling and supporting learning experiences. Enabling value indicators investigated in this study include the role of network facilitators, school management's support and supervision, and ICT used to raise awareness about informal learning networks. These enabling factors create an enabling environment that promotes learning, engagement, and achieving network goals.

Characteristics of the strategic value cycle in networked learning emphasize the importance of strategic decision-making, recognition of participants' contributions, negotiation of objectives, and the overall strategic direction of the network (e.g., Tynjälä & Nikkanen, 2009; Prenger et al., 2019). These indicators emphasize the role of participants' autonomy in negotiating objectives, which can trigger changes and improvements within the network.

The orienting value cycle suggests considering the broader landscape and external audiences in networked learning. The characteristics of this cycle highlight the mindset and actions of network members with their orientation towards external stakeholders, exploration of boundaries, and connections with relevant groups or institutions (e.g., Tynjälä & Nikkanen, 2009; Kubiak, 2009; Melo & Beck, 2015). These indicators and characteristics emphasize the significance of being mindful of the external audiences and highlight the value of exploring boundaries, seeking new connections, and collaborating with external stakeholders and organizations to enhance the impact and effectiveness of networked learning.

The transformative value cycle highlights the impact of learning networks that go beyond surface-level changes and can lead to transformative effects. Characteristics of the transformative value observed in our study are improved cultural norms, mindset shifts, change in participants' identity, reduction of professional isolation (e.g., Sharimova & Wilson, 2022; Moore & Kelly, 2009). These indicators demonstrate that participation in learning networks can profoundly change individuals' perspectives, behaviors, and professional practices.

These findings carry critical theoretical implications. They confirm existing theories on learning networks while introducing new perspectives that expand our understanding of networked learning dynamics. The observed patterns suggest that learning networks, through their diverse value creation cycles, have multifaceted impacts that overextend traditional educational paradigms. These theoretical implications urge reconsideration and further refinement of existing frameworks, inviting the development of more holistic models that better encapsulate the complexities of networked learning environments.

4.2. Main Themes or Patterns Emerged from the Analysis.

The critical characteristics of value creation observed in this study, as summarized in Table 3.10, emphasize the transformative potential of networked learning across diverse professional landscapes. These characteristics (e.g., interaction, engagement, strategic alignment, recognition, decision-making, shared leadership, and collaboration) are essential for immediate learning outcomes and triggers for broader organizational and systemic change. Theoretically, our findings resonate with Wenger's social theory of learning (Wenger & Trayner, 2020), which declares that learning is fundamentally a social phenomenon and extends it by illustrating the mechanisms through which networked learning can operationalize value within professional contexts. Practically, the alignment of networked learning with strategic organizational documents (e.g., Foster et al., 2002 & Tynjälä & Nikkanen, 2009) suggests that institutions can harness these networks for strategic planning and development, going beyond ad-hoc professional development efforts. The recognition of participants' contributions and the promotion of shared leadership not only foster a culture of inclusivity and distributed expertise but also have the potential to democratize knowledge creation and innovation processes within professional settings (Azorín et al., 2019). Future research should delve into the longitudinal impact of these characteristics on organizational learning cultures and their role in the sustainability and adaptability of professional learning networks in the face of technological and economic shifts. Further investigation into how these characteristics interact with diverse professional identities and practices can offer insight into facilitating effective networked learning environments."

Table 3.10

The Key Characteristics of Value Creation Cycles

Value creation cycle	Key characteristics
Immediate Value	-Activities and interactions fostering immediate value -Importance of establishing meaningful connections -Utilizing formal and informal learning networks
Potential Value	-Acquisition of new skills and knowledge -Creating documents, tools, and methods for improvement -Autonomy and relevance in learning network

	-Collaborative learning and innovation
Applied Value	Assistance in executing work-related tasks -Improvement in practices and skills -Increased collaboration and interaction -Reduction of errors and changes in thinking
Realized Value	-Small accomplishments and significant effects -Examples of improved practices and outcomes -Tangible and observable results -Contribution to educational goals
Enabling Value	-Role of network facilitators and management support -ICT technologies and infrastructural support -Organizational aspects and guidance for participants -Creating an enabling environment for learning
Strategic Value	-Strategic decision-making and negotiation -Use of strategic documents and external consultants -Power dynamics, partnerships, and shared leadership -Improvement in strategies and trust-building
Orienting Value	-Orientation towards external stakeholders -Exploration of boundaries and connections -Relevance to school practices and external collaboration -Brokering and establishing connections
Transformative value	-Impact on cultural norms and mindset -Changes in identity and professional isolation -Influence on work culture and paradigm shifts -Beliefs about learning and professional development

4.3. Implications of the Findings for Theory and Practice in Networked Learning

The findings have several implications for both theory and practice in networked learning. These implications provide insights into how networked learning can be designed in a more helpful way for different stakeholders. Our findings contribute to the theoretical understanding of networked learning by identifying key themes and patterns in the value-creation process. This enhances our knowledge of the factors that influence the effectiveness and outcomes of networked learning initiatives. For practitioners and instructional designers, the results of our literature study can shine

a pathway to crafting more impactful networked learning environments. By integrating the critical elements identified—such as fostering collaboration, enabling robust support systems, and facilitating transformative learning experiences—practitioners can engineer strategies that boost learning outcomes and adapt to networked learning cohorts' specific needs and aspirations.

A recent study (Aangenedt et al., 2023) exemplifies the bridge between theory and practice in networked learning environments focused on facilitating behaviors in professional learning networks (PLNs) within higher education. This research identified critical facilitator behaviors across five themes—relationship, space, ownership, direction, and result—through a two-phase approach combining field research and expert panel insights. The introduction of the "Facilitator Compass" model underscores the dynamic nature of value creation facilitated by academic staff in PLNs. This practical example highlights the importance of facilitative leadership in enhancing learning networks' effectiveness, offering a concrete framework that aligns with our theoretical insights on value creation cycles. This model serves as a guide for practitioners to cultivate meaningful, productive learning environments that are responsive to the needs of participants, showcasing a direct application of theoretical concepts in practice. Furthermore, the study on Teacher-Learning Groups TLGs within a teacher training college illustrates how integrating value creation and networked learning principles might contribute to teachers' professional development. By fostering a collective identity and leveraging distributed leadership, these groups enhance sustainable knowledge creation and curriculum development, demonstrating a practical application of networked learning in promoting educational innovation and professional growth (Vrieling et al., 2019).

Overall, the implications of the findings emphasize the need to consider multiple dimensions of value creation in networked learning, ranging from learning outcomes and collaboration to strategic alignment and transformative effects. By incorporating these insights into theory and practice, networked learning initiatives can be designed and implemented more effectively, leading to enhanced learning experiences, professional development, and societal impact.

4.4. Challenges

Besides all the benefits of network learning, some obstacles and challenges must be considered.

First, networked learning requires reliable technology infrastructure, access to digital tools, and digital literacy skills, which can pose challenges for participants with limited resources or technological proficiency (Poortman et al., 2021). This challenge highlights a theoretical need to re-examine learning equity in digital spaces and invites practical solutions such as targeted digital literacy programs (e.g., Choudhary & Bansal, 2022). Second, collaboration in networked learning may face obstacles such as time zone differences, language barriers, unequal participation, and varying levels of commitment among participants (e.g., Hytönen et al., 2014; Tynjälä & Nikkanen, 2009). These barriers pose practical problems and reflect the complex dynamics of globalized learning, suggesting a need for more flexible and culturally sensitive collaboration models (for review, Banfield & Lackie, 2009). Third, sustaining participant engagement and motivation over time can be challenging in networked learning, especially when participants face competing priorities or lack a sense of accountability and time (e.g., Prenger et al., 2019; Moore & Kelly, 2009). The theoretical implications here involve understanding motivation in self-directed learning environments, while from a practical perspective, the development of engaging, gamified learning modules could mitigate this issue (Mahat et al., 2022). Fourth, networked learning enterprises must balance providing participants autonomy and choice in learning topics while ensuring alignment with learning objectives and strategic goals (Pataraia et al., 2014; Mejis et al., 2016). It invites the development of adaptive learning pathways that align personal and professional goals with broader strategic outcomes. Fifth, scaling networked learning while maintaining quality and addressing resource constraints can be challenging. Ensuring long-term sustainability and institutional support is crucial for their continued success (e.g., Moore & Rutherford, 2012; Alasoini, 2014; Risien & Goldstein, 2021). Sixth, assessing learning outcomes and evaluating the effectiveness of networked learning initiatives can be complex, requiring the development of appropriate evaluation frameworks and methodologies (De Laat et al., 2014). Seventh, in designing a social learning environment, we must account for cultural diversity, contextual differences, and varying educational systems, ensuring that learning experiences are inclusive, equitable, and sensitive to local contexts (Bozkurt et al., 2021; Szelei et al., 2019). Recognizing these potential benefits and challenges can inform the design, implementation, and management of networked learning initiatives, enabling practitioners to leverage the benefits while proactively addressing the associated challenges.

4.5. Strengths and Limitations

Our study provides a comprehensive overview of value creation based on Wenger and Trayner (2020) in networked learning by examining multiple dimensions and cycles. Our finding may help identify and highlight key themes and patterns that emerge from the analysis, offering valuable insights into the value creation processes and their implications for theory and practice. We also acknowledge the potential benefits and challenges of value creation in networked learning contexts, presenting a balanced perspective. Our result evidences the complicated value-generation processes in educational settings and is a starting point for future investigations into this evolving field.

The limitation of our study is that first, the study relies primarily on existing literature and references, which may limit the depth and breadth of insights compared to studies that include primary research or empirical data collection. Moreover, some observational and empirical evidence often needs to be included. Second, while the study synthesizes existing literature, it may benefit from incorporating empirical evidence or case studies to strengthen the findings and provide more concrete examples. Third, the study's reliance on existing literature and references means that the analysis is based on information available until the knowledge cutoff date of September 2023. Newer research and developments may be excluded, potentially limiting the study's currency. Fourth, the findings and insights presented in our study may be influenced by the specific contexts, methodologies, and research indicators covered in the reviewed literature. The generalizability of the findings to different contexts or populations should be considered. Fifth, the selection and interpretation of literature and references may introduce some bias or subjectivity. Ensuring a systematic and comprehensive review process can mitigate this limitation. Finally, some themes or patterns identified in the analysis may overlap or have similar implications, leading to potential redundancy or repetition in the study's findings. Addressing and considering these limitations in interpreting and presenting future study findings can contribute to a more robust understanding of value creation in networked learning contexts.

4.6. Our Suggestion for Future Research

Based on the presented results and considering the limitations mentioned earlier, here are some avenues for future research that can help address those limitations and further advance the field of networked learning. First, we see a great need for more empirical research to gather primary data on value creation in networked learning contexts. This can involve surveys, interviews, observations, or case studies that explore the experiences, perceptions, and outcomes of individuals engaged in networked learning. Second, longitudinal studies can help examine the long-term effect of network learning in different contexts. This can provide insights into the sustainability and scalability of value-creation processes over time. Third, by conducting correlational studies, we can explore contextual factors, such as different educational levels, disciplines, or cultural settings, that influence the effectiveness of networked learning enterprises and value creation in the network. Fourth, Investigate the role of emerging technologies, such as artificial intelligence, virtual reality, or social networking platforms, in facilitating value creation in networked learning. Examine how these technologies enhance participants' collaboration, engagement, and knowledge sharing. Fifth, there is a considerable need to explore innovative pedagogical approaches and instructional strategies to optimize value creation in networked learning. This can include inquiry-based, project-based, problem-based, or design-thinking methodologies tailored to networked environments. Finally, policy and governance and ethical considerations are two prominent issues that need to be addressed in future research. The role of the institutional structures, regulations, and support mechanisms necessary to foster effective value creation and ensure equity and inclusivity in networked learning contexts need to be considered, as how privacy, data protection, and the ethical use of technologies can be integrated into the design and implementation of networked learning initiatives. In summary, these proposed directions for future research seek to bridge the gaps identified in the present study and to chart new environments in networked learning, thereby contributing to a more profound, impactful, and ethically grounded understanding of its value creation potential.

5. Conclusion

In conclusion, our extensive review of the literature on value creation in networked learning has provided valuable insights into critical factors, processes, and outcomes that define the effectiveness of networked learning initiatives. Our findings emphasized the complex dynamics of value creation and highlighted its vital role in enhancing educational experiences and outcomes. Also, our findings support a deeper investigation into the role of technology, the impact of network characteristics, and the cultural, social, and contextual factors that drive value creation, including addressing equity, diversity, and inclusion. By expanding the knowledge of value creation in networked learning, researchers, practitioners, and policymakers can collaborate to develop evidence-based practices, design effective interventions, and inform policy decisions. This study highlights the importance of ongoing research, collaboration, and innovation in shaping the future of professional education and networked learning.

References

Aangenendt, M., Sjoer, E., & Wallner, C. (2023). Facilitation of value creation in professional learning networks. *Higher Education Studies, 13*(3), 31. https://doi.org/10.5539/hes.v13n3p31

Abdirahman, Z.-Z., Bourquin, L., Sauvée, L., & Thiagarajan, D. (2018). Food safety implementation in the perspective of network learning. *International Journal of Food Studies, 7*, 17-29. https://doi.org/10.7455/IJFS/7.2.2018.A2

Abdirahman, Z.-Z., & Sauvée, L. (2013). The Implementation of a Quality Management Standard in a Food SME: A Network Learning Perspective. *Journal on Food System Dynamics, 3*(3). https://doi.org/10.18461/ijfsd.v3i3.333

Alasoini, T. (2014). Learning from learning networks. Experiences of the Finnish Workplace Development *Programme. International Journal of Action Research, 10*(3), 310-338.

Azorín, C., Harris, A., & Jones, M. (2020). Taking a distributed perspective on leading professional learning networks. *School Leadership & Management*, *40*(2-3), 111-127. https://doi.org/10.1080/13632434.2019.1647418

Baker-Doyle, K. J., & Yoon, S. A. (2011). In search of practitioner-based social capital: a social network analysis tool for understanding and facilitating teacher collaboration in a US-based STEM professional development program. *Professional development in Education, 37*(1), 75-93.

Banfield, V., & Lackie, K. (2009). Performance-based competencies for culturally responsive interprofessional collaborative practice. *Journal of Interprofessional Care*, *23*(6), 611-620. https://doi.org/10.3109/13561820902921654

Barry, W. (2023). The role of 'knowledgeable others' in supporting academics' professional learning: implications for academic development. *Perspectives: Policy and Practice in Higher Education, 27*(1), 16-25. https://doi.org/10.1080/13603108.2022.2131650

Bergh, P., Thorgren, S., & Wincent, J. (2011). Entrepreneurs learning together: The importance of building trust for learning and exploiting business opportunities. *International Entrepreneurship and Management Journal, 7*, 17-37. https://doi.org/10.1007/s11365-009-0120-9

Beyers, F., & Leventon, J. (2021). Learning spaces in multi-stakeholder initiatives: The German Partnership for Sustainable Textiles as a platform for dialogue and learning? *Earth System Governance, 9*, 100113. https://doi.org/https://doi.org/10.1016/j.esg.2021.100113

Bozkurt, A., Yazıcı, M., & Aydın, I. (2018). Cultural Diversity and Its Implications in Online Networked Learning Spaces. In E. Toprak & E. Kumtepe (Eds.), Supporting Multiculturalism in Open and Distance Learning Spaces (pp. 56-81). IGI Global. https://doi.org/10.4018/978-1-5225-3076-3.ch004

Burgess, M., Currie, J., & Maor, D. (2004). Technology Enhancements across Cultures in Higher Education. In Online Professional Development for Teachers. *Information Age Publishing Inc* (pp. 159-176).

Choudhary, H., & Bansal, N. (2022). Barriers Affecting the Effectiveness of Digital Literacy Training Programs (DLTPs) for Marginalised Populations: A Systematic Literature Review. *Journal of Technical Education and Training*, *14*(1), 110-127.

Coghlan, D., & Coughlan, P. (2014). Effecting Change and Learning in Networks Through Network Action Learning. *The Journal of Applied Behavioral Science, 51*(3), 375-400. https://doi.org/10.1177/0021886314540210

Council, N. R. (2012). Education for Life and Work: Developing Transferable Knowledge and Skills in the 21st Century. *The National Academies Press.* https://doi.org/doi:10.17226/13398

De Laat, M., & Schreurs, B. (2013). Visualizing Informal Professional Development Networks: Building a Case for Learning Analytics in the Workplace. *American Behavioral Scientist, 57*(10), 1421-1438. https://doi.org/10.1177/0002764213479364

De Laat, M. (2011). Bridging the Knowledge Gap: Using Social Network Methodology for Detecting, Connecting and Facilitating Informal Networked Learning in Organizations. In Proceedings of 44th Hawaii International Conference on System Sciences.

De Laat, M., Schreurs, B., & Sie, R. (2014). Utilizing Informal Teacher Professional Development networks using the Network Awareness Tool. In. https://doi.org/10.4324/9780203591093

Edwards, S., & Romeo, G. (2003). Interlearn: An online teaching and learning system developed at Monash University. In Proveedings of World Conference on eLearning in Corporate, Government, Healthcare and Higher Education (ELEARN), Phoenix, AZ.

Foster, J., Bowskill, N., Lally, V., & McConnell, D. (2002). Managing Institutional Change for Networked Learning: A Multi-Stakeholder Approach. In C. Steeples & C. Jones (Eds.), *Networked Learning: Perspectives and Issues* (pp. 125-141). Springer London. https://doi.org/10.1007/978-1-4471-0181-9_8

Fu, W. K., Lo, H. P., & Drew, D. S. (2006). Collective learning, collective knowledge, and learning networks in construction. *Construction Management and Economics, 24*(10), 1019-1028. https://doi.org/10.1080/01446190500228258

Gao, L., Ward, R., & Fabricatore, C. (2023). The value creation in communities of inquiry: a systematic synthesis. *SN Social Sciences*, *3*(5). https://doi.org/10.1007/s43545-023-00659-x

Garrison, D. R. (2007). Online community of inquiry review: Social, cognitive, and teaching presence issues. *Journal of Asynchronous Learning Networks,11*(1), 61-72.

Hanraets, I., Hulsebosch, J., & De Laat, M. (2011a). Experiences of pioneers facilitating teacher networks for professional development. *Educational Media International, 48*(2), 85-99.

Hytönen, K., Palonen, T., Lehtinen, E., & Hakkarainen, K. (2014). Does academic apprenticeship increase networking ties among participants? A case study of an energy efficiency training program. *Higher Education, 68*(6), 959-976. https://doi.org/10.1007/s10734-014-9754-9

Katz, S., & Earl, L. (2010). Learning about networked learning communities. *School Effectiveness and School Improvement, 21*(1), 27-51. https://doi.org/10.1080/09243450903569718

Kelliher, F., & Reinl, L. (2011). From Facilitated to Independent Tourism Learning Networks: Connecting the Dots. *Tourism Planning & Development, 8*(2), 185-197. https://doi.org/10.1080/21568316.2011.573919

Khalil, D., Baldauf, J., Medina-Cetina, Z., Wowk, K., Herzka, S., Ricardo Bello, B., . . . Munoz Ubando, L. A. (2021). Learning organization as a framework for networks' learning and collaboration. *The Learning Organization, 28*(4), 428-443. https://doi.org/https://doi.org/10.1108/TLO-05-2020-0089

Knight, L. (2002). Network Learning: Exploring Learning by Interorganizational Networks. *Human Relations, 55*(4), 427-454. https://doi.org/10.1177/0018726702554003

Koper, R. (Ed.). (2009). Learning Network Services for Professional Development. Berlin: Springer. https://doi.org/10.1007/978-3-642-00978-5

Kubiak, C. (2009). Working the Interface: Brokerage and Learning Networks. *Educational Management Administration & Leadership, 37(*2), 239-256. https://doi.org/10.1177/1741143208100300

Kubiak, C., & Bertram, J. (2010). Facilitating the development of school-based learning networks. *Journal of Educational Administration, 48*(1), 31-47. https://doi.org/10.1108/09578231011015403

Lave, J., & Wenger, E. (1991). Situated Learning: Legitimate Peripheral Participation. Cambridge University Press. https://doi.org/DOI: 10.1017/CBO9780511815355

Lefebvre, V., Radu Lefebvre, M., & Simon, E. (2015). Formal entrepreneurial networks as communities of practice: a longitudinal case study. *Entrepreneurship & Regional Development, 27*(7-8), 500-525. https://doi.org/10.1080/08985626.2015.1070539

Leff, B., Ritchie, C., Freeland, D. G., Jamshed, N., Major, A., Gallopyn, N., Sheehan, O. C. (2022). The National Home-Based Primary Care Learning Network: A Practice-Based Quality Improvement and Research Network. *Journal of the American Medical Directors Association, 23*(8), 1424-1426. https://doi.org/https://doi.org/10.1016/j.jamda.2022.02.017

Leung, A., Xu, Q., Wu, G., & Luthans, K. (2019). Industry peer networks (IPNs): Cooperative and competitive interorganizational learning and network outcomes. *Management Research Review, 42*, 122-140. https://doi.org/10.1108/MRR-02-2018-0057

Mahat, J., Alias, N., & Yusop, F. D. Systematic literature review on gamified professional training among employees. *Interactive Learning Environments*, 1-21. https://doi.org/10.1080/10494820.2022.2043910

Martins, J. T., & Ling, S. (2017). Local enterprise partnerships: Socialisation practices enabling business collective action in regional knowledge networks. *Knowledge and Process Management, 24*(4), 269-276. https://doi.org/https://doi.org/10.1002/kpm.1546

McCormack, C., Ambler, T., Martin, B., Waite, K., & Wilson, A. (2016). Narrative-based evaluation demonstrates the value of a higher education professional learning network. *Studies in Educational Evaluation, 50*, 79-87. https://doi.org/https://doi.org/10.1016/j.stueduc.2016.07.003

Meijs, C., Prinsen, F. R., & de Laat, M. F. (2016). Social learning as approach for teacher professional development; how well does it suit them? *Educational Media International, 53*(2), 85-102. https://doi.org/10.1080/09523987.2016.1211333

Melo, S., & Beck, M. (2015). Intra and Interorganizational Learning Networks and the Implementation of Quality Improvement Initiatives: The Case of a Portuguese Teaching Hospital. *Human Resource Development Quarterly, 26*(2), 155-183. https://doi.org/https://doi.org/10.1002/hrdq.21207

Moore, T. A., & Desmond, R. (2011). Primary Strategy Learning Networks: A Local Study of a National Initiative. *Educational Management Administration & Leadership, 40*(1). https://doi.org/10.1177/1741143211420612

Moore, T. A., & Kelly, M. P. (2009). Networks as power bases for school improvement. *School Leadership & Management, 29*(4), 391-404. https://doi.org/10.1080/13632430903152070

Networked Learning Editorial, C. (2021). Networked Learning: Inviting Redefinition. *Postdigital Science and Education, 3(*2), 312-325. https://doi.org/10.1007/s42438-020-00167-8

Nieminen, L., & Lemmetyinen, A. (2015). A value-creating framework for enhancing entrepreneurial learning in networks. *Journal of Enterprising Communities, 9*(1), 76-91. https://doi.org/https://doi.org/10.1108/JEC-04-2013-0012

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D. & Brennan, S. E. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *International journal of surgery, 88*.

Pataraia, N., Margaryan, A., Falconer, I., & Littlejohn, A. (2015). How and what do academics learn through their personal networks. *Journal of Further and Higher Education, 39*(3), 336-357. https://doi.org/10.1080/0309877X.2013.831041

Peters, L. D., Johnston, W. J., Pressey, A. D., & Kendrick, T. (2010). Collaboration and collective learning: networks as learning organisations. *Journal of Business & Industrial Marketing, 25*(6), 478-484. https://doi.org/10.1108/08858621011066062

Pietri, D. M., Stevenson, T. C., & Christie, P. (2015). The Coral Triangle Initiative and regional exchanges: Strengthening capacity through a regional learning network. *Global Environmental Change, 33*, 165-176. https://doi.org/https://doi.org/10.1016/j.gloenvcha.2015.05.005

Poortman, C. L., Brown, C., & Schildkamp, K. (2022). Professional learning networks: a conceptual model and research opportunities. *Educational Research*, *64*(1), 95-112. https://doi.org/10.1080/00131881.2021.1985398

Prenger, R., Poortman, C. L., & Handelzalts, A. (2018). The Effects of Networked Professional Learning Communities. *Journal of Teacher Education, 70*(5), 441-452. https://doi.org/10.1177/0022487117753574

Ramstad, E. (2009). Developmental evaluation framework for innovation and learning networks. *Journal of Workplace Learning, 21*(3), 181-197. https://doi.org/10.1108/13665620910943924

Risien, J., & Goldstein, B. E. (2021). Boundaries Crossed and Boundaries Made: The Productive Tension Between Learning and Influence in Transformative Networks. *Minerva, 59*(4), 539-563. https://doi.org/10.1007/s11024-021-09442-9

Roosipõld, A. (2012). Changes in Work and Organizational Structure, using a 'Supportive Learning Network'. *International Journal of Learning, 18*, 229-252. https://doi.org/10.18848/1447-9494/CGP/v18i11/47810

Sammons, P., Mujtaba, T., Earl, L., & Gu, Q. (2007). Participation in network learning community programmes and standards of pupil achievement: does it make a difference? *School Leadership & Management, 27*(3), 213-238. https://doi.org/10.1080/13632430701379412

Sanchez de Pablo, J. D., Guadamillas, F., Dimovski, V., & Skerlavaj, M. (2008). Exploratory study of organizational learning network within a Spanish high-tech company. Zbornik Radova Ekonomskog Fakulteta u Rijeci / Proceedings of Rijeka School of Economics, 26.

Santo, R., Ching, D., Peppler, K., & Hoadley, C. (2016). Working in the Open: lessons from open source on building innovation networks in education. *On the Horizon, 24*(3), 280-295. https://doi.org/10.1108/OTH-05-2016-0025

Santos, P., Vaz, S., & Versiani, Â. (2017). Rethinking the business school's value proposition: The coordination of learning networks. *International Journal of Management in Education, 11*, 311. https://doi.org/10.1504/IJMIE.2017.084939

Schreurs, B., Cornelissen, F., & De Laat, M. (2019). How do Online Learning Networks Emerge? A Review Study of Self-Organizing Network Effects in the Field of Networked Learning. *Education Sciences*, *9*(4).

Shaari, I. (2020). Lateral networks of teachers in a centralised education system: Structures, processes, and development of teacher agency. *Asia Pacific Journal of Education, 40*(4), 516-532. https://doi.org/10.1080/02188791.2020.1838879

Sharimova, A., & Wilson, E. (2022). Informal learning through social media: exploring the experiences of teachers in virtual professional communities in Kazakhstan. *Professional Development in Education*, 1-13. https://doi.org/10.1080/19415257.2022.2097291

Soetanto, D. (2017). Networks and entrepreneurial learning: coping with difficulties. *International Journal of Entrepreneurial Behavior & Research, 23*(3).

Soleymani, A., de Laat, M., Itard, L. C. M., & Specht, M. M. (2022). *How Networked learning can facilitate professional development?* In Proceeding of 13th International Conference on Networked Learning, Sundsvall, Sweden.

Sorensen, E. K. (2005). Networked eLearning and collaborative knowledge building: Design and facilitation. *Contemporary Issues in Technology and Teacher Education, 4*(4), 446–455.

Spilker, M. J., Prinsen, F., & Kalz, M. (2019). Valuing technology-enhanced academic conferences for continuing professional development. A systematic literature review. *Professional Development in Education, 46*(3), 482–499. https://doi.org/10.1080/19415257.2019.1629614

Stoll, L. (Ed.) (2004). Developing leadership for learning communities. Developing leadership: Creating the schools of tomorrow. Sage Publications Ltd, https://doi.org/10.4135/9781446288931

Szelei, N., Tinoca, L., & Pinho, A. S. (2020). Professional development for cultural diversity: the challenges of teacher learning in context. *Professional Development in Education*, *46*(5), 780-796. https://doi.org/10.1080/19415257.2019.1642233

Toiviainen, H., & Vetoshkina, L. (2018). Learning for the Complex Object of Work in a Digital Printing Network. *Studia paedagogica, 23*, 25. https://doi.org/10.5817/SP2018-2-3

Tynjälä, P., & Nikkanen, P. (2009). Transformation Of Individual Learning Into Organisational And Networked Learning In Vocational Education. In M.-L. Stenström & P. Tynjälä (Eds.), Towards Integration of Work and Learning: Strategies for Connectivity and Transformation (pp. 117-135). Springer Netherlands. https://doi.org/10.1007/978-1-4020-8962-6_7

Varga-Atkins, T., Qualter, A., & O'Brien, M. (2009). School professionals' attitudes to professional development in a networked context: developing the model of 'believers, seekers and sceptics. *Professional development in education, 35*(3), 321–340.

Vrieling, E., Wopereis, I., Van Den Beemt, A., De Laat, M., & Brand-Gruwel, F. (2019). Analysing social learning of Teacher-Learning groups that aim at knowledge creation. In Research in networked learning (pp. 207–222). https://doi.org/10.1007/978-3-030-18030-0_12

Wenger, E., Trayner, B., & De Laat, M. (2011). Promoting and assessing value creation in communities and networks: A conceptual framework. Retrieved on 23rd of October 2024 from http://www.open.ou.nl/rslmlt/Wenger_Trayner_DeLaat_Value_creation.pdf

Wenger, E., & Wenger-Trayner, B. (2020). Learning to make a difference: value creation in social learning spaces. Cambridge University Press.

Part 2.

Pedagogical Challenges:
Learning Networks in Focus

This part is based on:

Soleymani, A., Itard, L., de Laat, M., Valle Torre, M., & Specht, M. (2022). Using Social Network Analysis to Explore Learning Networks in MOOCs Discussion Forums. *CLIMA 2022 Conference*. https://doi.org/10.34641/clima.2022.300
&
Soleymani, A., Van Den Brom, P., Ahmed, S., Konings, M., Sjoer, E., Itard, L., Zeiler, W., De Laat, M., & Specht, M. (2023). Learning Networks and Professional Development in Building Energy Management Systems Industry. *Education Sciences, 13*(2), 215. https://doi.org/10.3390/educsci13020215

Introduction

As we move from the foundational insights into networked learning and its transformative potential for professional development discussed in part one, "Foundation of Transformation," we encounter the next section, "Pedagogical Challenges." This part consists of two case studies focusing on the dynamics and inherent challenges of implementing networked learning effectively across diverse platforms and learning environments. By identifying and analyzing these challenges, this part aims to bridge significant gaps in current pedagogical practices and provide precise strategies for enhancing learning outcomes in networked settings.

Chapter Four examines a comprehensive social network analysis of MOOC learners across three distinct courses. This chapter provides a complete understanding of learner engagement and network structure and identifies potential areas for pedagogical intervention to optimize learning processes within MOOCs.

Chapter Five shifts the spotlight toward a qualitative examination of professional learning networks through interviews with industry partners involved in our project. This chapter is a significant part of this dissertation, as it aims to uncover professional learners' specific needs and challenges, thereby contributing valuable perspectives to the discourse on networked learning in professional development contexts.

Chapter 4.

Using Social Network Analysis to Explore Learning Networks in MOOC Discussion Forums

Abstract

Learning and educational challenges in the field of indoor climate and building services like energy systems are mainly due to the transformation of professional practices, a significant shift in the way in which people work, communicate, and share their knowledge, and the need for additional workforce, either juniors or coming from other disciplines. Networked learning is among the most important factors influencing professional development and workplace learning. Our goal in this study is to understand the characteristics of learning networks and patterns of interaction using Social Network Analysis (SNA) techniques in three MOOC discussion forums. The result of this study shows not only the importance of learning networks and peer support in the professionalization of learners but also how the pedagogical approach of instructors in MOOCs can foster learning networks. This novel approach to developing learning networks and communities not only helps connect young professionals and experienced practitioners digitally but also promotes professional development and innovation in the energy installation sector.

Keywords: Professional learning networks, Social network analysis, Lifelong learning, Massive Online Open Courses

1. Introduction

Massive Open Online Courses (MOOCs) have received significant attention recently. MOOCs allow students and professionals to educate or up-skill themselves, learn new skills, communicate, and build a professional network. Through MOOCs, several thousand learners actively engage in a learning process with self-organized participation and different goals, backgrounds, knowledge, and skills but with a common interest (McAuley et al., 2010). Many MOOC participants use this learning opportunity for continued education and professional development for different reasons, from personal curiosity to enhancing workplace or professional skills.

Learning and educational challenges in indoor climate and building services like energy systems are mainly due to the transformation of professional practices and learning networks and the need for an additional workforce, either juniors or other disciplines. Therefore, MOOCs and their learning opportunities can tackle many educational challenges and help professional development. Besides the benefits of MOOCs for professional development, they also provide an excellent opportunity for learners to communicate with their peers and shape a learning community or network. As also mentioned by McAuley et al. (2010), MOOCs can "model and build collaborative networks of unprecedented size that transcend time and space," and the "network ties created between people during a MOOC have the potential to continue as sustainable and relevant personal and professional connections beyond the boundaries of the course itself" (p. 35). Therefore, there is a significant need to understand the learner's behavior and learning networks in MOOCs.

To build knowledge about how professional learning in MOOCs can serve as a catalyst for the development of learning networks and foster continued networked learning amongst peers driven by workplace challenges as experienced in daily practice, in this research, we investigate peer interaction and support in MOOCs developed for Buildings as Sustainable Energy Systems (BSES) professional certificate program in EdX platform by researchers at TU Delft, the Netherlands.

In the last 15 years, online social networks have grown dramatically, enabling companies like Facebook, Twitter, and Linked-In to collect and analyze user data in detail. These social network

technologies have also supported and developed Learning Networks (LN). Social Network Analysis (SNA) can be used to understand and help educational communities and learning networks to identify structures and essential topics and links to enhance the learning outcomes and professional exchange (De Laat et al., 2007; Haythornthwaite & De Laat., 2010; Schreurs et al., 2019a; Schreurs et al., 2019b).

Siemens (2005), in explaining the theory of connectivism, mentioned that learning is a process of network formation and connections are the key to networked learning. Literature reviews have shown that the use of learning communities and learning networks can improve individuals' and organizations' ability to learn (Topsectoren, 2019). As Lave and Wenger (1991) describe, learning communities have been used for people who interact regularly, share the same concern or passion for something, and aim to improve their knowledge and practice. Networks of Practice (NoP) or learning networks (Brown & Duguid., 2001) have been used to describe a more informal and developing social network that encourages and supports the sharing of knowledge and information between people who gather around the same practice and profession. Social Network theory claims that the structure of social relations can explain the different social science variables and facilitate or hinder the results for individuals (Borgatti et al., 2009). Reviewing the literature in online learning settings shows the correlation between network structure and measures and academic achievements like academic performance (Cho et al., 2007; Russo & Koesten., 2005), knowledge construction (Aviv et al., 2003; Rossi., 2010), and a more positive attitude toward the learning experience (Dawson., 2008; Lowes et al., 2007). Therefore, there is a need to conduct more research on network learning in the online learning environment. Also, exploring the mechanisms involved in shaping networks and knowing about the structure of learning networks and, in general, network thinking can expand our understanding of the learning process as a social phenomenon. Given these questions, this case study tries to address the crucial aspects of the social learning process and professional development in MOOCs using social network analysis (SNA) techniques.

2. Research Methods

For this study, we use the discussion forum posts of participants who engaged in three MOOCs. Course 1: Energy Demand in Buildings (EDB), course 2: Energy Supply Systems for Buildings (ESSB), and course 3: Comfort and Health in Buildings (CHB). These online courses are part of the "Buildings as Sustainable Energy Systems professional certificate program" on the EdX platform provided by researchers at TU Delft, the Netherlands. The MOOCs are freely available, and students pay only if they want a certificate. MOOC's discussion forum data was arranged in a MongoDB database. A Python script extracted three variables: discussion ID, discussion creator, and discussion poster. Each thread created in the forum is a discussion ID. The discussion creator refers to the user ID that initially created the thread, and the participants who participated in that thread are named discussion posters.

Course one, Energy Demand in Buildings (EDB), was the biggest course with over 6500 participants, and courses 2 and 3 were smaller by around 5000 participants. As we mentioned earlier, these courses were freely available to everyone. Still, the participants also had a chance to receive the certificate by passing a specific assignment covering the contents of the entire course and paying for the program, and we called this group the "Certified" participants. Therefore, only 7-10 percent of participants were certified. In the result section, we will explore if there is any difference between these two groups of participants. Three tutors and moderators were also involved in discussion forums to mediate the discussions and answer participants' questions. Participants of these MOOCs include a range of people, from high school students who are interested in indoor energy systems to senior HVAC designers who want to update or upscale their knowledge.

In our Analysis, we entered all the posts in each course discussion forum. These courses were presented for the first time, and we analyzed the first round of data from these courses. This series of courses was designed to promote learning through social interaction and focused more on student-centered structure instead of only teacher-centered interaction (for example, students were expected to answer teacher questions and address learning tasks based on video lectures).

3. Results

Social Network Analysis gives us a descriptive overview of our network structure and identifies patterns. We summarized the descriptive overview of the network of forum interaction in Table 4.1.

As shown in the table, the number of replies to peer posting (edges) increases with the number of participants in the forum (vertices). Graph density measures how many ties or connections exist between learners, compared to how many connections or ties between learners are possible. Evaluating the network's density can help us understand how connected the networks are compared to how connected they might be, and this research can also reveal the difference between networks. In this case, our graph density, which is the number of unique edges (replies to peer posting) out of all possible edges, decreased in the MOOC one, which had a higher number of participants (the number of possible replies to peer posting increased steadily with the number of vertices (participants) in the network).

Table 4.1

Descriptive overview of the forums' interaction.

Network Metrics	MOOC 1	MOOC 2	MOOC 3
Vertices[1]	278	98	100
Unique edges[2]	503	156	161
Edges with Duplicates[3]	274	128	112
Total edges[4]	777	284	273
Edge weight avg.[5]	2.92	1.93	2.69
Reciprocated vertex pair ratio[6]	0.04	0.03	0.02
Reciprocated edge ratio[7]	0.09	0.06	0.04
Graph density[8]	0.006	0.01	0.03
In/outdegree avg.[9]	2.12	2.07	1.98
In/outdegree median[10]	1	1	1
Indegree range[11]	0-89	0-12	0-14
Outdegree range[12]	0-57	0-30	0-30

1. Vertices (number of participants): This represents the total number of unique participants in the discussion forum.
2. Unique edges (number of replies to a post): This indicates the number of unique connections or interactions (replies) between participants.
3. Edges with Duplicates: This counts the number of repeated interactions between the same participants.
4. Total edges: The sum of unique edges and edges with duplicates, representing all interactions in the network.
5. Edge weight avg.: The average number of interactions per connection. A higher value suggests more frequent interactions between participants.
6. Reciprocated vertex pair ratio: The proportion of participant pairs that have mutual interactions (both participants have replied to each other).
7. Reciprocated edge ratio: The proportion of interactions that are reciprocated, meaning both participants have replied to each other.
8. Graph density: A measure of how connected the network is. It is calculated as the ratio of actual connections to possible connections. A higher density indicates a more interconnected network.
9. In/outdegree avg.: The average number of incoming and outgoing connections per participant. This gives an idea of how active participants are in terms of receiving and sending replies.
10. In/outdegree median: The median number of incoming and outgoing connections per participant, providing a central tendency measure that is less affected by outliers.
11. Indegree range: The range of incoming connections (replies received) per participant, showing the variation in how many replies participants receive.
12. Outdegree range: The range of outgoing connections (replies sent) per participant, showing the variation in how many replies participants send

We can define the reciprocal vertex pair ratio as the ratio between ingoing and outgoing connections. The higher ratio can show that a person engages in more two-way interaction or exchange. Our first MOOC, with the higher number of active participants in the forum, had a higher reciprocated vertex pair ratio than MOOCs 2 and 3. The percentage of replies to peer posts with a reciprocal relationship (mutual interchange) can be defined as the reciprocated edge ratio. Again, our first course had a higher score, which replicated the higher number of mutual interactions in peer replies.

In an edge-weighted network, weight may represent the length of the edges (in this case, replies to peer posting). Therefore, considering the average edge weight in our MOOCs, they show that participants in course two (Energy Supply Systems for Buildings (ESSB)) were less interested in communicating with their peers in comparison with courses 1 and 3. Furthermore, although the number of participants in course one was around 20 percent more than in the two other courses, the total number of vertices and edges in this course is significantly higher.

However, when we categorize the participants into certified and non-certified participants, we can see that certified participants were more active in the discussion forums. They tried to shape more mutual relationships with their peer and interact more. In Table 4.2, more information about the networked measures of these two groups of participants is presented.

Table 4.2

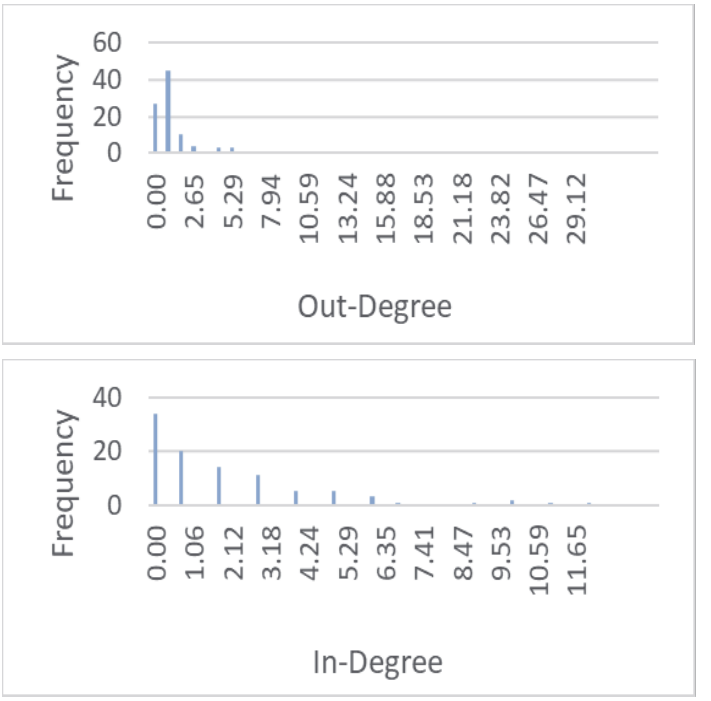
Networks Measures - Considering Certified and Not Certified Participants

Network Metrics	MOOC 3		MOOC 2		MOOC 1	
	Not certified	Certified	Not certified	Certified	Not certified	Certified
Vertices	9	52	24	55	35	140
Unique edges	8	68	18	85	38	218
Edges with Duplicates	2	23	23	48	64	184
Total edges	10	91	41	133	102	402
Edge weight avg.	1.2	1.37	8.90	1.73	7.84	3.73
Graph density	0.11	0.02	0.03	0.02	0.03	0.01

However, we can detect some basic patterns besides the differences between these three networks. In directed networks, like discussion forums (someone answers someone else post and receives an answer), we have two measures of the connections linked to a vertex. In-degree is considered as the total number of connections that point inward at a vertex (In our case, the number of replies that someone receives for the post), and out-degree is the total number of connections originated from a vertex (number of replies that someone gives to someone else post) (Hansen et al., 2020). In our sample, all three networks show a similar pattern in the in/outdegree average distribution, as shown in Figure 4.1. Many of the network actors had support ties with around two other peers, which we considered "core" participants. Also, edge weights show that most ties between participants are not just a single communication, but they tend to have more responses. This can represent the depth of discussions necessary for shaping the productive learning network.

Figure 4.1

Proportion of Out and In-Degree Distribution in MOOC 2



4. Discussion

Social Networks are "a set of relations, interactions, and connection with affordances for learning, such as information flows helpful linkages, joint problem solving, and knowledge creation" (Wenger et al., 2011, p. 9). In this research, we investigated the role of discussion forums in facilitating professional networks and networked learning in MOOCs. Understanding learners' behavior in learning networks in MOOCs, the structure of these networks, and patterns can help us understand the fundamentals of professional development.

In agreement with current findings (Pampouri et al., 2021), our results show the fundamental role of MOOCs design and the pedagogical approach of MOOCs instructors in gaining the desired out of these new online learning opportunities. Social network measures can help the energy sector on how to go forward with a networked learning-based approach to promote network community-based peer learning given the challenges experienced in their workplace. Professional networks allow for raising challenges in various workplaces and encourage learning and problem-solving based on a rich and diverse context of professional experiences. Based on our results of Social Network Analysis, we can suggest several design elements for future MOOCs in the technical field, such as energy management systems in buildings. Building thriving online communities has been studied and extensively discussed by Kraut and Resnick (2012), who introduced designs encouraging learners to share and exchange knowledge in online communities. First, it is suggested that a simple contribution request can raise greater compliance among learners than lengthy and complicated requests. Second, in agreement with the previous findings (de Lima et al., 2019), mediators can play an essential role in facilitating the discussions, providing quick and practical information about the course contents, and solving the learners' challenges during the course. In our MOOCs, mediators and tutors were actively engaged in discussion, and our network measures show their effects.

Third, along with the findings in the medical professional development field (Lin et al., 2016), participants are more interested in sharing their knowledge and experience through online discussion forums when their peers have similar professional roles, work contexts, or experiences. For example, tutors asked participants to share their background and personal experiences with

others in this series of MOOCs. It could increase the interactions (e.g., Measured using in and out-degree in our networks). Finally, we need to focus on the quantity of interactions and the quality of exchanges that can play a significant role in a productive discussion forum (Tibi, 2016; Woo & Reeves, 2008). High-quality and meaningful interaction can be considered an exchange that stimulates the intellectual curiosity of learners (Pear & Crone-Todd, 2002). Exchanging the information that is directly relevant to the learners' real-life situation and applied to similar cultures or applied settings (Brown et al., 1989), providing clear guidelines for discussions and interactions (Pear & Crone-Todd, 2002), and setting or defining the expectations of learners, both in formal and informal learning context (Rovai, 2001) are the most key strategies to have a successful and a high-quality online discussion forum. Future research can investigate the quality of exchanges in online learning forums using modern content analysis methods to better understand the social learning process and empower the potential of learning networks and communities.

5. Conclusion

Massive Open Online Courses (MOOCs) have multiplied in recent years. The role of this form of education and learning in professional development is undeniable. In this research, we tried to investigate peer interaction and support in the discussion forums of three MOOCs. We investigated the characteristics of these learning networks and their patterns of interactions to see how our pedagogical approach can affect this learning process. By analyzing learners' behavior, network structure, and interaction patterns, we investigated the effective design and pedagogical strategies that can foster meaningful engagement and knowledge sharing in online learning environments like MOOCs. Our findings suggest several key elements that can help build thriving online communities in technical fields such as EMS. First, simple and clear contribution requests from the course instructors could enhance learner compliance and participation in the forums. Also, we emphasize the role of mediators in facilitating discussions and addressing challenges. Second, by encouraging the participants to share their professional backgrounds and experiences, we could increase the frequency of interactions. These findings are in line with previous research in the field of medical education. Finally, both the quantity and quality of interactions emerged as critical factors. With a balanced focus on these two aspects of online networks, we can stimulate

intellectual curiosity. By adopting strategies that prioritize accessible contribution opportunities, proactive facilitation, and meaningful exchanges, MOOCs and similar online learning platforms can better support networked learning and professional growth. Future research should explore content analysis methods to assess interaction quality, further uncover the dynamics of social learning processes, and enable the full potential of learning networks and communities.

References

Aviv, R., Erlich, Z., Ravid, G., & Geva, A. (2003). Network Analysis of Knowledge of Knowledge Construction in Asynchronous Learning Networks. *Online Learning, 7*(3), https://doi.org/10.24059/olj.v7i3.1842

Borgatti, S. P., Mehra, A., Brass, D. J., & Labianca, G. (2009). Network Analysis in the Social Sciences. *Science, 323*(5916), 892–895. https://doi.org/10.1126/science.1165821

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated Cognition and the Culture of Learning. *Educational Researcher, 18*(1), 32–42. https://doi.org/10.3102/0013189X018001032

Brown, J. S., & Duguid, P. (2001). Knowledge and Organization: A Social-Practice Perspective. *Organization Science, 12*(2), 198–213.

Cho, H., Gay, G., Davidson, B., & Ingraffea, A. (2007). Social networks, communication styles, and learning performance in a CSCL community. *Computers & Education, 49*(2), 309–329. https://doi.org/10.1016/j.compedu.2005.07.003

Dawson, T. (2016). Metacognition and learning in adulthood. https://doi.org/10.13140/RG.2.1.2231.0649

de Lima, D. P. R., Gerosa, M. A., Conte, T. U., & de M. Netto, J. F. (2019). What to expect, and how to improve online discussion forums: The instructors' perspective. *Journal of Internet Services and Applications, 10*(1), 22. https://doi.org/10.1186/s13174-019-0120-0

Hansen, D., Shneiderman, B., Smith, M., & Himelboim, I. (2020). Social network analysis: Measuring, mapping, and modeling collections of connections. in Elsevier eBooks, pp. 31–51. https://doi.org/10.1016/B978-0-12-817756-3.00003-0

Haythornthwaite, C., & Laat, M. (2010). Social networks and learning networks: Using social network perspectives to understand social learning. In Proceedings of the 7th International Conference on Networked Learning Denmark: Aalborg University Copenhagen.

Klimaat, M. van E. Z. en. (2019). Samen aan de slag – roadmap Human Capital Topsectoren 2020-2023—Kamerstuk—Topsectoren [Kamerstuk]. Ministerie van Economische Zaken en Klimaat. Retrieved on 24 October from:

https://www.topsectoren.nl/publicaties/kamerstukken/2019/november/12-11-19/roadmap-hc-topsectoren

Kraut, R. E., Resnick, P., Kiesler, S., Burke, M., Chen, Y., Kittur, N., Konstan, J., Ren, Y., & Riedl, J. (2012). Building Successful Online Communities: Evidence-Based Social Design. *The MIT Press*. https://doi.org/10.7551/mitpress/8472.001.0001

Laat, M., Lally, V., Lipponen, L., & Simons, P. R. J. (2007). Investigating patterns of interaction in networked learning and computer-supported collaborative learning: A role for Social Network Analysis. *International Journal of Computer-Supported Collaborative Learning, 2*(87). https://doi.org/10.1007/s11412-007-9006-4

Lave, J., & Wenger, E. (1991). Situated Learning: Legitimate Peripheral Participation. Higher Education from Cambridge University Press; *Cambridge University Press*. https://doi.org/10.1017/CBO9780511815355

Lin, T. C., Lai, M. C., & Yang, S. W. (2016). Factors influencing physicians' knowledge sharing on web medical forums. *Health Informatics Journal, 22*(3), 594–607. https://doi.org/10.1177/1460458215576229

Lowes, S., Lin, P., & Wang, Y. (2007). Studying the Effectiveness of the Discussion Forum in Online Professional Development Courses. *Journal of Interactive Online Learning, 6*(3), 181–210.

McAuley, A., Stewart, B., Siemens, G., & Cormier, D. (2010). The MOOC model for digital practice. Retrieved on 24 October from: http://www.islandscholar.ca/islandora/object/ir:15366

Pampouri, A., Kostelidou, S., Sionta, E., Souitsme, M., & Mavropoulos, A. (2021). Massive Open Online Courses (MOOCS): A Review. In Proceedings of 15th International Technology, Education and Development Conference. https://doi.org/10.21125/inted.2021.1468

Pear, J. J., & Crone-Todd, D. E. (2002). A social constructivist approach to computer-mediated instruction. *Computer & Education, 38*(1–3), 221–231. https://doi.org/10.1016/S0360-1315(01)00070-7

Rossi, D. (2010). Learning relationships in online contexts: An educational response to declining rates of participation and a means of support for undergraduate students. Studies in Learning, Evaluation Innovation, and Development, 7(3), 1–17. https://hdl.handle.net/10018/53725

Rovai, A. P. (2001). Building classroom community at a distance: A case study. *Educational Technology Research and Development, 49*(4), 33–48. https://doi.org/10.1007/BF02504946

Russo, T. C., & Koesten, J. (2005). Prestige, Centrality, and Learning: A Social Network Analysis of an Online Class. *Communication Education, 54*(3), 254–261. https://doi.org/10.1080/03634520500356394

Schreurs, B., Cornelissen, F., & De Laat, M. (2019). How do Online Learning Networks Emerge? A Review Study of Self-Organizing Network Effects in the Field of Networked Learning. *Education Sciences, 9*(4). https://doi.org/10.3390/educsci9040289

Schreurs, B., Van den beemt, A., Moolenaar, N., & Laat, M. (2019). Networked individualism and learning in organizations: An ego-network perspective on informal learning ties. *Journal of Workplace Learning, 31*, 95–115. https://doi.org/10.1108/JWL-05-2018-0070

Siemens, G. (2005). Connectivism: A Learning Theory for the Digital Age. International Journal of Instructional Technology and Distance Learning.

Brown, J.S., Collins, A., & Duguid, P. (1989). Situated Cognition and the Culture of Learning. *Educational Researcher, 18*(1).

Tıbı, M. H. (2016). Essential Components in Structuring Asynchronus Discussion Forums. *Turkish Online Journal of Distance Education, 17*(2). https://doi.org/10.17718/tojde.12429

Wenger-Trayner, E., Trayner, B., & Laat, M. (2011). Promoting and Assessing Value Creation in Communities and Networks: A Conceptual Framework.

Woo, Y., & Reeves, T. C. (2008). Interaction in Asynchronous Web-Based Learning Environments. *Journal of Asynchronous Learning Networks, 12*, 179–194.

Chapter 5.

Learnings Networks and Professional Development in Building Energy Management Systems Industry

Abstract

Buildings use about 40% of the total global energy worldwide. Therefore, the energy management system sector is one of the most influential sectors in recognizing changes and transforming energy use. New data science technologies used in building energy management systems might bring many technical challenges and raise significant educational challenges for energy management systems professionals. Learning and educational issues are mainly due to the transformation of professional practices and networks, emerging technologies, and a significant shift in how people work, communicate, and share their knowledge across the professional and academic sectors. In this study, we have investigated three companies active in the HVAC (Heating Ventilation, and Air Conditioning) sector to identify the primary motivation and barriers to knowledge adoption, transfer, and exchange between different professionals in the energy management sector and explore the technologies used in this field using the boundary-crossing framework. The results of our study show the importance of understanding professional learning networks in the HVAC 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 technological analysis are needed to understand current educational problems better.

Keywords: learning networks; professional development; energy transition

1. Introduction

In 2020, the TransAct project was launched, focusing on researching technologies and innovations to improve learning networks in 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 electrical and mechanical equipment such as lighting, power systems, heating, and ventilation. This topic is chosen because the HVAC systems are responsible for most of a building's energy use. HVACs 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 considerable challenges related to the energy transition. 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 know about data management and analytics techniques (Radar 2020, 2014). Transition skills, such as problem-solving, critical thinking, creativity, and collaboration (Topsectoren, 2017), and technical skills, such as data analytics and machine learning, are becoming increasingly important. The future picture is more innovative, digital, integral, efficient, productive, quality, and attractive to new generations (Reiner et al., 2019). In the context of such changes in the sector, there is an urgent need for continuous lifelong development.

Lifelong learning is "all learning activities that are undertaken throughout life, to improve knowledge, skills, and competencies within a personal, civic, social and employment-related perspective" (Commission of the European Communities, 2001, p.33). It concerns adult learning, whether in formal and informal learning pathways or concluded with a diploma or certificate (Gielen et al., 2017). To enhance lifelong development, people must have the opportunity to participate in learning and be willing to learn (Topsectoren, 2017). 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. Due to more dynamic job profiles and the

distribution of jobs between humans and robots, more focus on professional development came to learning at the workplace (Topsectoren, 2017).

The use of learning communities and learning networks can strengthen the learning capacity of individuals and organizations (Topsectoren, 2019). As Lave and Wenger (1991) 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 people who gather around the same practice and profession. There are a few differences between learning networks and communities (1991). First, in networks, the relationships between network members are more informal than in communities. Second, powerful interpersonal relationships and group unity shape the fundamentals of communities, while networks are more widespread, and the relationships can be weak or strong. Finally, network relationships can be temporary, but people tend to form more permanent and lifelong community connections.

Additionally, as mentioned in "Networked Learning: Inviting Redefinition" (Networked Learning: Inviting Redefinition, 2021), "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" (Networked Learning: Inviting Redefinition, 2021, p. 319). This article combines theories and principles from networked learning with challenges and transitions 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, and so on. Learning communities related to informal learning exist in various network forms, such as field labs (Fieldlab als aanjager van het innovatie ecosysteem, 2016) and living labs (Maas et al., 2017; Nyström et al., 2014), collaborative innovation networks, e.g., (Xie et al., 2016) centers of expertise at universities of applied sciences, e.g., (Reiner et al., 2019) and

centers for Innovatief vakmanschap (English translation: innovative craftsmanship) at vocational schools, e.g., (De kracht van praktijkleren in het mbo, 2020). 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 both facilitate access to educational resources and improve 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 essential for creating, documenting, and utilizing knowledge in the networks (Addicott et al., 2010). 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 (Schultze & Leidner, 2002; Alavi et al., 2005; Massey et al., 2006). 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, 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 (Xue, 2017). 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 unavailable, and no alternative information source is 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, 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 daily. Due to the increase in data availability in this sector, the required skills are also 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 must collaborate and communicate, and employees from the sector must gain new skills. As a result, there is an obvious need for new and updated educational resources, networking, and communication technologies between professionals in the field to facilitate knowledge-sharing.

The following will present different theoretical approaches and types of learning communities and networks. Then, we will use the boundary-crossing approach 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 learning in which ICT fosters connections between learners and their peers, learners, tutors, and learners and learning resources (De Laat et al., 2014; Goodyear & Steeples, 1998). These connections or ties result in learning networks. Carvalho and Goodyear (2014) 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" (p. 264). Additionally, learning networks are understood as a collection of ties between people or between people and learning objects (Schreurs et al., 2019). Learning networks can appear ad hoc or long-term in teams, groups, and communities or 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 (Haythornthwaite & De Laat, 2012).

Haythornthwaite and De Laat (2012) point out that attention to relations is the key to a social network approach to learning. 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. It can be a direct relationship, with a child learning from a parent, a novice from an expert, or an apprentice from a master artisan. 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. (2008) 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

occurs 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 valuable tools for improving organizational performance. They argue that network visualizations and identifying key players and their characteristics should become part of a standard managerial toolkit. Most of this research still describes what networks offer in general terms and not so much the specifics of 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 the qualities involved (see also Skerlavaj et al., 2010a; Skerlavaj et al., 2010b).

Learning networks and networked learning are central concepts in professional development and growth (Cross & Parker, 2004; Duguid, 2005; Fullan & Hargreaves, 2012), and we need to consider that working, innovation, and learning are interconnected (Billett, 2001; Marsick & Watkins, 2001). A better understanding of professional development in networks linked to working practices is only possible by considering and analyzing how informal learning happens and how knowledge is created and shared in communities. By reviewing the current literature, we identified a lack of experimental research for understanding informal learning in professional development (De Laat & Schreurs, 2013), and these informal learning networks are often implicit, ad hoc, spontaneous, and invisible to others (Cross & Parker, 2004). Studying all the above-mentioned educational challenges, organizations also mainly 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 needs to be addressed or appropriately considered by organizations for professional development.

Moreover, a large body of research shows the benefits of such learning activities (e.g., Argyris & Schön, 1996; Harris, 1990). Informal learning helps them understand how to interpret, adapt, share, organize, contextualize, and sustain new knowledge (Lohman, 2006). Furthermore, it is known as a better, more productive way to make professional development happen. Although networks have

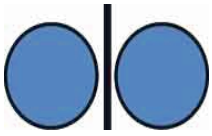
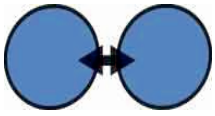
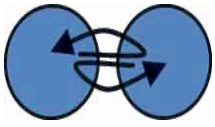
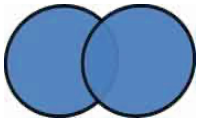
shown extensive benefits for professional development, the behavior of learners in the networks and the strategies they use to maintain their interaction within the networks are still unclear.

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 (Enochsson et al., 2020). This theory assumes that boundaries between practices show learning potential (Graven et al., 2003). In the boundary-crossing theory, boundaries are not seen as physical borders, for example, between buildings, but as social-cultural differences between practices leading to a discontinuity in actions or interactions (Akkerman & Bakker, 2011). Professionals can face boundaries when working 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 at boundaries to ensure or restore continuity in actions and interactions (Akkerman & Bakker, 2014). Boundary objects can help bridge different practices. These objects allow people to work together (Akkerman & Bakker, 2011). Table 5.1 summarizes the boundary-crossing theory mentioned in (Akkerman & Bruining, 2016, p. 246).

Table 5.1

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)
Identification 	Organizations or units come to (re)define their different and complementary nature.	People come to (re)define their different and complementary roles and tasks.	A person comes to define his or her own simultaneous but distinctive participatory positions.
Coordination 	Organizations or units seek means or procedures for institutional exchange and cooperation.	People seek shared means or procedures for exchange and cooperative work.	A person seeks means or procedures to distribute or align his or her own participatory positions in multiple practices.
Reflection 	Organizations or units come to value and take up another's perspective to look at their own practice.	People come to value and take up another's perspective.	A person comes to look differently at his or her own participatory position because of the other participatory position.
Transformation 	Units face a shared problem space and start collaborative work or merge institutionally.	People face a shared problem, start collaborative work, and may build group identity.	A person develops a hybridized position in which previously distinctive ways of thinking, doing, communicating, and feeling are integrated.

Here, we use the multilevel boundary-crossing approach that Akkerman and Bruining (2016) describe. They suggest 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" (Akkerman & Bruining, 2016, p. 247), e.g., between HVAC organizations and educational institutes. Interpersonal involves "actions and interactions between specific groups of people from different practices" (Akkerman & Bruining, 2016, 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 participate in a learning community besides their work. 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 (Graven et al., 2003). 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 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 (Akkerman & Bakker, 2011). 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 (Bakker & Akkerman, 2014). At the institutional level, this research project 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 simultaneous but distinctive participatory positions in the daily work context and the learning community (Akkerman & Bruining, 2016). We use the identification level to identify different kinds of gaps related to learning mechanisms at the levels of coordination, reflection, and transformation (Enochsson et al., 2020). 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 methods to align his positions in multiple practices (Akkerman & Bruining, 2016). Often, boundary objects are used to enable effective collaboration between different practices (Star & Griesemer, 2016). These must be flexible and robust enough to maintain a distinct identity across practices.

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 practical. It should also be considered that technology calls for digital skills, which need to be more well-developed by everyone. New technologies can also be used for personalized learning tailored to learning needs and prior

knowledge (Topsectoren, 2017). In addition, it can facilitate monitoring the learning process (Topsectoren, 2017). 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 articulating one's perspective, and 'perspective taking,' which refers to taking the perspective of another practice (Akkerman & Bakker, 2011). 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 interpersonal level, it is about the reflection of an individual on their 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, more labor market flexibility, and an increased focus on learning in the workplace (Topsectoren, 2017). 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 need for more knowledge regarding the energy transition in the building sector and optimization of the 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 (Akkerman & Bruining, 2016). Transformation comes closest to proactive learning, which the top sectors see as a critical factor for economic growth. Yet, there are more achievable ways of learning than transformation. It depends on the purpose and context of learning in which the learning mechanism is emphasized (Akkerman & Bakker, 2012).

As indicated, we will look for gaps related to the learning mechanisms at different levels from the boundary-crossing theory. Enochsson et al. (2020) identify five different gaps concerning coordination: geographical, attitude, technological, competence, and administration gaps (Enochsson et al., 2020). A relational gap has been termed a gap in reflection, sometimes involving an emotional aspect. With transformation, they also mention a dichotomy and perspective gap

(Enochsson et al., 2020). We look at the technological boundary objects deployed and what people at different levels want to achieve concerning the learning mechanisms of coordination, reflection, and transformation by crossing boundaries.

Finally, considering the above-mentioned issues, we developed the following research questions:
RQ1: How can the studied companies' organizational culture and incentive structure influence their point of view toward learning networks?
RQ2: If there is any learning network in these companies, how have they been supported using emerging technologies?
RQ3: Considering the learning networks' role, what are our target companies' main challenges and future direction?
RQ4: How does boundary-crossing occur, what boundary objects are used, and which gaps can be identified in the companies studied?

3. Methods

To answer our research questions, semi-structured online interviews were conducted with three companies. The first company is a building service organization that involves designing and maintaining complex HVAC systems for large buildings. This company is a high-end company that also develops new data analysis platforms and collaborates extensively with universities. The second company is a networking and educational association in the field of HVAC. The third company, a building service organization, designs and maintains complex HVAC systems for large buildings. However, it is smaller compared to the first company.

Those three companies were chosen because they all reflect a specific part of the community. Studying these companies can be considered an example of how the current status of this field is performing. Two interviews were with each company's educational manager/representative and one with the organization's leading board member/adviser. In all of these interviews, three researchers interviewed one of the members of each company. All participants received the same set of questions, and the authors developed these questions to address the concerns and challenges mentioned earlier based on the research 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 is on incentive structure and motivational factors, and the last part focuses on their main challenges and 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 various 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 distinct 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 5.2 and the summary of the second section (challenges, future direction, and boundary-crossing) in Table 5.3.

Table 5.2

Summary of Organizational Culture, Learning Networks, and Incentive Structure.

Case	Organizational Culture	Learning Networks	Incentive Structure
1	-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.	-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.	-Some courses are mandatory for employees. -Free online courses. -Professional development programs. -Appreciation from colleagues. -Implementation in projects.
2.	-Most of the educational programs, courses, and workshops are provided offline and traditionally. -Course contents are updated based on audience requests and market demands.	-Online environment with a discussion forum for document-sharing and assignment submissions. -Course-based community.	-Professional development. -Certificate for career growth. -No program in place.
3.	-Collaboration with other educational organizations. -Monthly internal presentation.	-Networking with external learning content providers. -Within the organization and external experts.	-Personal coaching plan

Table 5.3

Summary of challenges, future direction, and boundary-crossing

Case	**Challenges**	**Future Direction**	**Boundary-Crossing**
1	-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.	-MS Yammer community forum. -Single central database for project summaries. -Tracking personal development in MS delve and online learning platform.	-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	-Lack of incentive structure.	-Strategies to increase the engagement of participants in the educational networking platform. -Advanced behavioral change approaches and gamification.	-Coordination takes place at the institutional level about courses. -Online network platform with a discussion forum.

3	-Knowledge-sharing with project partners is limited and lacks proper execution.	-Accessible knowledge database for experts. -Investing in learning networks.	-The personal coaching plan can be seen as a boundary object for employers at the intrapersonal level.

4.1. Case One: HVAC Company with an Existing Learning Platform

This organization is an HVAC company that designs, maintains, and exploits technical installations of buildings 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

Experts' education and professional development are highly appreciated in this company, which has around 900 employees in 13 locations. They have an agreement with an online course provider with more than 200 online courses. These courses include soft skills and technical expertise. They can add online courses on the platform, which their expert employees can develop. Knowledge-sharing is one of the main fundamental ideas of the organization, but knowledge transfer has yet to reach its full potential. Employees prefer to have personal connections with other employees to solve their problems and use phone calls or emails. Therefore, several informal learning networks must be visible to employees with similar issues and the management team. This shows the importance of informal networks and their role in the professional education of employees.

4.1.2. Learning Networks

This company's learning network consists of informal and formal learning networks. An external provider organizes an online learning platform 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 every employee must participate in every few years. Besides this online platform, this company provides offline training, 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 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. Academic 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 needs help 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 significant 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, the project employees require additional effort and time to document the learning points and prepare the summary of the whole project. At this moment, small projects need to keep more budget for the time required for documentation, which makes this task optional for employees. To make this happen, the company is looking for an incentive model for employees to share their knowledge actively. The knowledge can be exchanged through project summaries in a database with an innovative search engine or at a discussion board where experts against discussions or queries will share solutions.

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. They work in the same field and face similar problems and challenges daily but must be properly connected. Therefore, they cannot effectively share their knowledge and learn from each other's experiences. Additionally, the difficulty in removing the boundaries between experts working on construction sites and those working in the design and maintenance department is another main challenge in such an organization. This company has started making policies to encourage their employees to share their knowledge and network with their fellow professionals and to develop knowledge-sharing and sustainable communication infrastructure. They believe detecting informal learning networks,

recognizing their power, and facilitating their functions can help employees' professional development.

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 occurs between organizational units. A platform with more than 200 courses has been arranged at the institutional level. This can be seen as a technological boundary object concerning 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, only some courses are compulsory, creating an attitude gap. However, in the future, the organization wants to focus more on informal learning. Another gap has yet to be found in 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 indicated is a geographical gap, which is experienced by the distance between locations, challenges, and companies' future direction, and the essential 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 people who work in the same field, gain knowledge, and share. This association comprises more than 1700 individuals and 500 Dutch companies in the field of HVAC. Knowledge is shared through educational programs, workshops, an online knowledge data bank, magazines, congresses, regional meetings, and expert groups. They initiated an online networking platform open to all HVAC professionals to share knowledge more actively and encourage collaboration within the 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 academic 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. Still, 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 primary motivation for joining the community is professional development and networking. By completing the educational program, participants will receive a diploma or certificate that can boost their careers. Some companies in the installation industry even ask their employees to gain a specific certificate from this educational program. The online networking facility is an excellent opportunity for experts to connect, solve 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 such an association can unlock, a few key educational challenges must be solved. One of these challenges is the need for an 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 participant motivation and help career development.

4.2.5. Boundary-Crossing Perspective

The association comprises more than 1700 individuals and 500 Dutch companies in HVAC. As a result, boundary-crossing activities frequently take place at different levels. For example, coordination occurs 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 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 that increases the motivation of employees.

4.3. Case 3: Building Service Company for Designing and Maintaining Complex HVAC Systems for Large 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 try to provide the best services for their customers and highly appreciate their employees' education and professional development. 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 can often educate each other within the company. Still, if needed, employees can also receive formal education from external providers.

4.3.2. Learning Network

Although this company has no formal independent learning platform, it crosses organizational boundaries by networking with other learning content providers. This helps them always have access to updated knowledge in the field and even share their experiences and knowledge with other experts and service providers. 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 they provide for their employees to help them with their career development and professional growth. Employees are highly encouraged to participate in educational programs and study if needed.

4.3.4. Main Problems and Future Direction

This company mentioned that they have very up-to-date knowledge. Still, the companies they work with (contractors, maintenance engineers, and so on.) need to have the knowledge, which means that their HVAC designs could be executed better.

4.3.5. Boundary-Crossing Perspective

Case 3 describes a small organization that depends on other knowledge and skills, providing organizations with the professionalization of employees. Boundary-crossing is, therefore, a necessity. It has ensured that the learning potential is well utilized and that current knowledge is exchanged. 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 HVAC companies might be one of the main boundaries in the field. As also discussed earlier, other groups of professionals in various locations or different companies face similar problems in their everyday work. Still, 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 also because the knowledge gap for experts in the field can cause serious problems. Knowledge snowballs raise the importance of learning networks, which may help cover the knowledge gap in the field. A few companies in the installation industry have created a knowledge database for experts. Still, 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 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 analytics techniques have increased (Radar 2020, 2014). 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, as well as the challenges, barriers, and problems they have experienced in embedding these technologies.

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

Regarding our research questions (What types of learning communities and networks exist in the studied companies? How do these networks and communities perform regarding knowledge management? What educational technologies have been used to promote communication and facilitate knowledge-sharing in the HVAC sector? How does boundary-crossing occur, what boundary objects are used, and which gaps can be identified in the companies studied?). The first case, an HVAC company with an existing learning platform, emphasizes educational culture and employee professionalization. This company provides formal education for employees, but the main challenge in this section is motivation. Professionals, especially senior experts, prefer face-to-face connections, informal communication, and networking and obtain their knowledge through phone calls, emails, and messaging apps.

Employees prefer informal networks to access knowledge, learn, and solve 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 for this company is adapting the new technologies with the 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 challenging and frustrating. Again, as 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 critical but adapting these educational technologies can also be a significant concern for companies' professional development. Our third case is an MEP (mechanical, electrical, and plumbing) consultancy company with no independent learning platform. They must connect with other educational institutes to gain the knowledge and skills needed for their work. However, it is not only a one-way connection; they also share their experiences and expertise with other organizations through informal or formal education.

6. Conclusions

Although we did our best to select three companies that properly reflect our target sample in this qualitative study, we still need a complete picture of current statutes in the field. Only focusing on these three companies allowed us to go deeper inside each company and investigate their learning networks. This insight can be helpful and valuable for all experts, researchers, and policymakers in this field.

Within the large HVAC company from Case 1, boundary-crossing mainly occurs between the organizational units. In contrast, in the small MEP consultancy company from Case 3, boundary-crossing occurs between this organization and other organizations. Boundary-crossing with other organizations is also encouraged here through a personal coaching plan. All three companies use technological boundary objects but focus 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 (Enochsson et al., 2020). It is striking that all the gaps that have been identified relate to learning mechanism coordination: geographical, attitude, technological, competence, and administration gaps. Continuing 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.

References

Addicott, R., McGivern, G., & Ferlie, E. (2006). Networks, Organizational Learning, and Knowledge Management: NHS Cancer Networks. *Public Money & Management, 26*(2), 87–94. https://doi.org/10.1111/j.1467-9302.2006.00506.x

Akkerman, S., & Bakker, A. (2011). Boundary Crossing and Boundary Objects. *Review of Educational Research, 18*(2). https://doi.org/10.3102/0034654311404435

Akkerman, S. F., Bakker, A. (2012). Crossing Boundaries Between School and Work During Apprenticeships. Vocation and Learning, 5, 153-173. https://doi.org/10.1007/s12186-011-9073-6

Akkerman, S., & Bruining, T. (2016). Multilevel Boundary Crossing in a Professional Development School Partnership. *Journal of the Learning Sciences, 25*(2), 240–284. https://doi.org/10.1080/10508406.2016.1147448

Alavi, M., Kayworth, T., & Leidner, D. (2006). An Empirical Examination of the Influence of Organizational Culture on Knowledge Management Practices. *Journal of Management Information Systems, 22*, 191–224. https://doi.org/10.2753/MIS0742-1222220307

Argyris, C., & Schon, D. A. (1997). Organizational Learning II: Theory, Method, and Practice. *Industrial and Labor Relations Review, 50*(4), 701.

Bakker, A., & Akkerman, S. F. (2014). A boundary-crossing approach to support students' integration of statistical and work-related knowledge. *Educational Studies in Mathematics, 86*(2), 223–237. https://doi.org/10.1007/s10649-013-9517-z

Billett, S. (2001). Learning through work: Workplace affordances and individual engagement. *Journal of Workplace Learning, 13*(5), 209–214. https://doi.org/10.1108/EUM0000000005548

Carvalho, L. & Goodyear, P. (2014). *The architecture of productive learning networks*, *Routledge eBooks*. https://doi.org/10.4324/9780203591093.

Cross, R., & Parker, A. (2004). The Hidden Power of Social Networks: Understanding How Work Really Gets Done in Organizations. Harvard Business Press Books.

De kracht van praktijkleren in het mbo. (2020). Retrieved 25 October 2024, from https://www.ser.nl/nl/Publicaties/sbb-positionpaper-llo

De Laat, M. and Schreurs, B. (2013). 'Visualizing informal professional development networks,' *American Behavioral Scientist*, 57(10), 1421–1438. https://doi.org/10.1177/0002764213479364.

De Laat, M., Schreurs, B., & Sie, R. (2014). Utilizing Informal Teacher Professional Development Networks Using the Network Awareness Tool. In The Architecture of Productive Learning Networks. in *Taylor & Francis eBooks*.

Duguid, P. (2005). Networks and Knowledge: The Beginning and End of the Port Commodity Chain, 1703–1860. *Business History Review, 79*(3), 493–526.

Enochsson, A.-B., Kilbrink, N., Andersén, A., & Ådefors, A. (2020). Connecting school and workplace with digital technology: Teachers' experiences of gaps that can be bridged. *Nordic Journal of Vocational Education and Training, 10*(1), 43–64. https://doi.org/10.3384/njvet.2242-458X.2010143

European area of lifelong learning | EUR-Lex. (2001). Retrieved 25 October 2024, from https://eur-lex.europa.eu/EN/legal-content/summary/european-area-of-lifelong-learning.html

Fullan, M., & Hargreaves, A. (2012). Reviving Teaching With 'Professional Capital.' Education Week. Retrieved 25 October 2024, from https://www.edweek.org/policy-politics/opinion-reviving-teaching-with-professional-capital/2012/06

Gielen, P., Moerman, P., & Bobeldijk, M. (2017). Inspireren Voor Leven Lang Leren. Hoe (De Samenwerking Met) Beroepsonderwijs Er (Ook) Uit Kan Zien. KATAPULT. Retrieved 25 October 2024, from https://www.wijzijnkatapult.nl/files/downloads/Kennisbank/Publicatie_Leven_lang_leren.pdf

Goodyear P., & Steeples C. (1998). Creating shareable representations of practice. *Research in Learning Technology*, *6*(3). https://doi.org/10.3402/rlt.v6i3.11162

Graven, M., & Lerman, S. (2003). Wenger, E. (1998). Communities of practice: Learning, meaning, and identity. *Journal of Mathematics Teacher Education, 6*(2), 185–194. https://doi.org/10.1023/A:1023947624004

Harris, S. G. (1990). The fifth discipline: The art and practice of the learning organization, by Peter Senge, New York: Doubleday/Currency, 1990. *Human Resource Management, 29*(3), 343–348. https://doi.org/10.1002/hrm.3930290308

Haythornthwaite, C. and De Laat, M. (2011) 'Social Network Informed Design for Learning with Educational Technology,' in *Advances in higher education and professional development book series*, pp. 352–374. https://doi.org/10.4018/978-1-61350-080-4.ch018.

Lohman, M. (2006). Factors influencing teachers' engagement in informal learning activities. *Journal of Workplace Learning, 18*, 141–156. https://doi.org/10.1108/13665620610654577

Maas, T., van den Broek, J., & Deuten, J. (2017). Living labs in Nederland: Van open testfaciliteit tot levend lab. Rathenau Instituut. Retrieved 25 October 2024, from https://www.rathenau.nl/nl/publicatie/living-labs-van-open-testfaciliteit-tot-levend-lab

Massey, A., & Montoya-Weiss, M. (2006). Unraveling the Temporal Fabric of Knowledge Conversion: A Model of Media Selection and Use. *MIS Quarterly, 30*, 99–114. https://doi.org/10.2307/25148719

Marsick, V.J. and Watkins, K.E. (2001) 'Informal and incidental learning,' *New Directions for Adult and Continuing Education*, *2001*(89), 25–34. https://doi.org/10.1002/ace.5.

Networked Learning: Inviting Redefinition (2021). *Postdigital Science and Education, 3*(2), 212-325. https://doi.org/10.1007/s42438-020-00167-8

Nyström, A.-G., Leminen, S., Westerlund, M., & Kortelainen, M. (2014). Actor roles and role patterns influencing innovation in living labs. *Industrial Marketing Management, 43*(3), 483–495. https://doi.org/10.1016/j.indmarman.2013.12.016

Pahor, M., Škerlavaj, M. and Dimovski, V. (2008) 'Evidence for the network perspective on organizational learning,' *Journal of the American Society for Information Science and Technology*, *59*(12), 1985–1994. https://doi.org/10.1002/asi.20912.

Radar 2020. Installeren in de toekomst. (2012). UNETO/VNI/OTIB:. Retrieved 25 October 2024, from https://www.omgevingsweb.nl/nieuws/unetovniotib-radar-2020-installeren-de-toekomst/

Reiner, C., Bekke, H., Hooghiemstra, B. T. J., Mil, T. van, Ruiter, H. de, & Rullens, L. (2019). Centres of Expertise: Groeibriljant voor excellente samenwerking in het hbo. Retrieved 25 October 2024, from https://hbokennisbank.nl/details/sharekit_hr:oai:surfsharekit.nl:50f4acf1-4bdd-4b56-bb93-108b5f59183d?q=%22Hooghiemstra%2C+B.T.J.%22&p=0

Schreurs, B., van den Beemt, A., Moolenaar, N., & de Laat, M. (2019). Networked individualism and learning in organizations: An ego-network perspective on informal learning ties. *Journal of Workplace Learning, 31*(2), 95–115. https://doi.org/10.1108/JWL-05-2018-0070

Schultze, U., & Leidner, D. (2002). Studying knowledge management in information systems research: DISCOURSES and theoretical assumptions. *Management Information Systems Quarterly – MIS Quarterly, 26*(3), 213-242. https://doi.org/10.2307/4132331

Škerlavaj, M., Dimovski, V. and Desouza, K.C. (2010) 'Patterns and Structures of Intra-organizational Learning Networks within a Knowledge-Intensive Organization,' *Journal of Information Technology*, *25*(2), 189–204. https://doi.org/10.1057/jit.2010.3.

Škerlavaj, M., Dimovski, V., Mrvar, A., & Pahor, M. (2010). Intra-organizational learning networks within knowledge-intensive learning environments. *Interactive Learning Environments, 18*(1), 39–63. https://doi.org/10.1080/10494820802190374

Star, S., & Griesemer, J. (2016). Institutional Ecology, "Translations," and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907–1939. In Boundary Objects and Beyond: Working with Leigh Star. https://doi.org/10.7551/mitpress/10113.003.0011

Stolwijk, C. and Seiffert, L. (2016) *Fieldlab als aanjager van het innovatie ecosysteem*. Retrieved 25 October 2024, from https://repository.tno.nl/SingleDoc?find=UID%20106acb80-cc37-472e-beeb-c4db28f3dec3.

Topsectoren (2019). Samen aan de slag – roadmap Human Capital Topsectoren 2020-2023—Kamerstuk—Topsectoren [Kamerstuk]. Ministerie van Economische Zaken en Klimaat. Retrieved 25 October 2024, from https://www.topsectoren.nl/publicaties/kamerstukken/2019/november/12-11-19/roadmap-hc-topsectoren

Topsectoren. (2017). Onderzoeksagenda—Een uitwerking van toekomstige onderzoeksvragen. Retrieved 25 October 2024, from https://issuu.com/pbt-netwerk/docs/061217_pbt_llo_onderzoeksagenda_bin

Xie, X., Fang, L., & Zeng, S. (2016). Collaborative innovation network and knowledge transfer performance: A fsQCA approach. *Journal of Business Research, 69*(11), 5210–5215. https://doi.org/10.1016/j.jbusres.2016.04.114

Xue, C. T. S. (2017). A Literature Review on Knowledge Management in Organizations. *Research in Business and Management, 4*(1). https://doi.org/10.5296/rbm.v4i1.10786

Part 3.

Intervention and Evaluation

This part is based on:

Soleymani, A., De Laat, M., & Specht, M. (2025). Evaluating Value Creation, Motivation, and Personal Experiences in a Game-Based Professional Learning Network for Computer Science Education. *The Electronic Journal of e-Learning*. [in print].

&

Soleymani, A., De Laat, M., & Specht, M. (2025). Exploring Personal Experience and Value Creation in Postdigital Education: Insights from a Large-Scale MOOC Survey. Postdigital Science and Education. [under revision]

Introduction

Professionals and students often perceive educational value differently, leading to diverse experiences within professional learning networks. The previous chapter highlighted the critical role of motivation and incentive structures in shaping networked learning.

In Chapter Six, we examine the role of gamification in the networked learning environment provided by the Answers platform, which is designed for computer science students. Our findings offer insights into how gamification can enhance educational experiences and promote positive values within learning networks, ultimately contributing to more engaging and effective learning environments.

Chapter Seven shifts focus to the educational experiences of over 1,200 MOOC participants. By applying the value creation framework, we investigate how participants perceive and generate value from their MOOC experiences and try to provide a comprehensive understanding of the factors contributing to meaningful learning in large-scale online education.

Chapter 6.

Evaluating Value Creation, Motivation, and Personal Experiences in a Game-Based Professional Learning Network for Computer Science Education.

Abstract

Gamification has emerged as a promising strategy to enhance student engagement and learning outcomes in computer science education. This study uses Wenger's Value Creation Framework to evaluate and design the gamification elements in the Answers platform, a Professional Learning Network (PLN) developed at TU Delft. Using a mixed-methods approach with 372 participants, this research examines the platform's impact on learning, motivation, and social interaction.

Findings indicate that the platform significantly enhances academic engagement and applied value, as students actively use it for knowledge acquisition and problem-solving. However, social connectivity remains limited, as reflected in lower scores for relatedness and potential value. Qualitative insights reveal that students primarily engage with the platform for academic support rather than networking or peer collaboration.

This study contributes to e-learning practice by offering design recommendations to integrate collaborative learning elements better and foster social interaction within gamified learning environments. Additionally, it advances theoretical discussions on gamified PLNs by illustrating how Wenger's framework can be operationalized to assess value creation in digital learning networks. The findings highlight the need for a more holistic approach to gamification that extends beyond point-based rewards to include community-driven engagement mechanisms.

By addressing these gaps, this research provides actionable insights for educators, platform designers, and policymakers, supporting the development of more effective gamified learning environments that balance motivation, collaboration, and engagement in online education.

Keywords: Networked learning, Gamification, value creation, computer science education, Online

1. Introduction

1.1 Background and Context

Technology is evolving and changing every day. We face a rapid transition in how students in technical fields like computer science learn, interact, and work (Xu & Ouyang, 2022). They also need constant educational support to stay updated and solve their everyday problems effectively. Consequently, education and training providers play a crucial role in developing and delivering innovative learning solutions that meet these growing needs and ensure that learners are well-equipped to handle the challenges of a dynamic technological landscape. Students are expected to master complex concepts and skills, but maintaining motivation and engagement can be challenging. Many educational platforms need to implement a practical design that can satisfy students' demands, resulting in disengagement and suboptimal learning outcomes. Research has shown that while students may be proficient in using digital tools for entertainment and communication, this does not automatically translate into effective digital learning skills (Margaryan et al., 2011). The increasing reliance on technology in education, particularly in computer science, underscores the need for learning environments that scaffold meaningful engagement rather than assuming inherent technological fluency (Bennett & Maton, 2010). This study introduces "Answers," a novel Professional Learning Network (PLN) developed at TU Delft, aimed at redefining the educational landscape for computer science students.

Networked learning is an educational approach that uses digital and social networks to facilitate and enhance learning processes. It integrates technological tools and social connections to foster collaboration, resource sharing, and continuous learner interaction (Gourlay et al., 2021). PLNs

are a representation of networked learning, where individuals engage in communities or networks to share knowledge, resources, and experiences for professional development (Poortman et al., 2021). In higher education, particularly among computer science students, PLNs leverage platforms such as social media, online forums, and learning management systems to provide industry-relevant knowledge, peer support, and mentorship opportunities, thus embodying the principles of networked learning (Harding & Engelbrecht, 2015).

PLNs show promising results (Harding & Engelbrecht, 2015; Badoer et al., 2020). In networked learning, gamification is increasingly recognized as a powerful tool for enhancing professional development (Saleem et al., 2022; Li et al., 2023). Educators and trainers can significantly boost engagement and motivation among learners by incorporating game-like elements into networked learning environments. Amidst this transformation, gamification is a potent strategy to enhance learning experiences by combining game design elements into non-game contexts. Answers integrate gamification elements within a framework inspired by Wenger's theory of value creation (Wenger, Trayner, & De Laat, 2011). This integration seeks to engage students and deepen their learning and professional development through a networked learning environment.

1.2 Related Work

PLNs are dynamic ecosystems designed to meet the diverse professional needs of educators (Trust et al., 2016). They are structured online or offline communities where individuals actively share knowledge, skills, and best practices to achieve professional growth and development (Trust, 2012). They integrate people, spaces, and tools to facilitate ongoing professional development and knowledge exchange. The individuals within PLNs provide necessary feedback, support, and mentorship, enabling personal and professional growth (Trust et al., 2016). While leveraging networks for learning is not novel (Tobin, 1998), the digital age has amplified their potential, transforming PLNs into powerful platforms for professional development. PLNs are particularly effective in fostering collaboration and innovation among educators, offering opportunities for reflection and the exchange of best practices (Cook et al., 2017).

We use the Value Creation Framework developed by Wenger, Trayner and De Laat (2011) to frame and evaluate the value generated through learning activities in our PLN. This framework

identifies five cycles of value creation: immediate, potential, applied, realized, and transformative. Each cycle represents a distinct impact that network participation can have on individuals or groups (Dingyloudi et al., 2019). Immediate value refers to the initial benefits participants gain from engaging with the gamified learning platform, such as gaining new knowledge and skills. Potential value encompasses expected benefits, including enhanced career prospects, increased confidence, and expanded social connections. Applied value is evident when learners apply the knowledge gained from the platform in their professional and personal lives, leading to, for example, actual improvements in job performance and the initiation of new projects. Realized value manifests as significant achievements in learners' careers or personal development, such as job promotions, entrepreneurial successes, and academic achievement. Finally, transformative value reflects profound, long-term changes in learners' perspectives and behaviors, fostering lifelong learning habits and a deeper appreciation for the benefits of the PLN. This framework is particularly effective in educational settings, where learning outcomes contain academic performance and the broader development of essential skills and capabilities in today's interconnected world.

Building on the principles of value creation and the collaborative nature of PLNs, the integration of gamification in these networks can further enhance the learning experience by adding motivational elements that drive engagement and participation. Gamified learning environments can engage students effectively through intrinsic and extrinsic motivators, boosting motivation and improving academic performance (Buckley & Doyle, 2016; Schöbel et al., 2019). By intrinsic motivation, we refer to engaging in activities driven by internal satisfaction, such as interest, enjoyment, and the inherent challenge of the task, rather than external rewards or pressures (Ryan & Deci, 2000). However, the impact of specific gamification mechanics on intrinsic motivation remains contested. While game elements such as badges, leaderboards, and point systems are often designed to foster motivation (Li et al., 2024), their effectiveness in promoting intrinsic motivation has been debated (Hanus & Fox, 2015). According to the Self-Determination Theory (Deci & Ryan, 1985), intrinsic motivation arises from autonomy, competence, and relatedness. However, research suggests that extrinsic motivators, such as points-based reward systems, may undermine intrinsic motivation if they shift students' focus away from meaningful engagement (Deci et al., 2001).

Additionally, studies indicate that not all gamification strategies yield positive learning outcomes. Nicholson (2014) warns that superficial gamification, which relies primarily on pontification and extrinsic rewards, may fail to foster deep learning and long-term engagement. Furthermore, the effectiveness of gamification varies depending on curriculum design, student demographics, and instructional alignment (Dichev & Dicheva, 2017). Therefore, while gamification holds significant potential in professional learning networks, its impact is highly contextual and requires careful instructional design to ensure meaningful engagement rather than short-term compliance (Sailer & Homner, 2020).

However, the literature also highlights several other limitations. Many studies focus narrowly on specific game mechanics, often neglecting their long-term impact on learning outcomes or their integration with collaborative networks like PLNs. For example, Zhan et al. (2022) emphasize that the effectiveness of gamification varies significantly based on curriculum design and the thoughtful alignment of gamified elements with course objectives. Similarly, Videnovik et al. (2023) argue that while game-based learning enhances understanding and retention, its success depends on factors such as game design, curriculum integration, and student demographics. Additionally, prior research often lacks empirical data on how gamification affects social interaction and collaboration within learning networks (Li & Liu, 2023; Sailer & Homner, 2020).

To address these limitations and research gaps, our study critically examines the integration of gamification into professional learning networks (PLNs), evaluating both its benefits and limitations in fostering value creation, engagement, and intrinsic motivation within computer science education. This study addresses the ongoing discourse on gamification's effectiveness and challenges by leveraging Wenger's Value Creation Framework and examining qualitative and quantitative data.

1.3 Research Objectives

The motivation behind this research stems from the observed need for more engaging and effective educational tools that can address the unique challenges of computer science education. Traditional learning platforms often need to improve in fostering motivation and deep engagement, which are

critical components for mastering the complex concepts inherent in computer science (Videnovik et al., 2023).

The primary aim of this study is to evaluate how gamification within a PLN affects student engagement, intrinsic motivation, and the creation of immediate, potential, applied, realized, and transformative values. The research focuses on higher education, targeting computer science courses at the Bachelor's and Master's levels. By examining the integration of gamification elements with Wenger's Value Creation Framework, this study seeks to contribute to the growing body of knowledge on gamified learning environments and their effectiveness in fostering meaningful academic and professional development.

To achieve this aim, two key research questions guide this study: (1) How do learners perceive the gamified learning experience on the Answers platform? (2) How does the Answers system impact graduate students' value creation and intrinsic motivation? The findings provide insights into the design and implementation of gamified PLNs and their role in shaping student learning and engagement in technical education settings."

2. Methodology

This study aims to explore the impact of gamification on student engagement and learning outcomes within the "Answers" platform, a novel online learning environment developed for computer science education at TU Delft. The research addresses two primary questions: (1) How do learners perceive the gamified learning experience? (2) How does the "Answers" system impact value creation and intrinsic motivation?

We employed a mixed-methods approach, combining quantitative and qualitative data collection methods to comprehensively analyze the educational impact of the "Answers" platform. The mixed-methods design allows for integrating numerical data and in-depth personal experiences, providing a richer understanding of the research questions.

2.1 Participants

This study engaged 372 participants, including Bachelor and Master of Computer Science students, course instructors, and teaching assistants, who were actively involved with the Answers-EWI platform. This platform is freely available to all bachelor and master students, who can use it based on their preferences. This sample size is considered adequate for quantitative and qualitative analyses, as it meets the recommended thresholds for statistical power mixed-methods research (Creswell & Plano Clark, 2017). According to Cohen's (1992) guidelines for statistical power analysis, a sample size of over 300 is generally sufficient to detect medium to large effect sizes with a power of 0.80 at the 0.05 significance level in educational research. Eventually, 60 participants out of a total of 372 completed our questionnaires, and 10 participants were randomly invited for in-depth interviews.

2.2 Data Collection Methods

The methodology employed in this study involved multiple data collection methods to provide a comprehensive analysis of the educational impact of the "Answers" platform. The platform automatically generates log data that captures detailed information on user interactions, including the frequency and type of activities such as question posting, answering, and commenting. This log data provided quantitative metrics on engagement levels, enabling an analysis of how actively and in what ways students and instructors utilized the platform. Two questionnaires were distributed to all participants, including course instructors, TAs, and students, to gather data on perceived value creation and intrinsic motivation.

Questionnaire 1. Value Creation Questionnaire (VCQ). Based on Wenger, Trayner, and De Laat's (2011) five cycles of value creation, this questionnaire was designed to measure the different layers of value participants perceived as being created through their interaction with the platform. The items in the questionnaire corresponded to the immediate, potential, applied, realized, and reframing value. This Questionnaire has ten questions (five multiple choices and five open-ended questions). Each value creation cycle has one multiple-choice and one open-ended question. For example, the first question asks, "Participation changed me as a student (change in skills, attitudes, identity, self-confidence, feelings, etc.)." Participants must answer on a scale of 1 to 6 (Strongly disagree to strongly agree, respectively). If they respond positively (strongly agree, agree, or

slightly agree), they are asked to answer an open-ended question such as “Can you explain how participation changed you as a student?”. If they respond negatively (slightly disagree, disagree, and strongly disagree), the online questionnaire automatically asks: Can you explain why participation didn't change you as a student?

Questionnaire 2. Intrinsic Motivation Inventory (IMI) - 29-item Version by Ryan et al. (1983).
To measure this construct in our research, we employed the Intrinsic Motivation Inventory (IMI), a multidimensional measurement tool designed to assess participants' subjective experience related to a target activity (Ryan, 1982). The IMI includes several subscales, including interest/enjoyment, perceived competence, effort, value/usefulness, felt pressure and tension, and perceived choice. Each subscale captures different dimensions of intrinsic motivation, providing a comprehensive overview of how engaged and motivated participants feel. Higher scores indicate greater intrinsic interest in the activity (McAuley et al., 1989). In our study, the IMI was used to evaluate how the gamified elements of the Answers platform influenced students' intrinsic motivation.

This comprehensive tool assessed participants' levels of intrinsic motivation concerning their platform use. It includes five subscales: relatedness, interest/enjoyment, perceived choice, pressure/tension, and effort. The IMI was administered to help us understand the motivational dynamics influenced by the gamified elements of the platform.

Additionally, ten participants were randomly selected for in-depth, semi-structured interviews to further investigate value creation and the gamification experience. Eight out of ten participants were students, and two were TAs. These interviews were designed to capture value-creation indicators, personal stories, and participants' experiences with the gamification elements of the "Answers" platform.

Each data collection method complemented the others, providing a rich, multi-faceted view of the platform's educational impact. Together, these methods enabled a robust analysis of both the measurable outcomes of gamification and the qualitative experiences of those engaged with the platform.

2.3 Procedure

Answers development and refinement started in 2022, and after approximately one academic year of iterative testing and feedback sessions, students could start using the platform. Participants were recruited through course announcements and email invitations from the start of the academic year in 2023 (September). Informed consent was obtained from all participants, ensuring confidentiality and voluntary participation. Log data were collected automatically by the platform, while the VCQ and IMI were administered online at the end of the semester (around February 2024). Interviews were conducted via video conferencing with the Microsoft Team, recorded, and then transcribed for analysis. These interviews were conducted around a month after the end of the semester in March 2024.

2.4 Description of the Intervention

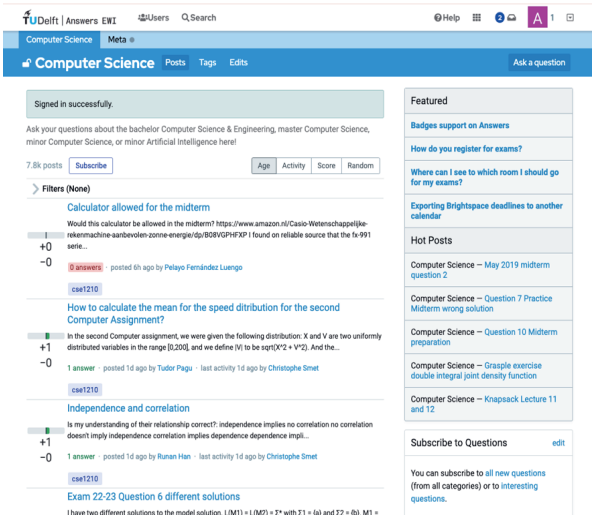
The Answers platform was designed to enhance student engagement and collaborative learning by integrating game-based elements that promote participation, knowledge sharing, and peer interaction.

2.4.1 Technical features

The Answers platform uses Ruby on Rails with MySQL as the primary database. It is a modification of the open-source platform Qpixel by the Codidact organization (https://github.com/codidact/qpixel). User data is protected through end-to-end encryption and secure data storage practices. The platform complies with GDPR, ensuring that user privacy is maintained. User authentication is handled via the TU Delft single sign-on (SSO) mechanism. The source code is available at https://gitlab.ewi.tudelft.nl/eip/answers/qpixel. Figure 6.1 provides a snapshot of the platform and illustrates its core functionalities and user interface.

Figure 6.1

A Snapshot of Answers Platform



2.4.2 Design Principles

Among the various gamification strategies available, we selected points and badges as our primary mechanisms, aligning them with the principles of Wenger's Value Creation Framework (Wenger-Trayner & Wenger-Trayner, 2020) to foster immediate, potential, and applied value within the learning network.

Points can serve as an immediate feedback mechanism, which could reinforce active participation by rewarding users for asking questions, answering queries, and engaging in discussions. Although several case studies showed the effectiveness of points in gamification (e.g., Huang & Hew, 2015; Ibànez et al., 2014), we should acknowledge the fact that "pontification" of education can sometimes lead to superficial engagement if not thoughtfully integrated into the learning design (Hellberg & Moll, 2023). Badges, on the other hand, were designed to recognize meaningful contributions and milestones. Also, they are designed to reflect individual achievements and community engagement (Aldemir et al., 2018). Table 6.1 provides an overview of badges and points designed for our platform.

Table 6.1

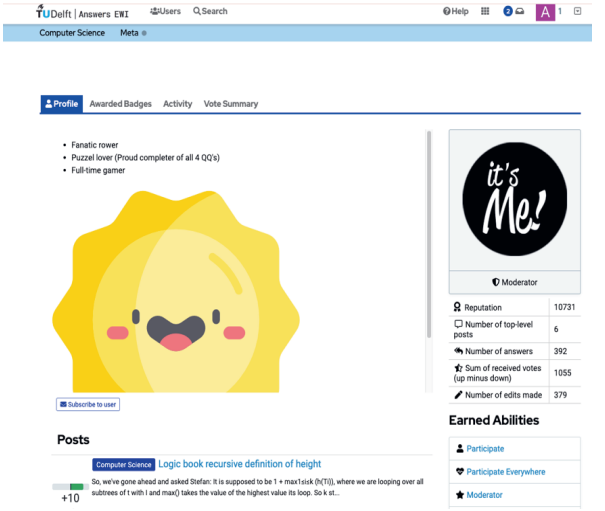
Description of Badges and Points

Badge	Description
Autobiographer	Complete your profile and upload a profile picture
First Question	Ask your first question
First Answer	Contribute your first answer
Self-Learner	Answer your own question with an answer that others find useful
Teacher	Help another community member with a good answer to their question
Badge based on points*	
Great Question	Ask a question that many others are also interested in
Great Answer	Help the community by contributing a very helpful answer
Famous Question	Ask a question that many others look at
Top Contributor	Every two weeks the top contributor for of each course will be awarded this badge (if the course has sufficient contributions)
* These points were based on network members' feedback.	

As mentioned earlier, these badges and points are inspired by the value creation framework (Wenger, Trayner, & De Laat, 2011). For example, one of the immediate value indicators is "participants bringing challenges they face for discussion" (Wenger-Trayner & Wenger-Trayner, 2020). We tried to encourage participants to ask questions on the Answers platform and bring the challenges they faced during the course by designing "First Question" and "Great Question" badges. Furthermore, one of the other typical indicators of potential value is the "Richness, diversity, and relevance of advice" (Wenger-Trayner & Wenger-Trayner, 2020) provided in the network. This inspired us to design "Great Answer" and "Top Contribution". Finally, one of the other Applied value indicators is "Stories from participants' context reporting innovations or newly discovered solutions or approaches" (Wenger-Trayner & Wenger-Trayner, 2020). This indicator helped us in designing the "Self-Learner" badge. Figure 6.2 illustrates an example of badges and recognitions, showcasing the types of achievements rewarded within the platform.

Figure 6.2

An example of Badges and Recognition



For the project's development, the teaching team of the computer science department initiated the concept of a system where students could exchange information, thereby building a knowledge base for future cohorts. Initial requirements were derived for posting questions and answers and ensuring the searchability of previously answered questions. After exploring existing solutions, Codidact/Qpixel, an open-source platform, was chosen as the foundation for the application. From this starting point, additional requirements were established to enhance the platform's suitability for educational purposes. Input was gathered from various stakeholders, including faculty and students, to understand their needs and expectations.

Two Computer Science students were tasked with implementing and integrating these features, adhering to an Agile development methodology to maintain flexibility and responsiveness to user feedback. User testing sessions were conducted throughout development to identify and address usability issues. Both quantitative and qualitative data were collected to inform design decisions. Features deemed generally applicable were contributed back to the Codidact project. After the initial deployment of the Answers platform, additional functionalities were added over time. Users

were notified of new functionalities and instructed how they worked through the platform. Technical support was offered to address any emerging issues. Regular updates and feature enhancements were deployed based on user feedback. The platform's performance was continuously monitored through analytics, and feedback sessions were conducted with users to identify areas for improvement.

2.4.3 Engagement and Interaction Evaluation

We expanded the platform's analytics capabilities to evaluate user engagement and interaction patterns. We track various metrics, such as the number of visits (tracks the frequency students visit the platform), activity frequency (counts the number of activities performed by the users, such as posting questions, answering questions, and commenting), and achievement and badges (monitors the badges users earn and their progress towards achieving specific milestones).

This intervention was introduced at the beginning of the academic year. It was available to all computer science students and faculty, providing a real-time, dynamic environment for enhancing educational experiences through gamified learning.

2.5 Data Analysis

The analysis of the collected data from the "Answers" platform involved a comprehensive approach, utilizing both quantitative and qualitative techniques to ensure a thorough understanding of the effects of gamification on learning outcomes and motivation.

The qualitative data collected from the Value Creation Questionnaire (Open-ended answers) and interviews were transcribed and analyzed using thematic analysis to identify recurring themes and patterns related to participants' perceptions of the gamification experience, value creation indicator, and stories. Qualitative data analysis software (Atlas ti) facilitated the coding of the data, which helped organize the data into meaningful categories based on the value creation framework. This method allowed for the in-depth exploration of how the gamification elements influenced learners' motivation, perceived value from the platform, and overall learning experience.

A mixed-methods data integration technique was used to integrate the quantitative and qualitative findings. This approach involved comparing and contrasting results from both data sets to draw comprehensive conclusions about the study's hypotheses. By triangulating the data, we aimed to validate the findings across different methods, enhancing the reliability and validity of the results.

3. Results

3.1 Quantitative analysis

3.1.1 Quantitative Analysis of Value Creation Questionnaire (VCQ)

The methodology section explains that the VCQ has five multiple-choice and five open-ended questions. The first question explored the immediate value cycles and asked, “Participation changed me as a student (change in skills, attitudes, identity, self-confidence, feelings, etc.).” then the participant can choose between strongly agree, agree, slightly agree, slightly disagree, disagree, and strongly disagree. If they answered strongly agree, agree, and slightly agree, we asked them, "Can you explain how participation changed you as a student? And if they answered slightly disagree, disagree, and strongly disagree, they need to answer, "Can you explain why participation didn't change you as a student?". This procedure is repeated for questions regarding potential, applied, realized, and transformative value creation cycles. In this section, you can find the results of the first part of the questionnaire, and in section 3.2.1, we explain the results of the open-ended questions. Table 6.2 presents the descriptive statistics for the VCQ subcategories and summarizes the distribution of responses across the five value creation cycles.

Table 6.2

Descriptive results of VCQ

VCQ Components	Number of Positive Value Responses	Average	Std Dev	Median	Range (Min - Max)
Immediate Value	38/60	3.7	1.36	4	1-6
Potential Value	9/60	2.08	1.18	2	1-5
Applied Value	53/60	4.51	1.17	5	1-6
Realized Value	24/60	2.88	1.30	3	1-5
Reframing Value	19/60	2.71	1.40	2	1-6

Table 6.2 presents the descriptive statistics of the Value Creation Questionnaire (VCQ), which examines five cycles of value creation based on the framework proposed by Wenger, Trayner, & De Laat (2011). The VCQ assesses the impact of the Answers platform on participants across different dimensions of value creation.

Immediate Value: Out of 60 participants, 38 indicated that the Answers platform created positive immediate value for them. Specifically, these participants responded, "Strongly Agree," "Agree," or "Slightly Agree" to the statement: "Participation changed me as a student (change in skills, attitudes, identity, self-confidence, feelings, etc.)." This result suggests that a significant proportion of participants perceived an immediate enhancement in their personal and academic development due to their engagement with the platform.

Potential Value: The second component of the VCQ evaluates the potential value in terms of social connections with peers and other students. Interestingly, only 9 participants out of 60 responded positively to the statement: "Participation affected my social connections (change in the number, quality, frequency, emotions, etc.)." The average score for this dimension was 2.08, indicating a relatively low impact of the platform on social relationships.

Applied Value: The third component measures the applied value created by the platform. A majority, 53 out of 60 participants, responded positively to the statement: "Participation helped my practices as a student (get new ideas, insights, materials, procedures, etc.)." The average score for this dimension was 4.51, reflecting a high level of practical benefits derived from the platform.

Realized Value: The fourth part of the VCQ investigates the influence of the Answers platform on participants' ability to influence the world as students, such as enhancing their voice, contribution, status, and recognition. 24 out of 60 participants responded positively to this dimension, with an average score of 2.88. These results indicate a moderate impact on participants' perceived influence and recognition within their academic and social contexts.

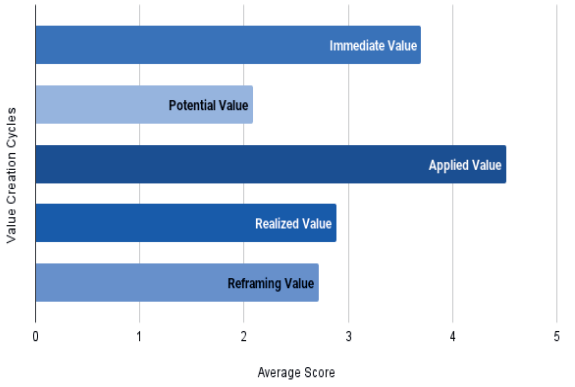
Reframing Value: The final part assesses the reframing value, focusing on profound, long-term changes in participants' perspectives and behaviors. Nineteen participants responded positively to

the statement: "Participation made me see my world differently (change in perspective, new understandings of the situation, redefine success, etc.)," with an average score of 2.71. This finding suggests that some participants experienced significant shifts in their worldview and understanding due to their involvement with the platform.

Figure 6.3 provides an overview of the average scores for each value creation cycle, illustrating the varying impacts of the Answers platform on different dimensions of value creation. The high average score for applied value highlights the platform's effectiveness in enhancing students' academic practices. In contrast, the lower scores for potential and reframing values underscore areas for improvement in fostering social connections and facilitating changes in perspectives.

Figure 6.3

Average Score of Value Creation Cycles



3.1.2 Descriptive Analysis of IMI

Table 6.3 presents the descriptive statistics of the Intrinsic Motivation Inventory (IMI) questionnaire, which measures various dimensions of intrinsic motivation on a scale from 1 (not at all true) to 7 (very true). The IMI assesses five subscales: relatedness, interest/enjoyment, perceived choice, pressure/tension, and effort, providing insights into participants' motivational dynamics when using the Answers platform. Figure 6.4 also presents the average scores for the IMI subscales and visualizes the variation across different motivational dimensions of IMI.

Table 6.3.

Descriptive Analysis of IMI Subtests

IMI Subscale	Average	Std Dev
Relatedness	-0.30	0.59
Interest/Enjoyment	2.64	0.87
Perceived choice	0.82	0.78
Pressure/Tension	0.22	0.90
Effort	2.09	0.71

The relatedness subscale explores the sense of connection between participants. As shown in Figure 6.4, scores for this subscale clustered around the lower end, indicating that participants did not feel significantly connected to others through the platform. For example, one of the questions in this subscale was, "I felt really distant from the other members of the network." These results suggest a need to enhance the social interaction features of the Answers platform to foster better connections among users.

The interest/enjoyment subscale scores were generally high, demonstrating that participants found the platform engaging and enjoyable. For instance, one of the questions in this subscale was, "While interacting with the other Answers-EWI members, I was thinking about how much I enjoyed it." The high scores indicate that gamification effectively enhanced user engagement and enjoyment.

The perceived choice subscale examines participants' sense of autonomy in networking and communicating with other Answers platform users. For example, one of the questions was, "I felt like I had a choice about interacting with the other network members." The results for this subscale showed mixed feelings among participants regarding their sense of control over their interactions and use of the platform. Therefore, it suggests that while some users felt autonomous, others did not perceive a strong sense of choice in their interactions.

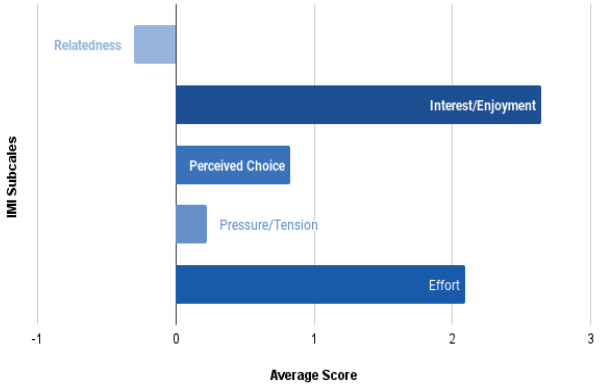
The low average score for the pressure/tension subscale indicates that most participants did not experience pressure or tension when interacting with the platform or other members. An example question from this subscale was, "I did not feel nervous about interacting with the other network

members." These results highlight that the platform's design effectively minimized stress and anxiety among users, creating a comfortable environment for interaction.

The effort subscale had a high average score, indicating that participants actively tried to maximize their experience and interactions within the network. For example, one of the questions in this subscale was, "I tried hard to have a good interaction with the other network members." This implies that users were willing to invest significant effort to benefit from the platform, reflecting a high level of engagement and commitment.

Figure 6.4

Average scores of IMI Subscales



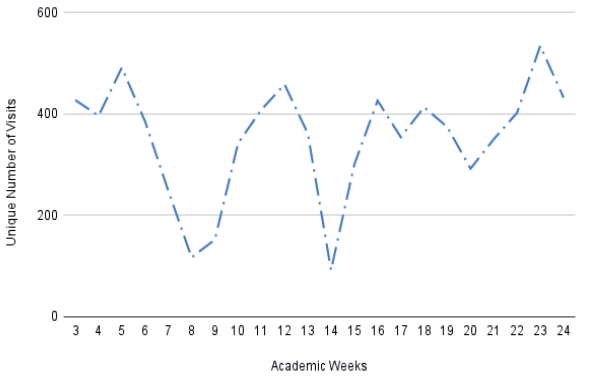
3.1.3 Descriptive Analysis of Engagement and Interaction Analysis

The analytics module of the Answers platform provided detailed insights into user engagement and interaction. Our key findings include visit frequency, activity Frequency, and number of badges earned. The average number of weekly visits was 347, indicating regular engagement with

the platform. As Figure 6.5 shows, participants constantly visit the Answers Platform, but we also see significant drops during holidays in weeks 8 and 14.

Figure 6.5

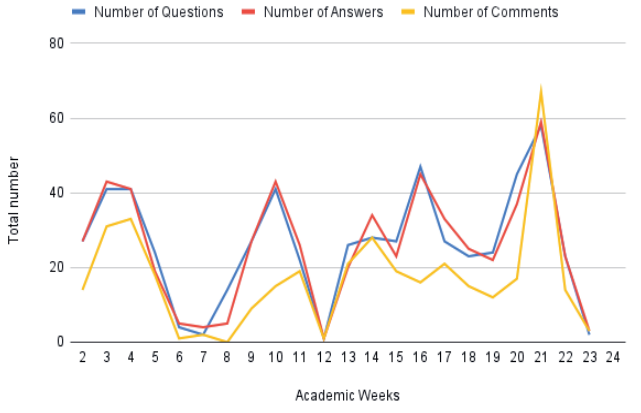
Visit Frequency



Activity Frequency analysis indicates that, in total, our platform users raised 616 questions, answered 608 times, and left comments 395 times. Most interactions were questions (38%), followed by direct answers (37%) and commenting (25%). An overview of these findings is illustrated in Figure 6.6.

Figure 6.6

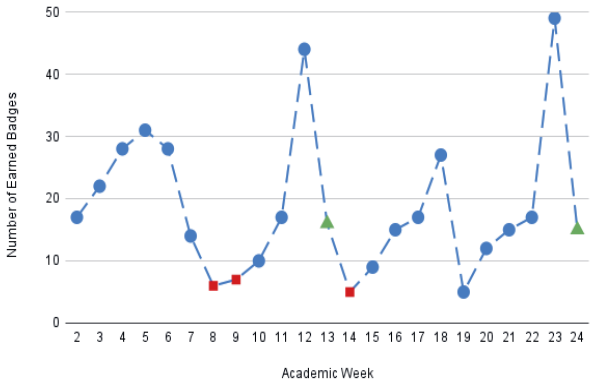
Activity Frequency of Answers Users



Answers' users earned 428 badges during the study period, reflecting their achievements and milestones. Figure 6.7 shows the patterns of users' peak activity during exam periods.

Figure 6.7

Total number of budges earned by Answers' users



**Red squares indicate holiday weeks, and green triangles indicate exam weeks.*

In conclusion, our quantitative analysis results indicate that while the immediate value perceived by participants is relatively high, this value is more personal than social. This can be supported by the low potential value and the relatedness subscale scores of IMI, which reflect limited social engagement and connection among users. This pattern suggests that students find the Answers platform valuable for individual learning but must utilize it to fully build social connections or collaborative learning.

Moreover, the engagement data, such as the frequency of visits and the number of questions asked, supports this interpretation. While students actively use the platform, the low relatedness scores suggest that these interactions are more transactional than community-building. This trend aligns with the qualitative analysis, where students expressed that they primarily use the platform for academic purposes rather than socializing.

These findings are consistent with Wenger, Trayner, & De Laat's (2011) value creation framework, which claims that personal value may only translate into potential value with intentional design

efforts to foster social connections. The following qualitative analysis section will explore these patterns further, providing more context and depth to these quantitative findings.

3.2 Qualitative Analysis

3.2.1 Qualitative Analysis of Open-ended Answers of VCQ

In VCQ, participants were asked multiple-choice and open-ended questions that explored the five value creation cycles: immediate, potential, applied, realized, and transformative. While the multiple-choice questions allowed participants to express their "level of agreement" with the provided statements related to these cycles, the open-ended questions provided more profound insights into the reasons behind their responses.

Participants who agreed with the statements for each cycle were asked to elaborate on how their participation influenced them, such as "Can you explain how participation changed you as a student?" Contrariwise, those who disagreed were prompted to explain why the participation did not have an impact, with questions like "Can you explain why participation did not change you as a student?" The responses to these open-ended questions were subjected to initial coding, which enabled us to group the data into different themes. This thematic analysis provided a richer understanding of the various dimensions of value creation experienced by the participants beyond what could be captured through the multiple-choice responses alone. A summary of these findings is presented in Table 6.4.

Table 6.4

Result of Qualitative Analysis of Open-ended Response of VCQ

Value Creation Cycle	Positive and negative value	Theme	Occurrence	Example Quotes
Immediate	Positive	Knowledge Acquisition	15	"I became more familiar with material."
		Improved Communication	7	"It is nice to be able to ask questions and having people respond. It helps with communication skills and understanding of the material."
		Problem Solving	7	"Solved questions I had."
		Peer Learning and Interaction	7	"I can see what type of problems others also struggle with, and it's very informative."
	Negative	Low Usage	6	"I didn't really participate and have not really used Answers.ewi that much"
		Utility-Driven	5	"It did not change my way of studying, just the way I sought out help"
		No Significant Impact	4	"It was not that much of an effect on me, I just received help when needed
		Challenges in Participation and availability of alternative support	5	"I feel like I would still be able to ask questions to my peers, or TAs during labs, without posting them on Answers"
Potential	Positive	New and Improved Social Connections	3	"Participation affected my social connections in a good way because I had the opportunity to make new friends."
		Increased Closeness and Unity	2	"It creates union between students."
		Professional and Peer Recognition	2	"It helped me recognize dedicated colleagues. It also made me a bit more confident in my skills, and made me dedicate more to cooperation."
	Negative	Educational Utility and Focus	18	"The people I interact with on Answers-EWI I either already know or I did not start interacting with them more."
		Lack of Social Interaction	17	"I only look at the answers."
		Low Engagement and Usage	6	"I didn't participate much for that to happen."
		Preference for Other Platforms and Methods	5	"While I do agree that it gives a positive emotion when someone took the time to answer your questions, I feel like other (unofficial) platforms give more social interactions. (Such as the WhatsApp groups)."
Appli	Positi	New Ideas and Approaches	9	"Provided innovative ideas and clear explanation of certain concepts."

		Problem-Solving and Insights	7	"I've gotten valuable answers from it that helped me with studying."
		Peer Learning and Perspectives	8	"It gives good extra views on topics by other students, lecturers and TAs."
		Additional Learning Support	20	"In the rare case that someone had the same problem that I did, it boosted my confidence because I wasn't the only person struggling."
	Negative	Low or No Usage	3	"I haven't really felt it was necessary to use it."
		Preference for Traditional Resources	2	"I guess, but getting that info from either course staff or course material would have helped a lot more."
		Lack of Useful Outcomes	2	"So far nothing useful has come of trying to use the platform."
Realized	Positive	Recognition and Confidence	4	"By answering questions, mostly in-person, I could make an impact in my study group. Moreover, I feel like it raised my level of confidence."
		Peer Interaction and Contribution	4	"The network makes it easy for a student to talk to other students about similar topics, so I think it has a big impact on students."
		Influence on Course and Problem-Solving	5	"It is an accessible way to bring possible problems forward to course staff."
		Potential and Limitations	4	"Personally it has not influenced me as a student, but I have seen posts where students help each other, and therefore the student that is helping is usually very appreciated."
	Negative	No Effect or Impact	7	"Not using the network has had no effect on me as far as I'm aware."
		Low Usage and Contribution	6	"I have not participated on EWI answers enough to feel like I was an influence there."
		Educational Utility and Question-Focused	5	"I only used answers to ask questions so it did not change my view of the world or influence or anything."
		Low Impact and Recognition Issues	5	"It's not that deep."
Transformative	Positive	Varying Perspectives and Changed Views	7	"It made me see the world differently in some area in which I changed my view after seeing an answer/asking a question."
		Shared Struggles and Supportive Environment	3	"It's very nice to see previous students / teachers helping out with students' questions, it's a very supportive environment."
		Self-Understanding and Inspiration	4	"Now I have a much more in-depth perspective of this field."
		Respective Support	4	"It is good that I see people help each other without any form of compensation."
	Negative	No Significant Impact	12	"No significant impact."
		Educational Utility	7	"It's just a help, it doesn't change world views."
		Low Usage	5	"I have not used answers.ewi that much so idk a lot of things do not apply to me."
		Question-Focused	5	"It helps me when I do not know what to do, but that is all I use it for."

Several patterns emerge that align with and expand upon the quantitative results presented earlier by reviewing the qualitative findings from the open-ended questions. The themes of 'knowledge acquisition' and 'improved communication' are frequently mentioned in the immediate value cycle, which aligns with the relatively high scores for perceived usefulness and engagement in the quantitative data. This finding suggests that while students benefit from the Answers platform regarding individual learning and skill development, their interactions could be more collaborative, as evidenced by the low relatedness scores in the IMI.

Another pattern observed is the frequent mention of 'lack of social interaction' in the potential value cycle, which corresponds with the low scores in the relatedness subscale of the IMI. These findings indicate a consistent challenge in fostering a sense of community and social connectedness on PLN platforms. Despite the platform's success in facilitating academic support, it fails to promote deeper social interactions among users.

Moreover, the recurring theme of 'preference for traditional resources' in both the applied and transformative value cycles provides additional context to the mixed feelings of autonomy and choice reported in the IMI. While the platform offers valuable resources, students may still rely on more traditional forms of support, such as direct interaction with course staff or peers, potentially limiting the platform's impact on broader educational outcomes.

Finally, these patterns reveal a complex interaction between the platform's design, its intended outcomes, and the actual experiences of its users. By contrasting these qualitative insights with the quantitative data, it becomes clear that while the platform is effective in certain areas, there are opportunities to enhance its social and collaborative dimensions to realize its full potential.

3.2.2 Qualitative Analysis of In-depth Interviews

This section presents the insights derived from ten in-depth interviews conducted with students and TAs who used the Answers platform. The interviews aimed to explore students' and TAs' experiences, motivations, value creation, and the platform's impact on their learning practices. The analysis revealed several key themes: awareness and communication of gamification features, expectations and experience, social connections and platform usage, instructors' and mediators'

influence, platform benefits, technology comparison, and trust and reliability. We briefly explain each of these themes in detail as follows.

Theme 1. Awareness and Communication of Gamification Features.

Nine out of ten interviewed participants noticed the gamification elements like badges. However, they needed to engage more deeply with them, indicating a need for better communication about these features. For instance, Participant Eight mentioned, "I didn't really notice a lot of change, but I haven't used answers in a while either." Similarly, Participant Four said, "I've noticed the badges, but I don't notice the points or other gamification elements on it."

Effective communication strategies are essential to ensure students understand and utilize new features. This includes targeted notifications and clear explanations about the benefits and functionalities of the gamification elements.

Theme 2. Expectations and Experience

Students expected the platform to be a resource for finding answers and sharing knowledge, and it met these expectations. However, engagement with gamification elements could have been higher. Participant One stated, "I kind of expected it to be what it is. It's an answer platform. If you ask questions, people can see your questions and respond." she added, "It was nice because there were answers and questions from the year before, which is very useful for general questions about course material." These findings raise the importance of providing clear guidance on the platform's benefits and capabilities, which could enhance student participation and engagement with gamification features.

Theme 3. Social Connections and Platform Usage

The platform was primarily used for academic purposes, with limited impact on fostering social connections. Many students preferred alternative, informal communication methods, such as WhatsApp and Discord, for social engagement and quick exchanges. Participant Two noted, "I don't really see it very much as a social platform." Similarly, Participant Four stated, "There are obviously WhatsApp groups or Discord servers made by students for networking."

Low engagement with the platform was largely attributed to the availability of alternative platforms that students found more efficient for networking and discussions. Participant Eight mentioned, "We mainly use WhatsApp for communication." These findings suggest that integrating the platform with existing student-preferred communication tools could improve engagement and enhance social interactions.

Theme 4. Instructors' and mediators' Influence

Instructor recommendations played a significant role in how students used the platform. Instructors' active involvement can enhance the platform's perceived value and encourage more frequent use. Participant Two mentioned, "It was great to get in touch with the lecturer through the platform." Similarly, Participant Eight said, "Some teachers use the forums actively, which is very helpful." Promotion of the platform during lectures and instructor participation can significantly increase its usage and effectiveness.

Theme 5. Platform Benefits and Technology Comparison

The platform provided valuable records of past discussions and immediate access to information, which benefited students. Participant Four, for example, mentioned, "It really helps to see previous questions and answers." Participant Nine added, "Having access to past discussions is very helpful." While AI tools like ChatGPT offer quick answers, students trust human responses for accuracy and context. Participant Ten stated, "I don't fully trust ChatGPT because I've seen what it can spit out, and it's not always smart." Ensuring the accuracy and reliability of the information delivered on the platform is critical.

Theme 6. Trust and Reliability

Students prefer human responses over AI-generated ones due to their reliability and accuracy despite the longer response time. Participant Four highlighted, "When I see someone answer your question, I look at the votes and see if I know the person already." Factors such as upvotes, the credibility of responders, and personal experience influenced trust in the platform. Ensuring the trustworthiness of the information provided is essential for the platform's success.

4. Discussion

4.1 Perceptions of the Gamified Learning Experience

The first research question explored how learners perceive the gamified learning experience on the Answers platform. The quantitative results indicated that most students perceived the platform positively, particularly in terms of its academic utility. The qualitative data supported this perspective, with students appreciating the Answer's role in accessing learning materials, answering questions, and understanding peers' challenges. However, engagement with gamification elements, such as badges and points, was mixed. While some participants reported feeling motivated by progress-based rewards, others found these elements unnecessary or unnoticeable. Previous research on gamification in education suggests that the effectiveness of game elements depends on individual preferences, perceived relevance, and alignment with intrinsic learning goals (Hamari et al., 2014; Sailer & Homner, 2020). To increase engagement, system designers and instructors could enhance awareness and visibility of gamification mechanics, try to satisfy the psychological needs of their participants (e.g., autonomy, competence, and relatedness) (Suh et al., 2016), integrate more meaningful incentives, and provide peer recognition for contributions.

4.2 Impact of Answers Platform on Value Creation and Intrinsic Motivation

Our second research question focused on how the platform impacts value creation and intrinsic motivation. The VCQ results highlighted strong applied value, with 88.3 percent of participants agreeing that the platform helped their academic practices. Interview responses confirmed this, as students noted that exposure to different problem-solving approaches enhanced their learning. This finding is consistent with Wenger's applied value cycle, where learners integrate new knowledge into their existing skill sets (Wenger, Trayner, & De Laat, 2011).

However, findings From IMI indicated low scores in the relatedness subscale, which suggests that students did not feel socially connected through the platform. This challenge in gamified learning environments, where game elements alone may not be sufficient to foster collaborative or social

learning experiences, has also been emphasized in another research (Kraut et al., 2008). Our qualitative analysis supports this, as students frequently mentioned relying on external communication tools (e.g., WhatsApp, Discord) for peer interaction.

4.3 Social Connections and Community Building

The platform's impact on social connections could have been more pronounced, with only 9 out of 60 participants reporting positive effects on their social interactions. Many students indicated that they primarily used the platform for academics rather than socializing. This finding shows the importance of informal learning networks and their roles in promoting professional development (Nijland et al., 2018; De Laat et al., 2014).

Researchers have identified several limitations in how gamification fosters social interaction. A key concern is that game mechanics can sometimes encourage superficial or competitive behavior rather than deep, meaningful collaboration. For instance, if poorly implemented, gamification with points might push students into “destructive competition” where they feel pressured or controlled by the game (Bovee et al., 2020). A 2024 review similarly warns that gamification can over-emphasize competition at the expense of collaboration (Wulan, 2024). When students focus too much on winning or rankings, true community-building may suffer.

There are also social and emotional considerations. Gamification can introduce social comparison that is not always healthy. A recent study on the “dark side” of gamified communities found that intense use of game elements can lead to stress, anxiety, or interpersonal conflicts (e.g., feelings of inequity or jealousy) if not moderated (Srivastava et al., 2022). In summary, gamification may encourage quantity over quality without careful design, foster unhealthy competition, or not engage students as intended.

However, one solution to maximize the social benefits of gamification while mitigating its drawbacks can be designed for cooperation, not just competition. Many studies emphasize collaborative gamification to foster meaningful peer interaction. This means structuring game elements so students work together (in teams or as a class) toward goals instead of solely

competing against each other. Cooperative or team-based challenges can satisfy students' need for social connectedness and shared purpose. An (2021) has found that social gamification (integrating social networking and teamwork into the game) tends to outperform purely individual gamification in terms of student interaction and even academic performance. Also, Dindar et al. (2021) compared gamified cooperation vs. competition and found no loss in achievement or motivation but significantly higher social relatedness in the cooperative condition. In practice, we can encourage community building using team points or group leaderboards instead of individual rankings. By making peers depend on each other for success, gamification can encourage help-seeking, communication, and a supportive learning community.

4.4 Engagement and Interaction

Descriptive analytics of engagement and interaction highlighted the platform's effectiveness in maintaining regular student involvement. The average number of weekly visits was 347, demonstrating consistent engagement. Moreover, users actively participated by raising 616 questions, providing 608 answers, and leaving 395 comments. This high level of activity aligns with existing literature on the positive impact of gamification on student engagement (Rivera & Garden, 2021; Alsadoon, 2023). However, our findings align with studies that argue that engagement metrics alone do not reflect deeper cognitive involvement or collaboration (Dillenbourg, 2021). Future studies should measure student-generated content depth, response quality, and long-term knowledge retention to provide a more comprehensive understanding of engagement.

4.5 Influence on Student Voice and Perspective

The realized and transformative value scores were moderate, with 40% of participants feeling that their ability to influence their learning environment improved. However, in follow-up interviews, some students expressed that Answers had enabled them to raise their academic concerns in ways that were not previously possible. This finding suggests that while the immediate transformative value may be unpretentious, the platform might contribute to a longer-term shift in student agency and participation. A potential area for future research is exploring how gamified platforms can

promote more structured student-led initiatives. An example could be developing feedback loops between students and instructors to address learning challenges or co-designing gamification elements to reflect student needs.

4.6 Practical Implications and Recommendations

Our findings have a few practical implications for designing gamified learning platforms. First, we aim to improve social interaction by integrating discussion-based features and collaborative activities, which can foster a stronger sense of relatedness. Second, educators need to enhance motivation mechanisms by moving beyond points and badges. To achieve this goal, platforms can integrate peer recognition systems, narrative-based progression, or personalized incentives. Finally, reinforcing engagement beyond task completion. Future studies should investigate how to sustain long-term engagement through adaptive game mechanics, explore interventions to improve social connectivity and measure long-term learning retention.

5. Conclusion

This study explores two main research questions. First, how do learners perceive the gamified learning experience on the Answers platform? Second, how does the Answers system impact graduate students' value creation and intrinsic motivation? The findings indicate that while the platform successfully enhances learning practices and engagement, its impact on social connections and broader perspectives is less pronounced. Points and badges have limitations in sustaining engagement; alternative motivational designs should be explored. Future research should focus on strategies to increase active participation and foster a sense of community, ensuring the platform's content remains relevant and challenging. Also, Wenger's Value Creation Framework provides a powerful lens for evaluating multi-dimensional learning outcomes in gamified environments. Platforms like Answers can maximize their impact on student learning and professional development by refining game design elements and fostering community-driven participation.

References

Aldemir, T., Celik, B., & Kaplan, G. (2018). A qualitative investigation of student perceptions of game elements in a gamified course. *Computers in Human Behavior*, *78*, 235-254. https://doi.org/10.1016/j.chb.2017.10.001

Alsadoon, H. (2023). The impact of gamification on student motivation and engagement: An empirical study. *Dirasat: Educational Sciences, 50*, 386-396. https://doi.org/10.35516/edu.v50i2.255

An, Y. (2021). A qualitative investigation of team-based gamified learning in an online environment. *Educational Process: International Journal, 10(*4). https://doi.org/10.22521/edupij.2021.104.5

Badoer, E., Hollings, Y., & Chester, A. (2020). Professional networking for undergraduate students: A scaffolded approach. *Journal of Further and Higher Education, 45,* 197–210. https://doi.org/10.1080/0309877X.2020.1744543

Bennett, S., & Maton, K. (2010). Beyond the 'Digital Natives' Debate: Towards a more nuanced understanding of students' technology experiences. *Journal of Computer Assisted Learning, 26,* 321–331. https://doi.org/10.1111/j.1365-2729.2010.00360.x

Bovee, B., Jernejcic, T., & El-Gayar, O. (2020). A gamification technique to increase engagement in asynchronous online discussion. *Research & Publications*, 416. https://scholar.dsu.edu/bispapers/416

Buckley, P., & Doyle, E. (2016). Gamification and student motivation. *Interactive Learning Environments, 24,* 1162-1175. https://doi.org/10.1080/10494820.2014.964263

Cohen, J. (1992). A power primer. *Psychological Bulletin, 112*, 155-159. https://doi.org/10.1037/0033-2909.112.1.155

Cook, R. J., Jones-Bromenshenkel, M., Huisinga, S., & Mullins, F. (2017). Online professional learning networks: A viable solution to the professional development dilemma. *Journal of Special Education Technology, 32*, 109-118. https://doi.org/10.1177/0162643417696930

Creswell, J. W., & Clark, V. L. P. (2017). Designing and conducting mixed methods research. *SAGE Publications.*

Deci, E. L., & Ryan, R. M. (1985). Intrinsic motivation and self-determination in human behavior. *Springer US*. https://doi.org/10.1007/978-1-4899-2271-7

Deci, E. L., Koestner, R., & Ryan, R. M. (2001). Extrinsic rewards and intrinsic motivation in education: Reconsidered once again. *Review of Educational Research, 71*(1), 1–27. https://doi.org/10.3102/00346543071001001

De Laat, M., Schreurs, B., & Sie, R. (2014). Utilizing informal teacher professional development networks using the Network Awareness Tool. *In The architecture of productive learning networks*. https://doi.org/10.4324/9780203591093

Dichev, C., & Dicheva, D. (2017). Gamifying education: What is known, what is believed and what remains uncertain: A critical review. *International Journal of Educational Technology in Higher Education, 14*, 9. https://doi.org/10.1186/s41239-017-0042-5

Dillenbourg, P. (2021). OECD digital education outlook 2021: Classroom analytics: Zooming out from a pupil to a classroom. https://doi.org/10.1787/336f4ebf-en

Dindar, M., Ren, L., & Järvenoja, H. (2021). An experimental study on the effects of gamified cooperation and competition on English vocabulary learning. *British Journal of Educational Technology, 52,* 142–159. https://doi.org/10.1111/bjet.12977

Dingyloudi, F., Strijbos, J.-W., & de Laat, M. F. (2019). Value creation: What matters most in communities of learning practice in higher education. *Studies in Educational Evaluation, 62*, 209–223. https://doi.org/10.1016/j.stueduc.2019.05.006

Gourlay, L., Rodríguez-Illera, J. L., Barberà, E., Bali, M., Gachago, D., Pallitt, N., Jones, C., Bayne, S., Hansen, S. B., Hrastinski, S., Jaldemark, J., Themelis, C., Pischetola, M., Dirckinck-Holmfeld, L., Matthews, A., Gulson, K. N., Lee, K., Bligh, B., Thibaut, P., Vermeulen, M., Nijland, F., Vrieling-Teunter, E., Scott, H., Thestrup, K., Gislev, T., Koole, M., Cutajar, M., Tickner, S., Rothmüller, N., Bozkurt, A., Fawns, T., Ross, J., Schnaider, K., Carvalho, L., Green, J. K., Hadžijusufović, M., Hayes, S., Czerniewicz, L., & Knox, J. (2021). Networked learning in 2021: A community definition. *Postdigital Science Education, 3*, 326–369. https://doi.org/10.1007/s42438-021-00222-y

Hamari, J., Koivisto, J., & Sarsa, H. (2014). Does gamification work? - A literature review of empirical studies on gamification. In 2014 47th Hawaii International Conference on System Sciences. *Presented at the 2014 47th Hawaii International Conference on System Sciences*, 3025–3034. https://doi.org/10.1109/HICSS.2014.377

Hanus, M. D., & Fox, J. (2015). Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance. *Computers & Education, 80*, 152–161. https://doi.org/10.1016/j.compedu.2014.08.019

Harding, A., & Engelbrecht, J. (2015). Personal learning network clusters: A comparison between mathematics and computer science students. *Educational Technology & Society, 18*(3), 173-184.

Huang, B., & Hew, K. (2015). Do points, badges, and leaderboard increase learning and activity: A quasi-experiment on the effects of gamification. *International Conference on Computers in Education* [Preprint]. Retrieved from https://library.apsce.net/index.php/ICCE/article/view/3213 (Accessed: March 10, 2025).

Ibáñez, M.-B., Di-Serio, Á., & Delgado-Kloos, C. (2014). Gamification for engaging computer science students in learning activities: A case study. *IEEE Transactions on Learning Technologies, 7*, 291-301. https://doi.org/10.1109/TLT.2014.2329293

Intrinsic Motivation Inventory (IMI) – selfdeterminationtheory.org. (n.d.). Retrieved from https://selfdeterminationtheory.org/intrinsic-motivation-inventory/ (accessed September 8, 2024).

Kraut, R., Wang, X., Butler, B., Joyce, E., & Burke, M. (2008). Beyond information: Developing the relationship between the individual and the group in online communities. *Information Systems Research, 10*. Retrieved from https://www.dhi.ac.uk/san/waysofbeing/data/communication-zangana-kraut-2008.pdf

Li, L., Hew, K. F., & Du, J. (2024). Gamification enhances student intrinsic motivation, perceptions of autonomy and relatedness, but minimal impact on competency: A meta-analysis and systematic review. *Educational Technology Research and Development, 72*, 765-796. https://doi.org/10.1007/s11423-023-10337-7

Li, M., Ma, S., & Shi, Y. (2023). Examining the effectiveness of gamification as a tool promoting teaching and learning in educational settings: A meta-analysis. *Frontiers in Psychology, 14*. https://doi.org/10.3389/fpsyg.2023.1253549

Li, W., & Liu, L. (2024). An examination of influential factors on gamification in higher education: A content analysis. *International Journal of Technology in Teaching and Learning*. https://doi.org/10.37120/ijttl.2023.19.1.01

Margaryan, A., Littlejohn, A., & Vojt, G. (2011). Are digital natives a myth or reality? University students' use of digital technologies. *Computers and Education, 56*, 429-440. https://doi.org/10.1016/j.compedu.2010.09.004

McAuley, E., Duncan, T., & Tammen, V. V. (1989). Psychometric properties of the Intrinsic Motivation Inventory in a competitive sport setting: A confirmatory factor analysis. *Research Quarterly for Exercise and Sport, 60*, 48-58. https://doi.org/10.1080/02701367.1989.10607413

Nicholson, S. (2014). A RECIPE for meaningful gamification. *In Springer eBooks* (pp. 1-20). https://doi.org/10.1007/978-3-319-10208-5_1

Nijland, F., Van Amersfoort, D., Schreurs, B., & De Laat, M. (2018). Stimulating teachers' learning in networks: Awareness, ability, and appreciation. In S. A. Yoon & K. J. Baker-Doyle (Eds.), Networked by Design. Routledge.

Poortman, C. L., Brown, C., & Schildkamp, K. (2022). Professional learning networks: A conceptual model and research opportunities. *Educational Research, 64*, 95-112. https://doi.org/10.1080/00131881.2021.1985398

Rivera, E. S., & Garden, C. L. P. (2021). Gamification for student engagement: A framework. *Journal of Further and Higher Education, 45,* 999-1012. https://doi.org/10.1080/0309877X.2021.1875201

Ryan, R. M. (1982). Control and information in the intrapersonal sphere: An extension of cognitive evaluation theory. *Journal of Personality and Social Psychology, 43*, 450-461. https://doi.org/10.1037/0022-3514.43.3.450

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology, 25*, 54-67. https://doi.org/10.1006/ceps.1999.1020

Ryan, R. M., Mims, V., & Koestner, R. (1983). Relation of reward contingency and interpersonal context to intrinsic motivation: A review and test using cognitive evaluation theory. *Journal of Personality and Social Psychology, 45*, 736-750. https://doi.org/10.1037/0022-3514.45.4.736

Sailer, M., & Homner, L. (2020). The gamification of learning: A meta-analysis. *Educational Psychology Review, 32*, 77-112. https://doi.org/10.1007/s10648-019-09498-w

Saleem, A. N., Noori, N. M., & Ozdamli, F. (2022). Gamification applications in e-learning: A literature review. *Technology, Knowledge and Learning, 27*, 139-159. https://doi.org/10.1007/s10758-020-09487-x

Schöbel, S., Janson, A., Hopp, J. C., & Leimeister, J. M. (2019). Gamification of online training and its relation to engagement and problem-solving outcomes. *Academy of Management Proceedings*, 1. https://doi.org/10.5465/AMBPP.2019.11949abstract

Srivastava, G., Bag, S., Rahman, M., Pretorius, J.-H., & Gani, M. O. (2022). Examining the dark side of using gamification elements in online community engagement: An application of PLS-SEM and ANN modeling. *Benchmarking: An International Journal, 30*. https://doi.org/10.1108/BIJ-03-2022-0160

Suh, A., Wagner, C., & Liu, L. (2016). Enhancing user engagement through gamification. *Journal of Computer Information Systems, 58*, 1-10. https://doi.org/10.1080/08874417.2016.1229143

Tobin, K. (1998). Issues and trends in the teaching of science. *In International Handbook of Science Education, 1*, 129-151.

Trust, T. (2012). Professional learning networks designed for teacher learning. *Journal of Digital Learning in Teacher Education, 28*, 133-138. https://doi.org/10.1080/21532974.2012.10784693

Trust, T., Krutka, D. G., & Carpenter, J. P. (2016). "Together we are better": Professional learning networks for teachers. *Computers & Education, 102*, 15-34. https://doi.org/10.1016/j.compedu.2016.06.00

Videnovik, M., Vold, T., Kiønig, L., Madevska Bogdanova, A., & Trajkovik, V. (2023). Game-based learning in computer science education: A scoping literature review. *International Journal of STEM Education, 10*, 54. https://doi.org/10.1186/s40594-023-00447-2

Wenger, E., Trayner, B., & De Laat, M. (2011). Promoting and assessing value creation in communities and networks: A conceptual framework. Rapport 18, Ruud de Moor Centrum, Open Universiteit. Retrieved from https://www.betterevaluation.org/sites/default/files/Wenger_Trayner_DeLaat_Value_creation.pdf (Accessed August 28, 2024).

Wenger-Trayner, E., & Wenger-Trayner, B. (2020). Learning to make a difference: Value creation in social learning spaces. Cambridge University Press. https://doi.org/10.1017/9781108677431

Wulan, D., Nainggolan, D., Hidayat, Y., Rohman, T., & Fiyul, A. (2024). Exploring the benefits and challenges of gamification in enhancing student learning outcomes. *Global International Journal of Innovative Research, 2*, 1657-1674. https://doi.org/10.59613/global.v2i7.238

Zhan, Z., He, L., Tong, Y., Liang, X., Guo, S., & Lan, X. (2022). The effectiveness of gamification in programming education: Evidence from a meta-analysis. *Computers and Education: Artificial Intelligence, 3*. https://doi.org/10.1016/j.caeai.2022.100096

Chapter 7.

Exploring Personal Experience and Value Creation in Postdigital Education: Insights from a Large-Scale MOOC Survey.

Abstract

This study explores how participants of Massive Open Online Courses (MOOCs) perceive value creation within online learning environments. Drawing on Wenger et al.'s (2011) Value Creation Framework, we developed and empirically validated a questionnaire, which was completed by 1,227 learners enrolled in MOOCs offered by TU Delft. The aim was to provide deeper insight into participants' experiences and the perceived impact of MOOCs on their personal and professional development. More specifically, this research explores the immediate, potential, applied, realized, and transformative value creation cycles. Our findings reveal significant insights into the multifaceted impacts of study behavior on learners' perceptions. Participants reported benefits such as skill acquisition, professional development, and enhanced confidence while highlighting areas needing improvement, such as practical application opportunities and course relevance. This study highlights the importance of aligning MOOC content with learner needs and providing ongoing support to maximize the educational value online courses can offer them. These insights contribute to understanding educational value in the postdigital age, advocating for the development and support of MOOCs to foster continued personal and professional growth.

Keywords: Value Creation Framework, Postdigital Education, MOOCs, Online Assessment

1. Introduction

Massive Open Online Courses (MOOCs) have emerged as an influential instrument for democratizing education and providing lifelong learning opportunities in the rapidly evolving landscape of postdigital education (Yuan and Powell, 2013; de Freitas et al., 2015). Despite their global reach and potential, concerns remain regarding their effectiveness, equitable access, and whether they genuinely democratize education or primarily benefit already privileged learners (Hansen & Reich, 2015; Littlejohn & Hood, 2018). The rapid expansion of digital technologies has transformed educational practices and fostered environments where traditional boundaries between the digital and physical dissolve (Haleem et al., 2022). In this context, MOOCs present the integration of digital technologies into lifelong and networked learning, which aligns with the hybrid characteristics of the postdigital condition (Jandrić et al., 2018). Postdigital education moves beyond viewing technology as an enhancement or supplement to traditional practices. Instead, it embraces the multi-dimensionality of digital systems with social, cultural, and material dimensions of education (Knox, 2023). As Jandrić et al. (2018: 895) argue, the postdigital is 'messy, unpredictable, digital and analog, technological and non-technological' and fundamentally challenges oversimplified views of educational technology. Considering this viewpoint, MOOCs can serve as platforms for knowledge dissemination and spaces where learners and educators navigate new socio-technical realities.

MOOCs are often described as transformative, providing unprecedented access to high-quality learning resources to a diverse global audience (Liyanagunawardena et al., 2013). However, the narrative of MOOCs as transformative tools is not without significant critique. For example, Kizilcec et al. (2013) found that learners from more privileged backgrounds, such as those with prior educational achievement, are more likely to complete MOOCs, which highlights the differences in course completion rates. Knox (2016) also critically examines the humanist assumptions underlying MOOCs and explores how these platforms may extend the existing educational inequalities. He argues that MOOCs often assume a universal learner and neglect the diverse socio-economic backgrounds of participants, which can lead to qualifying certain groups over others.

This study is situated within a critical discourse, acknowledging both the opportunities and limitations of MOOCs as postdigital learning spaces. Evaluating the educational experience of MOOC participants is not as straightforward as evaluating traditional educational programs, due to several factors such as the large and diverse population, varying levels of engagement, difficulty in capturing qualitative data, and the limited tools for such evaluation (Douglas et al. 2019; Lundqvist et al. 2020; Veletsianos et al. 2016). Most of the existing evaluation models heavily rely on quantitative data, such as completion rates and clickstream, which do not capture deeper learning experiences and complex interactions (Bergner et al. 2015; Tucker et al. 2014). Therefore, many traditional educational frameworks and theories have limitations in evaluating diverse and complex learning environments like MOOCs due to their strong emphasis on quantitative data, which may overlook subjective learner experiences (Dingyloudi and Strijbos 2015) or not being able to collect and evaluate culturally sensitive information (Kennedy et al. 2022).

To understand the educational procedure and student experience in complex learning environments like MOOCs, we need a theoretical foundation that could help us first capture both quantitative and qualitative data and, second, context-specific educational experiences in various settings. Exploring the previous research, we have identified several papers that critique and utilize the Value Creation Framework (VCF) by Wenger et al. (2011) for assessing MOOCs, demonstrating their potential advantage as flexible and qualitative evaluative tools over traditional frameworks (Dingyloudi and Strijbos 2015; Kennedy et al. 2022; Patel et al. 2019; Guldberg et al. 2019). Adopting Fawns's (2023) perspective, postdigital education requires us to critically assess technological integration and the broader ethical, political, economic, and social justice implications of educational practices. In this context, using Wenger et al.'s (2011) VCF helps explore how learners negotiate value within MOOCs' spaces that, despite offering unprecedented access, also carry risks of exacerbating inequalities and marginalizing certain groups. The study contributes to ongoing discussions about inclusive, ethical, and social approaches to designing and implementing postdigital learning environments by exploring these value dynamics.

The VFC categorizes value into five cycles: immediate, potential, applied, realized, and transformative. Immediate value refers to the initial benefits participants derive from engaging in

MOOCs, such as acquiring new knowledge and skills. Potential value encompasses the future benefits learners anticipate gaining from their MOOC experiences, including building their (professional) network, enhanced career prospects, and increased confidence. Applied value is observed when learners apply the knowledge gained from MOOCs in their professional and personal lives, leading to tangible improvements in job performance and new project initiatives. Realized value manifests as significant achievements in learners' careers or personal development, such as job promotions and entrepreneurial successes. Finally, transformative value reflects more profound, long-term changes in learners' perspectives and behaviors, fostering lifelong learning habits and a greater appreciation for online education (Wenger et al. 2011).

Previous research has highlighted the growing significance of MOOCs in addressing global educational challenges. For instance, Patel et al. (2019) adapted the VCF to evaluate the impact of MOOC-based learning on trachoma elimination practices at the local level. Their findings underscored the importance of MOOCs in providing relevant knowledge and skills to health workers, which they could then apply in their communities to combat trachoma. Similarly, Gamage et al. (2016) explored the effectiveness of MOOCs, highlighting how the VCF could identify quality variations in course design and delivery, thus emphasizing its advantages in providing clear insights into learners' experiences and the overall effectiveness of MOOCs.

However, understanding the full extent of MOOCs' impact requires a comprehensive examination of the value they create for learners. This study explores the multifaceted dimensions of value creation in MOOCs, leveraging the VCF developed by Wenger et al. (2011). These studies demonstrate that the VCF is a powerful tool for understanding and improving the learner experience in online education, especially in the context of lifelong learning and professional development. However, despite its usefulness, more research is needed to refine the framework further and explore its application across diverse educational settings to ensure its broader applicability and effectiveness. Also, our aim is to highlight MOOCs' potential to foster value creation that is not merely individualistic but deeply embedded in the postdigital era's collective, collaborative, and interconnected character.

TU Delft has established itself as a leader in online education, reaching over 3.6 million learners globally through a robust offering of 200 MOOCs, ten online academic courses, and more than 60 professional education courses. The university's pedagogical model emphasizes flexibility, personalization, and a learner-centered approach guided by inclusiveness, interactivity, and innovation. These MOOCs cover strategic themes like Energy Transition, Quantum Technology, and Artificial intelligence. They are designed to meet the needs of diverse global learners, providing a rich, interactive learning experience with significant community engagement. Through data-driven course design, TU Delft continuously enhances the quality and relevance of its MOOCs, ensuring they align with the latest educational research and technological advancements (TU Delft Extension School, n.d).

Building on insights into the values that MOOCs create for users, our study aims to investigate the value creation process in MOOCs offered by TU Delft. By surveying 1267 participants from TU Delft's MOOCs, we seek to answer the following research questions:

1. What immediate value do participants derive from engaging in MOOCs, and how does this initial engagement influence their overall learning experience?
2. How do participants perceive the potential value of MOOCs in terms of social connection?
3. How do participants apply the knowledge gained from MOOCs in their professional and personal lives, and what factors influence this application?
4. What kind of realized values can be observed among MOOC participants and why?
5. To what extent do MOOCs contribute to transformative value creation, and what do these look like?

By addressing these questions, this study aims to provide a comprehensive analysis of the value creation process in MOOCs, revealing the significant and multifaceted impacts on learners using VCF. These insights contribute to a better understanding of the role of digital education in fostering personal and professional growth, encouraging the continued development and support of MOOCs in the postdigital age.

2. Methodology

This study adopts a descriptive approach using the value creation framework by Wenger et al. (2011), which categorizes value creation into five distinct cycles: immediate, potential, applied, realized, and transformative. By exploring the specific types of value articulated by MOOC participants, this research provides valuable insights that can inform future course design, particularly in addressing student demographics and expectations. The findings aim to enhance understanding of how MOOCs impact learners and guide the development of more effective online learning experiences.

2.1. Participants

In this study, we invited 35000 previous TU Delft MOOC participants via email. 1960 participants responded to our invitation and completed our questionnaire. 773 participants needed to fill in the questionnaire completely. Therefore, we included 1227 responses.

2.2. Materials

Building upon Wenger et al.'s (2011) five-cycle value creation model, the Value Creation Questionnaire (VCQ) was developed to assess participants' perceptions of value generated through their MOOCs at multiple levels. The questionnaire comprised ten items, equally distributed between close-ended (multiple-choice) and open-ended questions. One multiple-choice and one open-ended query represented each of Wenger et al.'s value creation cycles.

For instance, participants were asked to rate their agreement (on a Likert scale of 1 (Strongly disagree) to 6 (Strongly agree)) with the statement, 'Participation changed me as a student (change in skills, attitudes, identity, self-confidence, feelings, etc.).' Positive responses (strongly agree, agree, or slightly agree) prompted an open-ended follow-up question: 'Can you elaborate on how participation changed you as a student?' Conversely, negative responses (slightly disagree, disagree, or strongly disagree) triggered a different open-ended question: 'Can you explain why

participation did not change you as a student?' The full version of the questionnaire is attached as Appendix 1.

2.3. Procedure

The study was conducted through an online survey distributed via email to 35,000 previous participants of TU Delft's MOOCs. Participants were informed about the purpose of the study and provided consent before completing the survey. The survey was available for four weeks, and one reminder was sent to maximize the response rate. Ethical approval was obtained from the institutional review board at TU Delft (approval number: 3849), and all data were collected following ethical guidelines.

2.4. Qualitative And Quantitative Data Analysis

Data were analyzed using a mixed-methods approach. Quantitative data were analyzed using descriptive and inferential statistics with SPSS software. Thematic analysis was conducted on qualitative data using ChatGPT (OpenAI 2024) on 13 May 2024.

2.4.1 LLM Use in Data Coding

Introduction of Researcher-Driven AI-assisted Qualitative Data Analysis (RDAQDA)

RDAQDA method (Nguyen-Trung 2024) was used to analyze the qualitative data from VCQ open-ended response. This method includes four stages of analysis using the LLMs. They are data familiarization, preliminary coding, template formation and refinement, and theme development. This method combines human expertise with AI capabilities to enhance the efficiency of our thematic analysis.

2.4.2 Detailed Analysis Process

The qualitative analysis involved the following steps:

Step 1: Data Familiarization. In this part, researchers thoroughly reviewed the dataset to gain an in-depth understanding of the content and context. Then, we tried to summarize and take note of

the most important points mentioned in the answers. To empower our analysis using ChatGPT as an LLM, we asked ChatGPT to do the same task with the following prompt:

Prompt 1. Can you please provide me with a summary of key ideas from all the responses in the uploaded file? [upload the first of the responses].

To make it manageable and compare the summary of ChatGPT with the researchers' summary, we separated the responses into ten smaller parts. For example, responses about immediate values were separated into positive (part 1) and negative responses (part 2), positive responses to potential values question (part 3), and negative responses to potential value (part 4) based on the participant's response to the first multiple-choice question. Therefore, in the end, we had ten separate parts. In the next steps, researchers compare their summaries with ChatGPT's output and a final summary document for each of the parts created.

Step 2. Preliminary Coding. In this step, our goal was to create a list of initial codes for each of the parts that we explained in the data familiarization step. In this step, to create a context and make sure ChatGPT understands the goal of the research, the research questions included in our prompt. The following prompt was used to extract the initials codes for each of the subparts:

Prompt 2. You're a qualitative research assistant. You will help me identify the relevant codes from the following text in response to this question: 'Question one about the immediate value?'. Our research question regarding this question is: 'Research question one'. Codes are labels that assign summative, salient, essence-capturing, and/or evocative attributes/meanings to a portion of data. The final outputs are a table like this: Column 1: Code; Column 2: Description of code meaning; Column 3: Quotation representing the code from the responses. Here is the transcript: [insert the transcript].
The researcher reviewed the table of initial codes to make sure that each response was assigned to the correct code by ChatGPT.

Step 3: Template refinement. In this step, the aim is to compact the initial codes and data to construct the clusters and then modify and finalize these initial categories. Therefore, the next prompt that has been used is as follows:

Prompt 3. From the above-refined list of codes, please group codes into clusters (i.e., more abstract codes) in response to the question: 'Question one and two.' Remember that our research question was 'Research question one.' For each of the clusters, please retain the specific codes and quotations from specific responses. If two or more responses fall under the same cluster, please put them together. The final output will be a table: Column 1: Cluster; Column 2: Codes; 3. Description of Cluster Meaning; Column 4: Quotation from responses.

Then, we followed the same prompt for each of the parts. Each of the created clusters was manually checked by the researcher to make sure that the responses clustered correctly.

Step 4: Theme development. In this final step, the goal is to create four main themes for each of the parts based on the previously redefined clusters. Therefore, we used the following prompt to extract these themes:

Prompt 4. From the above table of clusters, please generate themes across the clusters and codes in response to the question: '[questions 1 and 2 (about immediate value)]' where we investigate this research question: '[research question 1 (about immediate value)]'. The theme is defined as the recurrent and distinctive features of participants' accounts that characterize perceptions and/or experiences as you, as the researcher, see them as relevant to the research question of a particular study. Each theme should link the cluster(s) and/or code(s) with the context of '[immediate value]'. Themes must be relatively distinct from each other, although some overlap is inevitable. The final output will be a table: Column 1: Theme; Column 2: Clusters and Codes used for the theme; 3. Description of Theme Meaning; Column 4: Quotation from Transcripts.

By creating separated parts, we tried to maintain analytical consistency and reduce potential biases during AI-assisted analysis. Also, the coding template and themes were iteratively refined by incorporating feedback and insights from both human analysts and AI outputs.

3. Results

3.1. Descriptive Analysis of VCQ

The descriptive analysis of the VCQ demonstrates participants' experiences across the five value creation cycles: Immediate, Potential, Applied, Realized, and Transformative. Table 7.1 summarizes the value creation cycles and their corresponding multiple-choice questions in VCQ. Also, the results indicated in Table 7.2 provide insights into the average scores for each cycle, along with their standard deviations. As we explained in the methodology section, for each cycle, we have one multiple-choice question, and participants can respond on a Likert scale of 1-6.

Table 7.1

Value Creation Cycles and Their Corresponding Multiple-Choices Questions in VCQ

Value Creation Cycle	Related Question in VCQ
Immediate	Participation in TU Delft MOOC changed me as a student or professional (change in skills, attitudes, identity, self-confidence, feelings, and so on. [for example, it helped you to gain a new skill]).
Potential	Participation in TU Delft MOOC affected my social connections (change in the number, quality, frequency, emotions, and so on. [for example, it helped you find x new number of connections or friends]).
Applied	Participation in TU Delft MOOC helped my practices as a student or a professional (get new ideas, insights, materials, procedures, and so on. [for example, it helped you to get a new idea on how you can work more efficiently, or got access to materials that you haven't had before])
Realized	Participation in TU Delft MOOC changed my ability to influence my world as a student or a professional (enhance my voice, contribution, status, recognition, and so on. [for example, it helped you to raise your voice and affect the organization that you are working for or the school that you are studying])
Transformative	Participation in TU Delft MOOC made me see my world differently (change in perspective, new understandings of the situation, redefine success, and so on. [for example, it helped you redefine how to see a problem and gave a new approach to solve it]).

Table 7.2

Quantitative Analysis of Multiple-choices Questions of VCQ

Value Creation Cycle	Average score*	Sd
Immediate	4.86	0.95
Potential	3.27	1.52
Applied	4.98	0.97
Realized	4.11	1.40
Transformative	4.61	1.19
*Maximum score is 6		

As shown in Table 7.2, the applied value creation cycle received the highest average score of 4.98 (SD = 0.97), indicating that participants felt TU Delft MOOCs helped their practices. This finding was closely followed by the immediate value creation cycle results, with an average score of 4.86 (SD = 0.95), suggesting that participants obtained significant value from the initial engagement and activities within the MOOCs. The transformative cycle also scored highly, with an average of 4.61 (SD = 1.19), reflecting how the courses led to more profound and meaningful changes in participants' perspectives and practices.

In contrast, the potential cycle, which relates to the effect of the course on participants' social connection, had a lower average score of 3.27 (SD = 1.52), indicating variability in participants' perceived potential value. The realized cycle, representing the long-term impact and effectiveness of the MOOCs, received a moderate average score of 4.11 (SD = 1.40), highlighting the challenges in sustaining the benefits of learning over time.

To better and more precisely understand responses to multiple-choice questions, we divided them into positive and negative. It means that responses such as "Strongly Agree," "Agree," and "Slightly Agree" are considered positive, and "Slightly Disagree," "Disagree," and "Strongly disagree" are negative responses. Table 3 summarizes this analysis of multiple-choice responses. Our analysis shows that only 569 out of all 1227 collected (46.43%) responses perceived the

potential value positively. The highest positive responses belong to the applied cycle with 94.20% and immediate value with 93.40%.

Table 7.3

Descriptive Analysis of Open-ended Questions in VCQ

Value Creation Cycle	Number of positive values	Percentage of positive values	Number of negative values	Percentage of negative values
Immediate	1146/**1227***	93.40%	81/1227	6.60%
Potential	569/1227	46.43%	658/1227	53.63%
Applied	1156/1227	94.21%	40/1227	5.70%
Realized	870/1227	70.90%	357/1227	29.09%
Transformative	1060/1227	86.39%	167/1227	13.61%
*"**1227**" represent the total number of collected responses.				

3.2. Qualitative Analysis Open-End Responses

Participants prompted different follow-up open-ended questions based on the positive or negative responses to the multiple-choice questions. Thematic analysis of the open-ended responses from VCQ provides a better understanding of participants' experiences, broken down into positive and negative responses to each cycle of values. By analyzing these responses, we can identify the most effective educational processes in the MOOCs, as well as areas where students face challenges. These two perspectives not only highlight the strengths of MOOCs in terms of immediate implementation and practical application but also highlight the need for improvement in areas where participants expressed challenges, particularly in terms of emphasizing the realization and social connection.

Thematic analysis of positive responses to the immediate value creation showed that participants experienced significant benefits, particularly knowledge transfer, skills development, confidence building, and career growth. A summary of this finding is shown in Table 7.4. Many students reported gaining new knowledge and insights in various areas. Other participants emphasized how it helped them gain new skills and increased their confidence in their abilities. For example, one

participant mentioned that the course gave them confidence and knowledge that was previously lacking.

On the other hand, analysis of negative responses identified several areas of dissatisfaction among participants. Some felt the courses needed more practical opportunities with content or approaches that did not meet initial expectations. Some students found the courses too challenging or challenging. In contrast, others felt that the course had little or no impact on their career or personal development, highlighting the need for MOOCs to fill the gaps.

Table 7.4

Thematic Analysis of Open-Ended Response in VCQ - Immediate Value

	Positive/Negative	Theme	Description	Quote example
Immediate Value	Positive	Knowledge Enrichment	Participants gained new knowledge and insights in various fields.	It broadened my knowledge on water purification methods and gave me insight in how calculations such as for pressure within Reverse Osmosis worked.
		Skill Development	Participants reported acquiring new skills and enhancing existing ones.	It helped me gain a new skill and knowledge.
		Confidence Boost	Engagement in courses increased participant's confidence in their abilities and knowledge.	It gave me the confidence and knowledge that I lacked on the subject.
		Career Advancement	Participants felt the courses assisted them in their career growth and development.	Participation in the Coursework, helped me acquire a lot of knowledge in the field of biomedical engineering.

	Negative	No Practical Application	Participants felt the course lacked practical knowledge and application opportunities.	"Didn't get enough practical knowledge or the chance to exercise what I learned, while working in the construction industry"
		Expectation Mismatch	Participants had expectations about course content and format that were not met.	"I expected a much different course. There were very few video lectures and notes."
		No Hope for Change in Their Career	Participants felt the course had little impact on their career or personal development.	"It didn't have a big impact on my career or personal development."
		Course Difficulty	Participants found the course challenging or too complex.	"The first module was way too complicated for me."

The thematic analysis of the open-ended responses about potential benefit cycles reveals positive and negative experiences regarding communication and social relationships among MOOC participants. On the positive side, about 46% of the responses participants made new connections and expanded their networks. Some participants noted the value of shared learning experiences through group projects, which resulted in an improved sense of community. Thematic analysis of responses regarding the potential value is shown in Table 7.5.

In contrast, around 54 % of participants expressed dissatisfaction with the social aspects of the courses. Many reported that they did not communicate with others and noted that the internet limitation prevented them from communicating. Others mentioned that their learning style limited their social opportunities, and many did not participate in seminars or group activities. These findings suggest that while MOOCs can improve connections and bring value and cultural shifts, some online programs and these self-directed courses can prevent social interaction, too.

Table 7.5

Thematic Analysis of Open-Ended Response in VCQ - Potential Value

	Positive/Negative	Theme	Description	Quote example
Potential Value	Positive	Networking and Social Connections	Participants mentioned forming new connections and expanding their networks.	'Met a friend and we are still very much in contact.', 'Increased my network connections'
		Shared Learning Experiences	Engagement in group projects led to shared learning experiences and connections with diverse peers.	'Collaborating on group projects created a sense of community.'
		Confidence and Personal Growth	Participants reported increased confidence levels and personal growth through interactions in the course.	'Boosted my confidence to participate in discussions.'
		Global Engagement and Cultural Exchange	Engaging with diverse participants led to global engagement and cultural exchange.	'Exposure to diverse perspectives enhanced my learning.'
	Negative	Lack of Social Interaction	Participants mentioned the absence of social opportunities and interaction in the online courses.	"Because I never talked to anyone from Delft or within the edX Pre-University Calculus community."
		Self-Paced and Individual Learning	Participants focused on individual learning goals without actively seeking social connections.	"I took the course at my own pace and did not communicate with anyone else."
		Limited Participation in Forums	Many participants did not actively engage in the course forums or discussions.	"Not much social interaction and did not participate in group activities."
		Online Format Constraints	Challenges related to the online format restricting social interactions among participants.	"Being an online course, it was not manageable to maintain any connections."

The third part of VCQ explores the applied value creation cycle, and participants are asked to respond to the following question. “Participation in TU Delft MOOC helped my practices as a student or a professional (get new ideas, insights, materials, procedures, and so on. [for example, it helped you to get a new idea on how you can work more efficiently or got access to materials

that you have not had before]). Can you explain why participation did not help your practices as a student or a professional?" Alternatively, "Can you explain how participation helped your practices as a student or a professional?"

TU Delft MOOCs created positive applied value for their participants. Most participants mentioned these courses' impacts on their professional development. It means that the new knowledge and skills gained during the courses helped them to improve their professional role. This impact was not only in terms of professional development or advances in their career but also in personal growth. In an interesting case, a participant mentioned that the online courses helped him balance work, life, and school.

On the other hand, a small part of participants (around 4%) mentioned that these MOOCs had no impact on their professional development because they did not relate to course materials or did not use them for academic or professional growth. A summary of our analysis concerning applied value is shown in Table 7.6.

Table 7.6

Thematic Analysis of Open-Ended Response in VCQ - Applied Value

	Positive/Negative	Theme	Description	Quote example
Applied Value	**Positive**	Professional Development	Participants benefited in their professional roles, gaining new knowledge and skills.	"Gave me insight into EVs and also some of the people/companies working in that space"
		Learning and Education benefits	Participants highlighted the value of learning and education from the courses.	"The abundance of study materials and lecture videos have given me a very good learning experience and understanding complex topics in a detailed and fun way.".
		Personal Growth	Participants experienced personal growth and development through the courses.	"To plan my time properly between work, personal life and school"

		Innovation and Inspiration	Participants mentioned gaining new ideas, perspectives, and inspiration from the courses.	“TU Delft MOOCs often cover cutting-edge topics and research findings in various fields. By participating in these courses, you expose yourself to new ideas and perspectives that can inspire innovation and creativity in your academic or professional endeavors. Whether it's learning about emerging technologies, novel theories, or innovative solutions to real-world problems, these insights can broaden your thinking and challenge conventional wisdom.”
	Negative	No Impact on Professional Development	Participants did not find direct impact on their professional practices or studies.	"Participation didn't directly impact my practices as a student or professional because I haven't actively engaged with the resources provided by the TU Delft MOOC. While I acknowledge the potential benefits, I have yet to explore and utilize them effectively to enhance my practices." "Work in software development. Not AI related (YET)"
		No Personal Enrichment	Participants took courses for personal interest and enrichment without professional or academic gain.	"For me the courses were purely personal and had no professional or practical purpose." "They were mostly taken for personal enrichment, I am out of the workforce and not likely to return to school at this point, so there was no professional nor academic gain to be had."
		Lack of Relevance	Participants highlighted that the courses did not cover new techniques, study tips, or were not relevant to their studies or professional life.	"Because a lot of it didn’t apply to my studies" "It was just informational" "It wasn't relevant for my studies"
		Limited Engagement	Participants mentioned limited engagement, lack of practical use, or no impact due to factors like unfamiliar subject areas.	"No influence" "No ideas have occurred to me yet" "I didn’t engage enough for it to have an impact"

Evaluating the perceived realized value is challenging because this value cycle is context-related. It takes time for professional learning network members to understand and realize this value in many situations. Nevertheless, around 70% of our participants answered positively to the following statement: Participation in TU Delft MOOC changed my ability to influence my world as a student or a professional (enhance my voice, contribution, status, recognition, and so on. [for example, it helped you raise your voice and affect the organization you are working for or the school you are studying]). The themes Identified in open-ended responses include solidified knowledge, academic pursuit boost, self-confidence boost, and positive impact on professional development. A summary of the thematic analysis of realized value is shown in Table 7.7. On the negative side, the remaining participants mentioned that these MOOCs had no practical influence on their career or study path. Participants could not influence their world/or surroundings with the knowledge and skills gained during the course.

Table 7.7

Thematic Analysis of Open-Ended Response in VCQ - Realized Value

	Positive/Negative	Theme	Description	Quote example
Realized Value	**Positive**	Solidified knowledge	Enhanced knowledge and understanding gained from the course.	"I can apply the knowledge in my profession."
		Boost in academic pursuit	Participants experienced a confidence boost and presence enhancement in their academic journey.	"The participation built my presence which gave me a boost in my academic pursuit."
		Enhanced self-confidence	Increased self-confidence and ability to communicate with others.	"I feel more confident to talk with researchers or professional around the world."
		Positive Impact on professional development	Improved skills, knowledge, and abilities relevant to professional growth and challenges.	"As a professional i can push my boundaries to take up new challenges in combination of power and process."

	Negative	No Impact on Personal Development	Participants' personal growth and development through the course.	"Although I gained insight it had no effect as I struggle to find community within that niche in South Africa", "The course had more of a personal effect than an effect on my professional career."
		Lack of Practical Application	Absence of practical skills gained from the course.	"Only theory ideas, no developed practical competencies", "new skills were not directly applicable to my work"
		Limited Impact on External Environment	Participants expressing minimal influence on their surrounding world.	"It changed ME of course but I couldn't change anything outside of me.", "I don't think I have changed anything around me."
		No Perceived Value and Recognition	No change on views on the perceived value and recognition of MOOC participation.	"With no expendable recognition, MOOC falls into the category of personal interest/hobby.", "for some individuals ... it could very easily act as a career enabler."

Around 86 % of participants claimed that TU delft MOOCs made them see the world differently. They explained that these courses helped them understand environmental challenges, energy transition, and connected global challenges. Finally, one of the positive identified values was improving analytical and problem-solving skills, which helped the participants see their world differently. Besides these positive values, participants also mentioned that although these courses helped them gain new knowledge and skills, they did not necessarily change their views or perspectives about their surrounding worlds. A summary of these findings is shown in Table 7.8.

Table 7.8

Thematic Analysis of Open-Ended Response in VCQ - Transformative Value

	Positive/Negative	Theme	Description	Quote example
Transformative Value	Positive	Insight On Environmental Consciousness	Recognizing the role of sustainable practices	1. "I have come to recognize the critical role of electric vehicles (EVs) in reducing greenhouse gas emissions." 2. "Understanding EV technology connects me to the broader energy transition."
		Better understanding of Energy Transition	Understanding the shift towards sustainable energy sources	1. "My awareness extends beyond personal benefits. I realize that every EV on the road contributes to a collective effort toward a healthier planet." 2. "As I delve into EV infrastructure and charging solutions, I have come to appreciate the impact on urban planning."
		Global Impact	Acknowledging the interconnectedness of global challenges	1. "It helped me gain insights into the field and the technology associated with it." 2. "The course helped me create a more in-depth knowledge on the indicated topic."
		Problem-Solving Skills	Enhancing critical thinking and analytical abilities	1. "Engaging with the material and software has provided me with a deeper appreciation for the complexities of hydrodynamic processes." 2. "The course taught me the function and exactly how aircraft can fly."
	Negative	Enhanced Knowledge but no impact on worldview	Participants felt that the course added to their existing knowledge without fundamentally changing their worldview.	"It just enhanced my knowledge a little. But that's not enough to say that I see the world differently." "Although I learned a lot, it was more for a better understanding rather than new insights that changed my views."
		Improved Technical Skill Development but no impact on global perspective	Focus on acquiring technical skills rather than altering perspective on the world.	"Although I learned a new skill, it was not in an area that changed my worldview." "I took a technical course and hence it gave me a way to look at technical problems related to that domain differently, but it didn't affect the rest of my decisions."

		No General Impact on Worldview	Participants expressed that the course did not have a significant impact on how they see the world.	"No, I'm convinced my view of the world is quite good." "Participation in the TU Delft MOOC has not brought about any changes in how I see my world. It has not changed my perspective."
		Insufficient Depth for Worldview Change	Feedback indicates that the course content lacked depth or relevance to prompt a shift in worldview.	"Although it was mind-boggling, I was kind of known to the facts provided." "The content of the course was in line with expectations. It gave more depth that I had before, but it was not earth-shattering."

4. Discussion

This study employed Wenger et al.'s (2011) value creation framework to study the perceived values that TU Delft MOOCs offer. Our findings highlight positive outcomes and the areas needing improvement, offering valuable insights for educators, policymakers, and researchers.

4.1. Immediate Value

To answer our first research question, which was the immediate value participants derived from engaging in MOOCs, our results show that 93.40% percent of our participants perceived the positive immediate value of participating in MOOCs. They described these positive values as gaining new knowledge, developing new skills, feeling more confident, and seeing the hope for career advancement. On the other hand, 6.60% of participants expressed concern about mismatched expectations, lack of hope, frustration with a career change after doing the courses, and course difficulty. This suggests a need for MOOCs to differentiate their content and delivery methods to ensure that they offer unique and valuable learning experiences (Ucha, 2023).

The central identified positive theme was the confidence boost. Our participants described improved self-efficacy and confidence, like navigating technology and managing their time. These findings align with previous research on the impact of MOOCs on learner’s self-efficacy and confidence (Beirne et al., 2023; Beirne et al., 2021).

Mismatched expectations can lead to decreased satisfaction and reduced intention to continue using MOOCs (Lee et al., 2023; Daneji et al., 2019). Although a small portion of our participants report this negative feeling while doing the MOOCs, it is one of the main negative themes identified in our study.

4.2. Potential Value

Our second research question is about how our participants perceive the potential value of MOOCs in terms of social connection. Our finding reveals a mixed perception of this social connection in MOOCs as an indicator of potential value. Around 53 percent claimed these MOOCs had no positive impact on their social connections. Previous studies show that this social interaction can be mediated by immersive experience and psychological needs satisfaction (Fang et al., 2019). The identified theme in our studies shows that participants who emphasize their individual learning goals and have difficulty in online connections tend to interact less with their peers and be active on MOOC discussion forums.

However, this lack of social presence and interaction can increase the chance of drop-off and negative educational experiences (Zou et al., 2021; Estrada-Molina & Fuentes-Cancell, 2022). Therefore, course instructors and designers must develop innovative ways to implement and improve the social presence and interaction in their MOOCs. For example, recently, researchers have tried to implement AI tools in MOOCs to reach this goal (for review, Sen Loh et al., 2024).

4.3. Applied Value

In the value creation framework, values are described as interconnected cycles (Wenger et al., 2011). Also, our analysis revealed an interesting correlation or trend between Immediate, potential, and applied value. Thematic analysis of applied value shows learners could improve their professional development by using the knowledge and skills (Immediate value) and connection (potential value) gained through the MOOCs. To elaborate, participants highlighted improvements in job performance and implementing new ideas and practices in their everyday tasks. These outcomes demonstrate the practical benefits of MOOCs, enabling learners to apply theoretical

knowledge to real-world scenarios, thus enhancing their professional capabilities. The flexible nature of MOOCs allows learners to balance their studies with professional commitments. This flexibility enables continuous learning and skill development, which are crucial for career advancement (Bralic & Divjak, 2018).

However, the lack of practical application opportunities was a common criticism. Participants expressed needing more hands-on activities and practical exercises to translate theoretical knowledge into practical skills better. This is especially true when we want to target working professionals in the MOOCs (Liu et al., 2020). Addressing this gap could involve integrating more interactive components like simulations, case studies, and project-based learning.

4.4. Realized Value

Realized values are context-related and usually difficult to capture due to their long-term effect (Wenger et al., 2011). This can explain why we observed around 70% positive value perception (in comparison with around 95% positive responses in immediate and applied value). Nevertheless, participants reported significant achievements and improvements in job performance due to their participation in MOOCs. These central positive realized values were the boost in academic pursuit, which included gaining knowledge about time-saving techniques, enhanced productivity, and positive impacts on academic performance metrics.

On the other hand, some participants did not perceive significant improvements in their performance, and the central theme revealed was a limited impact on the external environment. This points to the necessity of providing ongoing support and follow-up resources to help learners effectively implement what they have learned (Rotar, 2022).

4.5. Transformative Value

The positive transformative impact of MOOCs was evident in 86.39% of participants. They claimed that the MOOCs provided them with a deeper insight into the global impacts of environmental challenges and fundamental topics like energy transition. Environmental challenges

and energy transition were two of the main themes of TU Delft MOOCs. Moreover, the results show that these two themes successfully changed the learners' perspectives and strategies when approaching these global concerns. Also, other research on the impact of MOOCs on global challenges shows that universities and their MOOCs can significantly contribute to knowledge exchange and professional networks' knowledge development (Laurillard & Kennedy, 2020)

However, not all participants realized the transformative potential. Some indicated that the courses needed to provide more depth or relevance to prompt a shift in their worldview. To explain this lack of perceived value, research has shown that a lack of teaching-based quality and insufficient depth in study materials in MOOCs can significantly decrease learning efficiency (Abhishek et al., 2023; Shanshan & Wenfei, 2022). This suggests a need for MOOCs to offer more in-depth content and opportunities for critical reflection to foster transformative learning experiences.

4.6. Implications for Practice

One of our goals in this research is to explore and evaluate MOOCs through learners' eyes. VCQ enables us to explore learners' behavior, perceived value, engagement, and satisfaction using qualitative and quantitative measures. Therefore, investigating MOOCs from the learner's perspective can help utilize learner-centered design that supports the needs and intentions of their participants embedded in the post-digital society (Moore & Blackmon, 2022).

Our finding that learners perceive significant value in skill acquisition aligns with previous MOOC research emphasizing the importance of practical skills development for learner motivation (Lee & Song 2022). Our finding also resonates with broader research on online learning that highlights the link between perceived relevance and learner engagement (Li et al., 2023; Pan, 2023). Furthermore, this finding supports the principles of authentic learning design, which advocate for learning experiences that are connected to real-world contexts and applications (e.g., Lombardi, 2007; O'Neill & Short, 2023).

Based on our findings in this research, we suggest considering the following features in designing a learner-centered MOOC.

4.7. Learner-Centered MOOC Design from the Value Creation Perspective

Based on our findings in this research, we suggest considering the following features in designing a learner-centered MOOC.

4.7.1. Setting a Clear Course Expectation

Course designers need to clearly outline the course content, structure, and learning objectives of the MOOC and set up difficulty levels to manage learner expectations and reduce mismatch. This feature also enables learners to match their current knowledge and skills with the MOOC's difficulty level. It increases learners' overall enjoyable experience at the first stage of their learning programs. Also, the other recent finding confirms that addressing learner expectations and communicating the usefulness of the MOOC ensures learners' satisfaction and continuance of the course (Rekha et al., 2023).

4.7.2. Fostering networking opportunities

By integrating collaborative projects, discussion forums, and an effective peer feedback system, we can implement networking opportunities in MOOCs. Encouraging learners to share their insights can create a valuable chance for them to build professional networks in the future (Soleymani et al., 2022). Also, MOOC designers must remember that more than just implementing discussion forums is needed for an effective social learning environment. Lack of support for social interaction (Rivera et al., 2024) and providing no quick feedback on contributions to the discussion forums (Wei et al., 2023) can negatively influence the student experience in MOOCs.

4.7.3. Encouraging professional development via real-world cases and relevant content

Course content significantly predicts MOOC retention via perceived effectiveness (Hone & El-Said, 2016). Therefore, our results show that when our participants did not understand the relevance of the course content to their field, and there were no real-world case studies in the MOOC, they were less likely to use or apply what they have learned in their everyday practice as students or professionals. The MOOC can be designed to support the transfer of online learning into offline action (Alyssa et al., 2020).

4.7.4. Implementing the “Impact Reflection Assignments”

One solution to raise awareness about positive realized value among our learners is encouraging them to think beyond their learning environment. Motivate them to consider how they can influence their surroundings (e.g., their organization or school). This can be done by an “Impact Reflection Assignment.” This assignment includes reflective activities where learners assess and discuss how their new knowledge and skills can influence and improve their external environment. Previous findings also confirm the fundamental role of reflection facilitation in improving the quality of the learning experience for learners (Daalhuizen & Schoormans, 2018).

4.7.5. Big Picture Design

Many TU Delft-provided MOOCs consider a bigger picture or theme while designing these educational programs. These big pictures are, for example, related to the environment, sustainability, energy transition, or AI in society. We believe this was a successful strategy. Our results here show that after completing the MOOCs, most of our participants started thinking beyond their boundaries and considering the global impacts of topics like energy and environment. Course designers can implement in-depth exploration contents or encourage critical debates in their MOOCs to promote positive transformative value.

4.8. Using Natural Language Processing (NLP) Tools for Thematic Analysis

ChatGPT is one of the most widely used NLP tools, with many applications in different fields, especially education research (Albadarin et al., 2024). A growing number of researchers use such tools for their thematic analysis to identify and interpret patterns in research data (Lee et al., 2024). ChatGPT is a valuable tool for research, especially for thematic analysis, as it enhances efficiency and provides additional insight into the qualitative data. However, there are essential challenges when using ChatGPT for thematic analysis. These challenges include hallucination of the Large Language Model (LLM) (For example, when the produced responses by LLM are not justified by the data used to feed the model), privacy issues, and high prompt-dependency (For example, requesting the same output in the prompt with different phrased can generate different output) (Dee

Paoli, 2023). Therefore, when using NLP tools like ChatGPT, we must consider the critical role of interaction between the human researcher and the tool to ensure reliable results.

4.9. Limitations

While this study offers valuable insight into learners' perception of value creation in MOOCs, several limitations must be acknowledged. First, one of the main concerns is the applicability of our results. This study surveyed participants from MOOCs offered exclusively by TU Delft, which may limit the generalizability of the findings to other institutions or contexts. Also, learners in these MOOCs may differ in demographic or professional backgrounds compared with other MOOCs offered by different organizations, which can potentially affect the applicability of our results to the broader population.

Second, although our qualitative analysis using ChatGPT facilitated an efficient thematic analysis, it also has some limitations. The quality of the AI-assisted coding depended heavily on the clarity of prompts and the researchers' validation of AI outputs. Despite our careful and manual checking of the process, some responses may have been overlooked.

Third, while the value creation framework provides a structured lens for our analysis, it is important to acknowledge the inherent subjectivity in interpreting and measuring perceived value. Besides this, we did not include the time interval between the MOOCs' end and the time participants answered our value creation questionnaire. Therefore, the timeframe and subjective nature of value creation might affect the results.

Finally, this research relies heavily on the qualitative results of our survey. While this approach allows for the analysis of large datasets like MOOCs and the identification of general trends, it provides limited insight into the complexities of individual learning experiences. Qualitative research methods, such as interviews or focus groups, could complement these findings by providing richer, and in-depth data.

5. Conclusion

This study provides a comprehensive analysis of the value creation process in MOOCs offered by TU Delft, revealing significant and multifaceted impacts on learners. The insights gained highlight the strengths and areas for improvement in MOOC design and delivery, contributing to a better understanding of the role of digital education in fostering personal and professional growth. By addressing the identified gaps and leveraging the potential of MOOCs, educators and institutions can enhance the learning experiences and outcomes for a diverse global audience.

Our findings expand our knowledge and understanding of value creation in online learning environments like MOOCs. The first value cycle investigated in this study was immediate value. Most of the participants reported that they gained new knowledge, developed skills, and increased their confidence. However, a small percentage experienced mismatched expectations, underscoring the importance of clearly defining course content and objectives to meet learner needs. Job performance improvements and real-world application of knowledge were the main two applied values reported by our participants. More practical exercises and hands-on activities needed to be implemented to improve the potential value. The potential value of this study focused on the social connection of participants. Our findings emphasize the need for innovative strategies to foster social presence and interaction through AI tools and collaborative activities.

Moreover, while most participants recognized the transformative value of MOOCs in shaping their perspectives on global issues like energy transition and sustainability, others found that the depth and quality of materials needed to be improved to drive a shift in their worldview. Practical applications suggested in this study included setting clear expectations, fostering networking opportunities, incorporating real-world cases, and encouraging reflective activities like "Impact Reflection Assignments." Future research should explore innovative methods, such as natural language processing techniques, to further understand learner behaviors and improve the efficacy of MOOCs in diverse educational and professional contexts.

References

Albadarin, Y., Saqr, M., Pope, N., & Tukiainen, M. (2024). 'A systematic literature review of empirical research on ChatGPT in education. *Discover Education, 3*(1). https://doi.org/10.1007/s44217-024-00138-2.

Beirne, E., Nic Giolla Mhichíl, M., Brown, M., & Mac Lochlainn, C. (2021). Confidence Counts: Fostering Online Learning Self-Efficacy with a MOOC. *EMOOCs 2021. Universitätsverlag Potsdam,* 2021, 201–208.

Beirne, E., Michíl, M. N. G., Brown, M., & Lochlainn, C. M. (2023). Clicking with Confidence: Influence of a Student Co-Designed MOOC on Students' Emotions and Online Learning Self-Efficacy. *Online Learning, 27*(2). https://doi.org/10.24059/olj.v27i2.3758.

Beirne, E., Nic Giolla Mhichíl, M., Brown, M., & Mac Lochlainn, C. (2021). Confidence Counts: Fostering Online Learning Self-Efficacy with a MOOC. *EMOOCs 2021*, 201–208. https://doi.org/10.25932/publishup-51722.

Bergner, Y., Kerr, D., & Pritchard, D. (2015). Methodological Challenges in the Analysis of MOOC Data for Exploring the Relationship between Discussion Forum Views and Learning Outcomes. In *Proceedings of the 7th Annual Conference on Educational Data Mining*.

Bralić, A., & Divjak, B. (2018). Integrating MOOCs in traditionally taught courses: Achieving learning outcomes with blended learning. *International Journal of Educational Technology in Higher Education*, *15*(1), https://doi.org/10.1186/s41239-017-0085-7

Calvo, S., Lyon, F., Morales, A., & Wade, J. (2020). Educating at Scale for Sustainable Development and Social Enterprise Growth: The Impact of Online Learning and a Massive Open Online Course (MOOC). *Sustainability, 12*(8), 3247. https://doi.org/10.3390/su12083247

ChatGPT. OpenAI. 2023. URL: https://chat.openai.com/ [accessed 2024-09-02]

Chan, H. P., & King, I. (2017). Leveraging Social Connections to Improve Peer Assessment in MOOCs. *Proceedings of the 26th International Conference on World Wide Web Companion*, pp. 341–349. https://doi.org/10.1145/3041021.3054165

Coates, W. C., Jordan, J., & Clarke, S. O. (2021). A practical guide for conducting qualitative research in medical education: Part 2—Coding and thematic analysis. *AEM Education and Training*, *5*(4), e10645. https://doi.org/10.1002/aet2.10645

Daalhuizen, J., & Schoormans, J. (2018). Pioneering Online Design Teaching in a MOOC Format: Tools for Facilitating Experiential Learning. *International Journal of Design, 12*(2), 1–14. https://www.ijdesign.org/index.php/IJDesign/article/view/2663/818

Daneji, A. A., Ayub, A. F. M., Khambari, M. N. M. (2019). The effects of perceived usefulness, confirmation, and satisfaction on continuance intention in using massive open online course (MOOC). *Knowledge Management & E-Learning: An International Journal, 11*(2). https://doi.org/10.34105/j.kmel.2019.11.010

De Paoli, S. (2024). Performing an Inductive Thematic Analysis of Semi-Structured Interviews With a Large Language Model: An Exploration and Provocation on the Limits of the Approach. *Social Science Computer Review, 42*(4), 997–1019. https://doi.org/10.1177/08944393231220483

Douglas, K., Zielinski, M., Merzdorf, H., Diefes-Dux, H., & Bermel, P. (2019). Meaningful Learner Information for MOOC Instructors Examined Through a Contextualized Evaluation Framework. *International Review of Research in Open and Distance Learning, 20,* 205–220. https://doi.org/10.19173/irrodl.v20i1.3717

Estrada-Molina, O., & Fuentes-Cancell, D. (2022). Engagement and desertion in MOOCs: Systematic review. *Comunicar, 30* (70), 111-124. https://doi.org/10.3916/c70-2022-09

Fang, J., Tang, L., Yang, J., & Peng, M. (2019). Social interaction in MOOCs: The mediating effects of immersive experience and psychological needs satisfaction. *Telematics and Informatics, 39*, 75–91. https://doi.org/10.1016/j.tele.2019.01.006

Freitas, S., Morgan, J., & Gibson, D. (2015). Will MOOCs transform learning and teaching in higher education? Engagement and course retention in online learning provision. *British Journal of Educational Technology*, 46. https://doi.org/10.1111/bjet.12268

Gamage, D., Perera, I., & Fernando, S. (2016). Evaluating effectiveness of MOOCs using Empirical Tools: Learners perspective. In *Proceedings of 10th International Technology, Education and Development Conference*, Valencia, Spain. https://doi.org/10.21125/inted.2016.0937

Guldberg, K., Achtypi, A., D'Alonzo, L., Laskaridou, K., Milton, D., Molteni, P., & Wood, R. (2019). Using the value creation framework to capture knowledge co-creation and pathways to impact in a transnational community of practice in autism education. *International Journal of Research & Method in Education, 44*, 1–16. https://doi.org/10.1080/1743727X.2019.1706466

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, *3*, 275-285. https://doi.org/10.1016/j.susoc.2022.05.004

Hew, K. F., & Cheung, W. S. (2014). Students' and instructors' use of massive open online courses (MOOCs): Motivations and challenges. *Educational Research Review, 12*, 45–58. https://doi.org/10.1016/j.edurev.2014.05.001

Hone, K. S., & El Said, G. R. (2016). Exploring the factors affecting MOOC retention: A survey study. *Computers & Education*, *98*, 157–168. https://doi.org/10.1016/j.compedu.2016.03.016

Jandrić, P., Knox, J., Besley, T., Ryberg, T., Suoranta, J., & Hayes, S. (2018). Postdigital science and education. *Educational Philosophy and Theory*, *50*(10), 893–899. https://doi.org/10.1080/00131857.2018.1454000

Kennedy, E., Masuda, C., Moussaoui, R. E., Chase, E., & Laurillard, D. (2022). Creating value from co-designing CoMOOCs with teachers in challenging environments. *London Review of Education, 20*(1), https://doi.org/10.14324/LRE.20.1.45

Kizilcec, R. F., Piech, C., & Schneider, E. (2013). *Deconstructing disengagement: analyzing learner subpopulations in massive open online courses*. LAK '13: Proceedings of the Third International Conference on Learning Analytics and Knowledge. https://doi.org/10.1145/2460296.2460330

Knox, J. (2016). Posthumanism and the massive open online course. In *Routledge eBooks*. https://doi.org/10.4324/9781315674032

Knox, J. (2023). Educational development in the postdigital era. In W. O. Lee, P. Brown, A. L. Goodwin, & A. Green (Eds.), *International Handbook on Education Development in Asia-Pacific* Springer. Advance online publication. https://doi.org/10.1007/978-981-16-2327-1_119-1

Laurillard, D., & Kennedy, E. (2020). The role of higher education in upscaling global professional development through open, online collaboration. In: Callender, C and Locke, W and Marginson, S, (eds.) *Changing Higher Education for a Changing World*. Bloomsbury Academic: London.

Lee, V.V., van der Lubbe, S., Hoon Goh, L., Valderas, J M. (2024). 'Harnessing ChatGPT for thematic Analysis: Are we ready? *Journal of Medical Internet Research, 26*, p. https://doi.org/10.2196/54974.

Lee, Y., & Song, H.-D. (2022). Motivation for MOOC learning persistence: An expectancy–value theory perspective. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.958945

Li, L., Zhang, R., & Piper, A. M. (2023). Predictors of student engagement and perceived learning in emergency online education amidst COVID-19: A community of inquiry perspective. *Computers in Human Behavior Reports*, *12*, 100326. https://doi.org/10.1016/j.chbr.2023.100326

Liu, M., Zou, W., Shi, Y., Pan, Z., & Li, C. (2020). What do participants think of today's MOOCs: An updated look at the benefits and challenges of MOOCs designed for working professionals. *Journal of Computing in Higher Education, 32*(2), 307–329. https://doi.org/10.1007/s12528-019-09234-x

Liyanagunawardena, T. R., Adams, A. A., & Williams, S. A. (2013). MOOCs: A systematic study of the published literature 2008-2012. *The International Review of Research in Open and Distributed Learning, 14*(3), 202–227. https://doi.org/10.19173/irrodl.v14i3.1455

Loh, H. S., Martins van Jaarsveld, G., Mesutoglu, C., & Baars, M. (2024). Supporting social interactions to improve MOOC participants' learning outcomes: A literature review. *Frontiers in Education, 9*. https://doi.org/10.3389/feduc.2024.1345205

Lombardi, M. (2007). *Authentic Learning for the 21st Century: An Overview*.

Lundqvist, K., Liyanagunawardena, T., & Starkey, L. (2020). Evaluation of Student Feedback Within a MOOC Using Sentiment Analysis and Target Groups. *The International Review of Research in Open and Distributed Learning, 21*. https://doi.org/10.19173/irrodl.v21i3.4783

Moore, R. L., & Blackmon, S. J. (2022). From the learner's perspective: A systematic review of MOOC learner experiences (2008–2021). *Computers & Education, 190*, 104596. https://doi.org/10.1016/j.compedu.2022.104596

Napier, A., Huttner-Loan, E., & Reich, J. (2020). Evaluating Learning Transfer from MOOCs to Workplaces: A Case Study from Teacher Education and Launching Innovation in Schools. *RIED, 23* (2), 45–64. https://doi.org/10.5944/ried.23.2.26377

N, Abhishek., Kulal, A., Divyashree, M.S., Dinesh, S. (2023). Effectiveness of MOOCs on learning efficiency of students: A perception study. *Journal of Research in Innovative Teaching & Learning* [Preprint]. https://doi.org/10.1108/JRIT-12-2022-0091

Nguyen-Trung, K. (2024). *ChatGPT in Thematic Analysis: Can AI become a research assistant in qualitative research?* https://doi.org/10.31219/osf.io/vefwc

O'Neill, G., & Short, A. (n.d.). Relevant, practical and connected to the real world: What higher education students say engages them in the curriculum. *Irish Educational Studies*, 1–18. https://doi.org/10.1080/03323315.2023.2221663

Pan, X. (2023). Online Learning Environments, Learners' Empowerment, and Learning Behavioral Engagement: The Mediating Role of Learning Motivation. *Sage Open*, *13*(4), 21582440231205098. https://doi.org/10.1177/21582440231205098

Patel, D., Leck, A., McCormick, I., Kennedy, E., & Parsley, S. (2019). Value Creation Framework to Assess MOOC-based Learning. In *Proceedings of Pan-Commonwealth Forum 9 (PCF9).* http://hdl.handle.net/11599/3259

Qi, D., Zhang, M., & Zhang, Y. (2022). Influence of Participation and Value Co-creation on Learner Satisfaction of MOOCs Learning: Learner Experience Perspective. *The Asia-Pacific Education Researcher, 31*(1), 61–70. https://doi.org/10.1007/s40299-020-00538-6

Rekha, I. S., Shetty, J., & Basri, S. (2023). Students' continuance intention to use MOOCs: Empirical evidence from India. *Education and Information Technologies, 28*(4), 4265–4286. https://doi.org/10.1007/s10639-022-11308-w

Rotar, O. (2022). Online student support: A framework for embedding support interventions into the online learning cycle. *Research and Practice in Technology Enhanced Learning, 17*(1), 2. https://doi.org/10.1186/s41039-021-00178-4

Shanshan, S., & Wenfei, L. (2022). Understanding the impact of quality elements on MOOCs continuance intention. *Education and Information Technologies, 27*(8), 10949–10976. https://doi.org/10.1007/s10639-022-11063-y

Soleymani, A., Itard, L., Laat, M. de, Torre, M. V., & Specht, M. (2022). Using Social Network Analysis to explore Learning networks in MOOCs discussion forums. In *Proceedings of CLIMA 2022, Netherlands*. https://doi.org/10.34641/clima.2022.300

Rivera, D.A., Frenay, M. and Swaen, V. (2024). 'The learning design of MOOC Discussion Forums: An analysis of forum instructions and their role in supporting the social construction of knowledge. *Technology Knowledge and Learning*, *29*, 585–615. https://doi.org/10.1007/s10758-023-09670-w.

Tucker, C., Pursel, B., & Divinsky, A. (2014). Mining Student-Generated Textual Data In MOOCS And Quantifying Their Effects on Student Performance and Learning Outcomes Mining Student-Generated Textual Data in MOOCS and Quantifying Their Effects on Student Performance and Learning Outcomes. *Computers in Education Journal, 5(4)*, pp. 84–95. https://peer.asee.org/22840

Ucha, C. R. (2023). Role of course relevance and course content quality in MOOCs acceptance and use. *Computers and Education Open, 5*, 100147. https://doi.org/10.1016/j.caeo.2023.100147

Veletsianos, G., Reich, J., & Pasquini, L. A. (2016). The Life Between Big Data Log Events: Learners' Strategies to Overcome Challenges in MOOCs. *AERA Open, 2*(3). https://doi.org/10.1177/2332858416657002

Wei, W., Liu, J., Xu, X., Kolletar-Zhu, K., & Zhang, Y. (2023). Effective interactive engagement strategies for MOOC forum discussion: A self-efficacy perspective. *PLOS ONE, 18*(11). https://doi.org/10.1371/journal.pone.0293668

Wenger-Trayner, E., Trayner, B., & Laat, M. (2011). Promoting and Assessing Value Creation in Communities and Networks: A Conceptual Framework. Ruud de Moor Centrum, OU, the Netherlands. http://bsili.3csn.org/files/2013/06/Wenger_Trayner_DeLaat_Value_creation.pdf.

Yuan, L., & Powell, S. (2013). MOOCs and Open Education: Implications for Higher Education. Centre for educational technology & interoperability standards. https://doi.org/10.13140/2.1.5072.8320

Zou, W., Hu, X., Pan, Z., Li, C., Cai, Y., & Liu, M. (2021). Exploring the relationship between social presence and learners' prestige in MOOC discussion forums using automated content analysis and

social network analysis. *Computers in Human Behavior, 115*, 106582. https://doi.org/10.1016/j.chb.2020.106582

Appendix 1

Value Creation Questionnaire

1. Participation in TU Delft MOOC changed me as a student or professional (change in skills, attitudes, identity, self-confidence, feelings, and so on. [for example, it helped you to gain a new skill]).

1. A. Can you explain why participation didn't change you?

1. B. 2 B. Can you explain how participation changed you?

2. Participation in TU Delft MOOC affected my social connections (change in the number, quality, frequency, emotions, and so on. [for example, it helped you find x new number of connections or friends]).

2. A. Can you explain why participation didn't affect your social connections?

2. B. Can you explain how participation affected your social connections?

3. Participation in TU Delft MOOC helped my practices as a student or a professional (get new ideas, insights, materials, procedures, and so on. [for example, it helped you to get a new idea on how you can work more efficiently or got access to materials that you have not had before])

3. A. Can you explain why participation didn't help your practices as a student or a professional?

3. B. Can you explain how participation helped your practices as a student or a professional?

4. Participation in TU Delft MOOC changed my ability to influence my world as a student or a professional (enhance my voice, contribution, status, recognition, and so on.[for example, it helped you to raise your voice and affect the organization that you are working for or the school that you are studying])

4. A. Can you explain why participation did not change your ability to influence your world as a student or a professional?

4. B. Can you explain how participation changed your ability to influence your world as a student or a professional?

5. Participation in TU Delft MOOC made me see my world differently (change in perspective, new understandings of the situation, redefine success, and so on. [for example, it helped you redefine how to see a problem and gave a new approach to solve it]).

5. A. Can you explain why participation didn't make you see your world differently?

5. B. Can you explain how participation made you see your world differently?

Chapter 8.

Summary and General Discussion

1. Summary

This dissertation tries to comprehensively understand networked learning in professional development by focusing on high-tech industries like energy management systems and the broader learning context, such as MOOCs and gamified learning networks. This project covered three insights using a literature review, case studies, and educational interventions into networked learning's role in promoting professional development.

After providing a general introduction about networked learning and professional development in Chapter One, Chapter Two explored how networked learning facilitates professional development by reviewing current literature. The main aim of this chapter was to understand the characteristics of networked learning. The findings, for example, emphasized the importance of formal and informal networked learning and suggested a hybrid learning model where both networks are recognized and respected. Our findings, in line with the previous literature reviews, showed that encouraging social learning could promote professional learning networks (O'Toole, 2019).

A second literature study was conducted to expand our knowledge of networked learning and get a clearer insight into it. Chapter Three explored networked learning and professional development literature from the perspective of the value creation framework (Wenger et al., 2011). This chapter illustrated how networked learning cycles contribute to value creation at multiple levels—immediate, potential, applied, realized, enabling, strategic, orienting, and transformative. Three main aspects of professional development identified in this chapter include:

1. Establish meaningful connections and utilize both formal and informal networked learning.
2. Creating opportunities for practical implementation of knowledge and expertise acquired through the network, and finally
3. The critical role of network facilitators and ICT technologies.

This chapter's findings align with Wenger's social learning theory, confirming that learning networks can be instrumental in organizational change and individual professional development.

After establishing a theoretical foundation via literature reviews in Chapters One and Two, chapters Three and Four, two case studies strengthened our understanding of networked learning and professional development. In Chapter Four, using Social Network Analysis (SNA), online discussion forums of three professional development MOOCs were investigated. The results show that the pedagogical design of MOOCs might enhance learners' engagement by facilitating knowledge sharing in forums.

Using Semi-structured interviews, Chapter Five tried to understand the challenges, barriers, and opportunities different educational program stakeholders face in their everyday working settings. This research was a significant part of this dissertation as it added practical points of view to our theoretical foundation established in previous chapters. For example, two of these practical challenges are motivating professionals to engage in formal learning networks when they prefer informal learning channels like phone calls, emails, and face-to-face interactions and the need for companies to adapt educational technologies to their traditional learning environments to promote professional development.

Combining our theoretical understanding of networked learning and professional development from Chapters Two and Three with our practical knowledge about the pedagogical issue in the MOOCs' context (Chapter Four) and the everyday challenges professionals face in learning networks (Chapter Five), the next part of this dissertation focused on gamification intervention and developing tools to investigate learning networks. Chapter Six explored a gamified learning network called Answers to investigate learners' value creation, motivation, and educational experience. While Answers was able to motivate learners to engage and share more knowledge in the networks, it was still unable to promote a sense of community.

Finally, Chapter Seven investigates learners' value creation and educational experience in the context of MOOCs. This research identified several educational challenges and potential room for improvement. For example, the lack of social connections and hands-on application of provided materials can be significantly improved in MOOCs. Most participants expressed their progress in gaining new knowledge and experience by participating in MOOCs. They even believed that these educational programs transformed how they see social challenges like energy transition.

2. Implications and Significance

The implication and significance of this dissertation can be discussed in the following sections.

2.1. Implications for Networked Learning Theory

The backbone of this dissertation was the value creation framework (Wengers et al., 2011), and our findings allow us to explore the contribution to extending existing theory, identify new patterns in value creation cycles, and refine our understanding of how professional learning networks function in different contexts and designs.

The first critical contribution is how the research in this dissertation extends the value creation framework into new professional contexts such as the energy management sector, HVAC systems, online education, and MOOCs. By applying this framework in educational and industry contexts, our findings suggest that these frameworks are adaptable across sectors.

The second contribution to the theory is emphasizing the role of facilitators in professional learning networks. In different parts of this dissertation, our findings emphasize the role of facilitators — both human (mediators and instructors) and system-based (e.g., platform or course design)—in shaping the learning experience. These crucial aspects of networks can have a significant role in implementing a successful professional learning network (Aangenendt et al., 2023), guiding and supporting learner engagement and knowledge sharing. Therefore, we suggest that networked learning theories incorporate a deeper analysis of the facilitator's role in formal and informal networks. Especially the role of facilitators in both digital/online and offline professional networks needs to be considered as one of the vital elements of networks' success and higher engagement.

2.2. Implications for Educational Practices

Our findings offer new insights into how networked learning can be applied and adapted in different educational contexts, from online networked learning environments to large-scale online learning settings like MOOCs.

The first implication of the finding for educational practice is using a social learning theory - value creation framework - for designing a gamified online learning environment. Our findings in the last part of this dissertation provide insight into how gamification can enhance learner's motivation and engagement. Therefore, the mixed results about the effectiveness of specific gamification elements have a few important implications. First, educational researchers and designers must pay attention to the strategic use of gamification. They should carefully consider the context in which they apply their gamification elements. While some learners can change their behavior and be motivated by points, badges, and leaderboards, others might need help finding these elements engaging. Our findings suggest that gamification should not be used as a one-size-fits-all approach but should be tailored to fit the specific goals of the course and the learners' preferences. Second, although gamification elements can boost extrinsic motivation in most cases, our findings raise the importance of fostering intrinsic motivation through meaningful learning activities. Educational designers should focus on creating tasks that stimulate curiosity, relevance to real-world problems, and opportunities for learners to take ownership of their educational journey.

2.3. Significance for Industry-Specific Professional Development

In this dissertation, by analyzing the unique demands of different industries, our research offers new insight into using and adopting a networked learning model to foster continuous professional development and innovation. More specifically, collaboration in professional learning networks can enhance problem-solving and innovation in industries facing challenges like the energy transition. Our findings imply the importance of cross-boundary learning, where professionals from different departments, organizations, or sectors share their expertise to develop innovative solutions. Therefore, following our previous discussion about the importance of facilitators in professional learning networks, we highlight the significance of fostering environments that support within-industry collaboration and cross-disciplinary interactions, leading to more comprehensive and practical solutions.

Additionally, our findings in different chapters emphasize the need for customized learning technologies that align with the specific needs of industries such as HVAC and energy

management. Still, many professionals and learners prefer face-to-face communication, informal knowledge sharing, or even communication with chatbots, which can make the adoption of digital learning tools challenging.

Finally, we should mention the importance of fostering lifelong learning in these industries to keep professionals competitive in evolving technological and regulatory landscapes. Companies and higher education institutes should implement modular, ongoing learning opportunities and create flexible learning networks that ensure knowledge retention and transfer.

3. Limitations of the Research

While this research provides valuable insights, several things could be improved. First, many findings rely on secondary data, such as literature reviews and qualitative interviews, which may not capture the full complexity of professional learning networks. The social network analysis in MOOCs (Chapter 4), for instance, focused on quantitative measures of interaction but did not delve deeply into the qualitative aspects of how these interactions impacted learning. Future research could benefit from more in-depth case studies and empirical investigations to provide a richer understanding of the dynamics of networked learning.

Another limitation is that the gamified learning platform (Chapter 6) and the MOOC studies (Chapter 7) primarily focus on learners' perceptions and self-reported data. While valuable, these methods may introduce biases, such as social desirability bias or limited scope in measuring long-term impacts. Finally, the study needs to explore how these findings apply across different cultural or geographical contexts, which may limit the generalizability of the results.

4. Recommendations for Future Research

Future research should address the following areas to build on the findings of this dissertation:
Conducting longitudinal and empirical studies would provide a more comprehensive understanding of the long-term effects of networked learning on professional development. These

studies could explore how learners apply networked learning outcomes in real-world settings over time.

Given the global scope of MOOCs and online learning platforms, future research should explore how networked learning operates in diverse cultural and geographical contexts. This would provide insights into how local contexts influence networked learning practices and outcomes.

More research is needed to explore the role of emerging technologies, such as artificial intelligence and virtual reality, in enhancing networked learning. Additionally, future studies could investigate how pedagogical approaches can be optimized to support collaboration and problem-solving in both formal and informal learning networks.

Exploring the qualitative aspects of interactions within professional learning networks, particularly in the context of MOOCs and gamified platforms, would provide a deeper understanding of the social dynamics that drive engagement and learning outcomes.

5. Influence on Future Policies, Practices, and Educational Approaches

This dissertation's findings could influence future policies and practices in education and professional development. First, emphasizing hybrid learning models suggests that policymakers and educators should consider integrating formal and informal learning opportunities in professional development programs. This approach is particularly relevant in industries undergoing rapid technological change, such as the energy management sector. Educational institutions and organizations should also focus on creating supportive learning environments that encourage collaboration and autonomy, as highlighted in Chapter 3. This could involve implementing policies that recognize and reward informal learning networks, promoting a culture of continuous learning.

Finally, the research underscores the need for educational technologies that facilitate social connections and real-world applications. Policymakers and educational leaders should invest in digital tools and platforms that deliver content and foster meaningful interactions and practical

skill development. These tools could help bridge the gap between theoretical learning and professional practice, ultimately enhancing the impact of professional development programs.

In conclusion, this dissertation provides valuable insights into the role of networked learning in professional development across various industries and digital platforms. The research advances educational practices and policies that promote lifelong learning and organizational growth in a rapidly changing world by addressing the challenges and opportunities in these learning networks.

Reference:

Aangenendt, M., Sjoer, E., & Wallner, C. (2023). Facilitation of Value Creation in Professional Learning Networks. *Higher Education Studies, 13*(3). https://doi.org/10.5539/hes.v13n3p31

O'Toole, C. (2019). "'Virtual Learning Environment Faculty Continuing Professional Development - Networked Learning Communities" A Critical literature review,' *Irish Journal of Technology Enhanced Learning*, 4(1), 48–67. https://doi.org/10.22554/ijtel.v4i1.50.

Wenger, E., Trayner, B., & Laat, M. de. (2011). Promoting and assessing value creation in communities and networks: A conceptual framework. Open Universiteit, Ruud de Moor Centrum. https://research.manchester.ac.uk/en/publications/promoting-and-assessing-value-creation-in-communities-and-network

Appendices

Samenvatting

Deze dissertatie streeft naar een omvattend begrip van netwerkleren in professionele ontwikkeling, met een focus op hightech-industrieën zoals energiemanagementsystemen en bredere leermodellen, zoals MOOCs en gamified learning-netwerken. Dit project omvatte drie belangrijke inzichten met behulp van een literatuurstudie, casestudies en educatieve interventies in de rol van netwerkleren ter bevordering van professionele ontwikkeling.

Na een algemene introductie over netwerkleren en professionele ontwikkeling in Hoofdstuk Eén, verkent Hoofdstuk Twee hoe netwerkleren professionele ontwikkeling faciliteert door middel van een literatuurstudie. Het hoofddoel van dit hoofdstuk was om de kenmerken van netwerkleren te begrijpen. De bevindingen benadrukten bijvoorbeeld het belang van zowel formeel als informeel netwerkleren en stelden een hybride leermodel voor waarin beide vormen worden erkend en gewaardeerd. Onze bevindingen, in lijn met eerdere literatuurstudies, toonden aan dat het bevorderen van sociaal leren kan bijdragen aan professionele leernetwerken (O'Toole, 2019).

Een tweede literatuurstudie werd uitgevoerd om onze kennis van netwerkleren verder uit te breiden en een duidelijker inzicht hierin te krijgen. Hoofdstuk Drie onderzoekt literatuur over netwerkleren en professionele ontwikkeling vanuit het perspectief van het waardecreatiemodel (Wenger et al., 2011). Dit hoofdstuk laat zien hoe netwerkleercycli bijdragen aan waardecreatie op meerdere niveaus: direct, potentieel, toegepast, gerealiseerd, faciliterend, strategisch, oriënterend en transformatief. Drie belangrijke aspecten van professionele ontwikkeling geïdentificeerd in dit hoofdstuk zijn:

1. Het opbouwen van betekenisvolle connecties en benutten van zowel formeel als informeel netwerkleren;
2. Het creëren van kansen voor praktische toepassing van verworven kennis en expertise binnen het netwerk;

3. De cruciale rol van netwerkfacilitatoren en ICT-technologieën.
De bevindingen van dit hoofdstuk bevestigen Wengers sociale leertheorie en laten zien dat leernetwerken een belangrijke rol kunnen spelen in zowel organisatieverandering als individuele professionele ontwikkeling.

Na het leggen van een theoretische basis via literatuurstudies in Hoofdstuk Eén en Twee, versterken twee casestudies in Hoofdstuk Drie en Vier ons begrip van netwerkleren en professionele ontwikkeling. In Hoofdstuk Vier wordt, met behulp van sociale netwerkanalyse (SNA), onderzocht hoe discussiegroepen in drie professionele ontwikkelings-MOOCs functioneren. De resultaten tonen aan dat het pedagogisch ontwerp van MOOCs de betrokkenheid van lerenden kan versterken door kennisuitwisseling in de forums te faciliteren.

Met behulp van semigestructureerde interviews wordt in Hoofdstuk Vijf geprobeerd om de uitdagingen, obstakels en kansen te begrijpen waarmee verschillende belanghebbenden van onderwijsprogramma's in hun dagelijkse werkomgeving worden geconfronteerd. Dit onderzoek is een belangrijk onderdeel van deze dissertatie, omdat het praktische perspectieven toevoegt aan de theoretische basis die in de voorgaande hoofdstukken is gelegd. Twee van deze praktische uitdagingen zijn bijvoorbeeld het motiveren van professionals om deel te nemen aan formele leernetwerken wanneer zij de voorkeur geven aan informele leerkanalen zoals telefoongesprekken, e-mails en persoonlijke ontmoetingen, en de noodzaak voor bedrijven om onderwijstechnologieën aan te passen aan hun traditionele leeromgevingen ter bevordering van professionele ontwikkeling.

Door onze theoretische kennis over netwerkleren en professionele ontwikkeling uit Hoofdstukken Twee en Drie te combineren met onze praktische kennis over pedagogische kwesties in de context van MOOCs (Hoofdstuk Vier) en de dagelijkse uitdagingen waarmee professionals in leernetwerken worden geconfronteerd (Hoofdstuk Vijf), richt het volgende deel van deze dissertatie zich op gamification-interventies en het ontwikkelen van tools om leernetwerken te onderzoeken. In Hoofdstuk Zes werd een gamified leernetwerk genaamd Answers ontwikkeld om de waardecreatie, motivatie en onderwijsbeleving van lerenden te onderzoeken. Hoewel Answers lerenden wist te motiveren om meer kennis te delen binnen het netwerk, slaagde het er nog niet in om een gemeenschapsgevoel te bevorderen.

Tot slot onderzoekt Hoofdstuk Zeven de waardecreatie en onderwijsbeleving van lerenden in de context van MOOCs. Dit onderzoek identificeerde verschillende educatieve uitdagingen en mogelijke verbeterpunten. Zo kunnen het gebrek aan sociale connecties en hands-on toepassing van het aangeboden materiaal aanzienlijk worden verbeterd in MOOCs. De meeste deelnemers gaven aan vooruitgang te hebben geboekt in het verwerven van nieuwe kennis en ervaring door deel te nemen aan MOOCs. Zij waren van mening dat deze educatieve programma's hun kijk op maatschappelijke uitdagingen zoals de energietransitie hebben veranderd.

Acknowledgments

Life rarely unfolds exactly as we imagine it will. It is filled with highs and lows, sometimes rising and sometimes falling. Nevertheless, if there is one lesson I have learned, it is to “keep trying and never give up.”

On Monday, April 13, 2020, at 13:30, Marcus Specht asked me: *When can you start working on the TransAct project?* For a moment, I was frozen. I could hardly believe my PhD journey at TU Delft was finally about to begin. In moments of doubt, when challenges pushed me to the edge, I remembered that Marcus trusted me, believing I was the right person for this project. This kept me going. Marcus, thank you for your trust and belief in me.

However, this journey began much earlier. Years ago, when I decided to study in Germany, my first hurdle was passing the IELTS exam, which was only available in Tehran—nearly 1000 kilometers from my hometown, Mashhad. My entire family—Mom, Dad, Sister, and even my grandmother—traveled with me by car to Tehran. Along the way, I kept thinking, *They believe in me, so I cannot let them down.* Thanks to their support, I passed the exam, received my university acceptance, secured a visa, and traveled to Germany. Mom, Dad, and Somi Jan, I sincerely appreciate your unwavering support throughout my studies.

On October 20, 2015, I landed in Hamburg, Germany, exhausted, sleepy, and unsure of my next steps. I accidentally boarded a train bound for Oldenburg (Holst) instead of Oldenburg (Oldb) and arrived late, with no idea where I would stay that night. After registering at the university just in time, I posted in a Facebook group, “Iranian students in Oldenburg,” seeking a place to stay. Abbas Chime responded, inviting me to stay in his room free of charge until I found housing. He even gave me his bed, sleeping on the floor, worried that the unfamiliar cold might be too much for me. Abbas, you cared for me like an older brother. Thank you for your incredible kindness.

My heart remained with Iran throughout these early days, where my beloved wife, Eli, was my most excellent source of support over the past decade. She stood by me through every high and low, giving me strength when I felt defeated. Her wisdom has guided me through challenging

situations. Eli Jonam, I am endlessly grateful for your kindness, support, and love, now and always. And dear Ermiya, you brought hope, beauty, true joy, and shineness to our lives in the dark days of Corona. You give a true meaning to our life. Dadi loves you so much.

My brother, Saeed, has been a profound role model, inspiring me with his positivity, energy, and work ethic. Saeed, thank you for being a constant source of motivation and supporting me throughout this journey.

Since moving to the Netherlands, I have had the privilege of meeting many wonderful people, including Ahmadreza, who is incredibly caring and generous. He goes above and beyond to help, returning multiple times to ensure a problem is solved. His wife, Reyhane, has become like a sister to us. Thank you, Dr. Ahmadreza Mir Mohammadi Kooshknoo and Dr. Reyhane Abolhasani Chime, for your friendship and kindness.

I am blessed with brilliant friends who bring me so much joy. Mahid Ghayeni, Ali Moradvandi, Ali Vahidi, and Mohammad Satouri, thank you for your friendship and for always being there to share in life's small joys.

Though we are far from family, we have friends here who feel like family. We look forward to weekends together and find it hard to say goodbye at the end of the evening. Thank you, Iman and Mahsa, Vahid and Mahdiye, Javad and Maeede, Mahdi and Mozhgan, for being such wonderful friends.

I would also like to acknowledge my master's thesis supervisor, Prof. Dr. Peter de Jong, who supported me as a supervisor and a true mentor—a "scientific father." Peter, thank you for your invaluable guidance.

I am grateful for my three brothers, Mohammad, Hamid, and Majid, who are always there for me. Prof. Dr. Mohammad Kazempourmofrad has offered assistance whenever I needed it, while Majid Reza and Hamid have taught me the true meaning of kindness and generosity. Thank you for your steadfast support.

My colleagues at LDE CEL have been an excellent source of support during the last few years. Xiaoling, Silvia, Bibeg, Ioana, Gosia, Noortje, Manuel, and Erna, thank you for making this journey enjoyable.

Finally, I sincerely thank the TransAct team: Dr. Ellen Sjoer, Maaike Koning, Prof. Dr. Laure Itard, Prof. Dr. Wim Zeiler, Dr. Paula van den Brom, and Samir Ahmed. It was a privilege to work alongside such talented and dedicated individuals.

A

List of Publications

Soleymnai, A., Ivanov, Y., Mathot, S., & de Jong, P. J. (2020). Free-viewing multi-stimulus eye tracking task to index attention bias for alcohol versus soda cues: Satisfactory reliability and criterion validity. *Addictive Behaviors, 100*. https://doi.org/10.1016/j.addbeh.2019.106117

Soleymani, A., Itard, L., de Laat, M., Valle Torre, M., & Specht, M. (2022). Using Social Network Analysis to explore Learning networks in MOOCs discussion forums. *In Proceedings of CLIMA 2022 Conference*. https://doi.org/10.34641/clima.2022.300

Soleymnai, A., Mazidi, M., Neimeijer, R., & de Jong, P. J. (2022). Eating disorder-specific rumination moderates the association between attentional bias to high-calorie foods and eating disorder symptoms: Evidence from a reliable free-viewing eye-tracking task. *Appetite, 171*. https://doi.org/10.1016/j.appet.2022.105934

Soleymani, A., van den Brom, P., Ahmed, S., Konings, M., Sjoer, E., Itard, L., Zeiler, W., De Laat, M., & Specht, M. (2023). Learning networks and professional development in the building energy management systems industry. *Education Sciences, 13*(2), 215. https://doi.org/10.3390/educsci13020215

Soleymani, A., De Laat, M., & Specht, M. (2023). Exploring Personal Experience and Value Creation in Postdigital Education: Insights from a Large-Scale MOOC Survey. *Research Square*. PREPRINT (Version 1). https://doi.org/10.21203/rs.3.rs-5043440/v1

Soleymani, A., Aerts, T., De Laat, M., & Specht, M. (2024). Gamified Networked Learning Environments in Higher Education: A Study on Student Engagement and Value Creation in Computer Science. *In Proceedings of ECGBL 2024, 18*(1), 755-761. https://doi.org/10.34190/ecgbl.18.1.2660

Soleymani, A., De Laat, M., & Specht, M. (2025). Evaluating Value Creation, Motivation, and Personal Experiences in a Game-Based Professional Learning Network for Computer Science Education. Electronic Journal of E-Learning. In print

Soleymani, A., De Laat, M., & Specht, M. (2024). Evaluating Professional Learning Networks Using Value Creation Framework; A Literature Study. *SSRN*. https://dx.doi.org/10.2139/ssrn.4870033

Soleymani, A., De Laat, M., Itard, L., & Specht, M. (2022). How Networked learning can facilitate professional development? *In Proceedings of Networked Learning 2022*. https://doi.org/10.54337/nlc.v13.8543