ISSN 2510-2591

Reports of the European Society for
Socially Embedded Technologies

volume 8 issue 1
2024

Proceedings of 22th European Conference on Computer-Supported Cooperative Work

Guest Editors

Adriana S. Vivacqua, Universidade Federal do Rio de Janeiro, Brazil
Augusto Esteves, Tecnico U. Lisboa, Portugal
Alberto Monge Roffarello, Politecnico di Torino, Italy
Claudia Müller, University of Siegen, Germany

Series Editor

Michael Koch

Impressum

The **'Reports of the European Society for Socially Embedded Technologies'** are an online report series of the European Society for Socially Embedded Technologies (EUSSET). They aim to contribute to current research discourses in the fields of 'Computer-Supported Cooperative Work', 'Human-Computer-Interaction' and 'Computers and Society'.

The 'Reports of the European Society for Socially Embedded Technologies' appear at least one time per year and are exclusively published in the Digital Library of EUSSET (https://dl.eusset.eu/). The main language of publication is English.

ISSN 2510-2591

https://www.eusset.eu/report-series/

The contents of the report series are made available in the EUSSET Digital Library at https://dl.eusset.eu/

EUSSET is an institute of Social Computing e.V., a non-profit association according to the German legal system – founded on November 13th 2012 in Bonn, Germany (Nordrhein-Westfalen Amtsgericht Bonn VR 9675).

c/o Prof. Dr. Volker Wulf
Fakultät III
Universität Siegen
57068 Siegen
E-Mail: volker.wulf@uni-siegen.de

Table of Contents

Exploratory Papers

Notes

Babashahi, Leili; Barbosa, Carlos Eduardo; Argolo, Matheus; de Almeida, Marcos Antonio; de Souza, Jano Moreira (2024): Syncing Minds: Analyzing Knowledge Work Practices in IT Projects Through Cross-Domain Collaboration. In: Proceedings of the 22nd European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies - Exploratory papers, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591), DOI: 10.48340/ecscw2024_ep01

Syncing Minds: Analyzing Knowledge Work Practices in IT Projects Through Cross-Domain Collaboration

Leili Babashahi[1], Carlos Eduardo Barbosa[1,2], Matheus Argôlo[1], Marcos Antonio de Almeida[1], Jano Moreira de Souza[1]
[1] Universidade Federal do Rio de Janeiro (UFRJ), Brazil
[2] Centro de Análises de Sistemas Navais (CASNAV), Brazil
Contact Author: leilib@cos.ufrj.br, eduardo@cos.ufrj.br, matheusargolo@cos.ufrj.br, malmeida@cos.ufrj.br, jano@cos.ufrj.br

Abstract. In the dynamic intersection of business and technology, teams of specialists must collaborate to solve complex problems and drive important projects. However, there's a space for improvement in our understanding of cross-domain collaboration within IT projects. This research addresses this gap by analyzing collaborative knowledge work practices, emphasizing the impact of industrial practices and organizational arrangements on knowledge sharing. Employing an extensive literature review with content analysis and thematic synthesis, the study uncovers key findings, including the delicate balance between formal and informal knowledge, obstacles in sharing process knowledge, the interplay between human and procedural factors, the significance of cross-functional cooperation, and the role of online and offline interactions. Moreover, it explores the impact of collaboration, competition, and satisfaction with communication mediums on knowledge quality, revealing hidden costs associated with expediting product development. Ultimately, this research contributes valuable insights to knowledge sharing and management research within cross-domain projects. It stresses the urgency for context-specific, evidence-based approaches to knowledge management in the IT sector.

1 Introduction

Collaborative knowledge work involves individuals or teams with diverse backgrounds coming together to share expertise and collaborate on projects or tasks, as highlighted by various studies (Hetemi et al., 2022b; Ghobadi and D'Ambra, 2012; Wiesner et al., 2016). This concept can be likened to friends pooling their study materials to help each other understand a subject before a major exam. In business and technology, specialized teams often need to join forces, share insights, and work collectively to tackle intricate problems and achieve significant milestones (Edmondson and Nembhard, 2009).

Barbosa et al. (2022) forecasts a future where automation streamlines tasks, affording workers more time. With information becoming increasingly accessible and inexpensive, facilitated by the Internet's expansive knowledge base, workers are poised to leverage this surplus time for learning, leisure, or supplemental employment. Companies can implement work-sharing strategies to address concerns of technological unemployment, as proposed by Lima et al. (2021), to redistribute work among employees effectively. Organizations frequently embark on IT projects to develop new technologies, software, or systems (Hetemi et al., 2022b; Precup et al., 2023; Hetemi et al., 2022a). These projects are inherently complex and require experts from various fields or domains (Hetemi et al., 2022b). Analogously, envision the construction of an automobile, where engineers, designers, and electronics specialists must collaborate seamlessly for a successful outcome. However, facilitating effective collaboration among experts from different domains can be complicated. They may use different terminology, employ distinct methodologies, or be situated in disparate geographical locations, introducing challenges to seamless collaboration (Hetemi et al., 2022b; Precup et al., 2023; Hetemi et al., 2022a).

In contemporary organizations, managers increasingly assemble cross-functional teams comprising individuals with diverse expertise to tackle complex problems within tight timeframes. Despite the prevalence of best practices to enhance cross-functional team performance, organizations often grapple with achieving optimal outcomes (Majchrzak et al., 2012). Nicolini et al. (2012) identify three essential types of work that facilitate cross-disciplinary collaboration: fostering motives for collaboration, enabling participants to traverse boundaries, and establishing the necessary infrastructure for collaborative activities to thrive. However, effective knowledge integration within cross-functional teams necessitates a transformative process. Making tacit knowledge explicit through codification can alleviate barriers to learning and enhance knowledge transfer within organizational routines (Bechky, 2003).

Various aspects of collaborative knowledge work in IT projects were explored, including professionals' interaction methods, strategies to overcome obstacles, and the role of technology in facilitating better collaboration. The overarching goal is to identify ways to enhance collaboration, leading to more efficient and successful IT projects and innovations amid the ever-changing technological landscape.

The review articles collectively address challenges and strategies related to knowledge sharing, collaboration, and cross-domain cooperation (Hetemi et al., 2022a; McNealy, 2017; Nambisan and Wilemon, 2000) within project-based organizations (McNealy, 2017), research and development (R&D) projects (Precup et al., 2023), inter-organizational collaborations (Hetemi et al., 2022a), cross-functional teams (Ghobadi and D'Ambra, 2012), collaborative product-service system design (Wiesner et al., 2016), large-scale infrastructure projects (Hetemi et al., 2022a), and the impact of information technology on knowledge sharing within teams (Hetemi et al., 2022b), among others. Thus, the study aims to address specific challenges and issues, proposing potential solutions within the scope of this investigation. The reviewed articles focus on understanding and improving collaboration among experts from diverse fields in Information Technology (IT) projects. The emphasis is on how these professionals can effectively communicate their expertise and cooperate to ensure the success of projects, particularly in the dynamic IT landscape (Edmondson and Nembhard, 2009). This is important in the constant evolution of technology, requiring businesses to adapt swiftly to maintain competitiveness.

This research addresses several challenges. One major issue is the effective sharing and collaboration of knowledge among individuals or teams with diverse expertise, spanning organizational boundaries (Hetemi et al., 2022a; Ghobadi and D'Ambra, 2012; Wiesner et al., 2016; Nambisan and Wilemon, 2000; Olaisen and Revang, 2017). Another challenge lies in the temporary nature of projects, which can impede efforts to create, share, and reuse knowledge (Hetemi et al., 2022b; Ghobadi and D'Ambra, 2012; Wiesner et al., 2016; Newell et al., 2006; Nambisan and Wilemon, 2000). The integration of information technology into organizational practices is a further challenge, requiring a balance between technology-driven knowledge sharing and human interactions, as well as effective use of IT tools for knowledge management (Hetemi et al., 2022b; Precup et al., 2023; McNealy, 2017; Ghobadi and D'Ambra, 2012; Wiesner et al., 2016; Newell et al., 2006; Nambisan and Wilemon, 2000; Olaisen and Revang, 2017; Choi et al., 2010). Additionally, difficulties arise in sharing explicit and tacit knowledge across domains and functional areas (Hetemi et al., 2022b,a; McNealy, 2017; Ghobadi and D'Ambra, 2012; Wiesner et al., 2016; Nambisan and Wilemon, 2000). Collaboration and coordination within multidisciplinary teams, particularly in complex and time-constrained projects, present ongoing challenges (Hetemi et al., 2022b; Precup et al., 2023; McNealy, 2017; Ghobadi and D'Ambra, 2012).

This research offers insights into how collaborative practices impact knowledge work across various contexts and industries, shedding light on teamwork dynamics. It may also provide a better understanding of knowledge-sharing strategies, not only in project-based organizations but also in diverse team setups. Furthermore, it underscores the pivotal role of information technology in supporting effective knowledge sharing and management within organizations. Ultimately, it enhances knowledge-sharing practices to improve organizational performance and competitiveness. In conclusion, these contributions deepen our understanding of collaborative knowledge work and its vital role in modern businesses.

2 Methodology

This section outlines the methodology for research collaborative knowledge work within IT projects. Our approach is ad-hoc, designed to comprehensively explore various facets of collaborative knowledge work in this dynamic domain.

Our research design adopts a qualitative approach to gathering and analyzing existing literature related to collaborative knowledge work in IT projects. This approach was chosen due to the complex and multi-faceted nature of the subject matter, which is related to knowledge sharing, collaborative work, and cross-domain cooperation within various project-based contexts, particularly information technology, which is our focus. Therefore, practically, the mission of this research is to address specific problems and suggest solutions to highlight the factors that help share knowledge and enhance project results.

2.1 Data Collection

We searched extensively ad-hoc literature using academic databases, journals, and conference proceedings, including Scopus, IEEE, and ACM databases. We also performed a snowballing process. Keywords and phrases in query strings included "collaborative knowledge work", "knowledge sharing in IT projects", "collaboration strategies", "knowledge sharing", "knowledge work", "project-based organizations", "collaboration in cross-functional teams", and "cross-domain knowledge sharing" were used to identify relevant articles.

Initially, about 50 articles were scanned to determine their relevance. A more focused review followed, analyzing titles and abstracts to identify pertinent. In this step, we selected 31 results for further analysis. In a thorough exploration, the studies that cited articles were also examined, and this process cascaded through several layers of articles hierarchically, creating a comprehensive exploration of the literature. As a result of this process, ten main articles were chosen for full reading, as shown in Table I.

The inclusion criteria for selecting research articles published in peer-reviewed journals and conferences are collaborative knowledge work in IT projects, knowledge work practices, knowledge work strategies in cross-functional teams,

Table I. List of the analyzed articles.

Year	Title	Reference
2023	Collaborative Tool to Support Knowledge Sharing and Innovation in an RD Project	Precup et al. (2023)
2022	Collaborative practices of knowledge work in IT projects	Hetemi et al. (2022b)
2022	Inter-organisational collaboration and knowledge-work: A contingency framework and evidence from a megaproject in Spain	Hetemi et al. (2022a)
2017	Knowledge management practice strategies in project-based Organizations	McNealy (2017)
2017	Working smarter and greener: Collaborative knowledge sharing in virtual global project teams	Olaisen and Revang (2017)
2016	Requirements for cross-domain Knowledge Sharing in collaborative Product-Service System design	Wiesner et al. (2016)
2012	Knowledge sharing in cross-functional teams: a coopetitive model	Ghobadi and D'Ambra (2012)
2010	The impact of information technology and transaction memory systems on knowledge sharing, application, and team performance: A field study	Choi et al. (2010)
2006	Sharing knowledge across projects: limits to ICT-led project review practices	Newell et al. (2006)
2000	Software development and new product development: Potentials for cross-domain knowledge sharing	Nambisan and Wilemon (2000)

knowledge work sharing in cross-domain projects, cross-domain knowledge sharing, and collaborative knowledge sharing in project teams. Besides their relevance, including articles in the selection list depended on their publication date. In this sense, all efforts were made to ensure that most articles were published later than 2010. The selected literature spans various contexts, methodologies, and findings to ensure a comprehensive review.

2.2 Data Analysis

The selected literature underwent content analysis. Each article's findings, methodologies, and key themes were systematically reviewed and categorized. In the research process, abstracts were carefully reviewed to pinpoint articles aligned with the review's objectives, prioritizing those directly contributing to the focus. An extensive literature review involved a further survey of around 30 articles. The main and sub-articles were analyzed to extract critical insights and findings on collaborative knowledge work within IT projects.

A thematic synthesis approach identified common themes and patterns across the literature. This involved extracting key insights, strategies, challenges, and outcomes related to collaborative knowledge work in IT projects and similar contexts. Themes, trends, patterns, and potential areas for future research were identified.

3 Results

We present the results in three parts. First, we briefly summarize the objectives and methodologies of the articles analyzed so that you can get to know them better. Then, we summarize the findings in the articles to present a synthesis of our findings. Finally, we analyze the findings and extract the proposed collaborative work best practices and strategies.

3.1 Synthesis of the Articles

Hetemi et al. (2022b) outline a framework for the future of crowd work, focusing on complex tasks in online marketplaces, using ideas from organizational behavior and distributed computing to explore how people work together on IT projects. They stress how crucial it is for people from different knowledge areas to collaborate and communicate effectively. They conducted interviews and studies with managers from six IT companies. They found three key ways: expressing differences to encourage new ideas, using shared documents and tools to help team members share knowledge, and making sure everyone on the team talks to each other often to achieve their goals.

Precup et al. (2023) address the challenges encountered in large research and development (R&D) projects that involve people from all over the world working virtually. They propose an online collaborative framework for managing these projects effectively. The framework has five components: Project Goals, Actions (work packages, tasks), Teams (Human resources), Results (Project outputs), and Community (collaboration tools) to enhance collaboration within virtual teams. It helps manage the project, keep everyone informed, and ensure people share their knowledge. While they don't explicitly discuss knowledge work practices, their plan aims to create an environment encouraging effective knowledge sharing and collaboration.

Hetemi et al. (2022a) examine how people share knowledge in large-scale projects with a high-speed rail project case study in Spain. They introduce a system with four different methods to understand better how knowledge flows in such projects. These methods encompass various ways of sharing knowledge, such as direct conversations, informal project documents, and group collaborations. Their findings highlight the importance of project setup, the type of knowledge involved, and how information is learned and shared. They also highlight the role of industry norms and regulations in shaping knowledge-work practices, particularly in the early stages of a project. They emphasize the importance of contextual knowledge governance and the need for aligning knowledge work with industrial features. They challenge the assumption that Information and

Communication Technology (ICT) tools guarantee effective knowledge management.

McNealy (2017) focuses on understanding how knowledge is managed within project-based organizations and its influence on business leaders' decisions. The study addresses the issue of profit loss attributed to insufficient knowledge sharing within companies. It identifies six key themes: communication, overcoming barriers, centralized resource centers, training and development, technology, and informational briefings. These themes explore how knowledge is transferred, the challenges encountered in managing knowledge, the resources and processes involved, methods for learning, digital tools for knowledge sharing, and the competitive advantage gained. The ultimate goal of this research is to enhance knowledge sharing, which, in turn, is expected to promote positive social change by encouraging collaboration and development at various levels within project-based organizations, including individuals, communities, organizations, cultures, and societies.

Ghobadi and D'Ambra (2012) introduce a predictive model for effective knowledge sharing in cross-functional project teams. They emphasize that knowledge sharing isn't just about sharing information; it's about ensuring that the shared knowledge is informative, useful, and seamlessly integrated into practical solutions. The study examines how cooperation and competition within project teams affect knowledge-sharing quality. Cooperation enhances understanding and knowledge-sharing quality, while different types of competition have diverse effects on knowledge quality. Competition for resources can impact cooperation and knowledge-sharing quality. When team members work together smoothly, they better understand and share innovative knowledge, resulting in higher-quality knowledge sharing. They investigate how various forms of competition influence the effectiveness of knowledge sharing. It explores how different competitive dynamics can shape the sharing of knowledge. When teams compete for intangible assets such as ideas or concepts rather than physical items, their cooperation tends to decrease, leading to a decline in the quality of knowledge sharing. Encouraging cooperation is proposed as a means to address this challenge and enhance knowledge-sharing quality. On the other hand, when teams compete for physical assets such as equipment or materials, it tends to promote communication and knowledge sharing among them. This can result in improved knowledge-sharing practices.

Wiesner et al. (2016) emphasize the growing importance of knowledge management in collaborative product and service design, particularly in Product-Service Systems (PSS), where tangible and intangible components are interdependent. The text outlines the roles of various stakeholders involved in PSS design, such as customers, PSS providers, production and service networks, and suppliers. It also identifies the types of knowledge that need to be shared, encompassing explicit (e.g., market needs, product specifications) and tacit knowledge (e.g., skills, know-how, emotions). Furthermore, it discusses requirements for effective knowledge sharing in PSS design, highlighting the necessity for tools and mechanisms capable of representing PSS-related elements, fostering collaboration across different domains, translating informal content into PSS terminology, and visualizing knowledge to facilitate its combination and evaluation. Overall, it highlights the need for an integrated method for sharing explicit and tacit knowledge in PSS design.

Newell et al. (2006) investigate the difficulties associated with knowledge sharing among projects within organizations. They propose an alternative approach that diverges from relying solely on ICT for inter-project knowledge exchange. Instead, their approach advocates for fostering connections and knowledge sharing within groups or networks within the organization. The emphasis is on comprehending and disseminating processes (the how and why of actions) rather than merely showcasing results (what was achieved). The study highlights the importance of individuals who can facilitate connections among diverse project teams to enable the sharing of valuable knowledge. It also recommends a hybrid approach combining ICT tools with personal networks for more effective knowledge sharing.

Nambisan and Wilemon (2000) aim to understand how software development and new product development can learn from each other and explore knowledge work practices by comparing new products and software development across a few dimensions. The *Teamwork Management* dimension discusses team-related aspects such as team formation, team building, team leadership, and the role of functional managers in both software development and new product development. In this context, knowledge work practices mean working well together as a team and having good leadership. *Accelerated Product Development* emphasizes the importance of speeding up product development and presents theoretical frameworks and strategies for achieving this goal. It highlights the need for efficient knowledge sharing to accelerate development processes.

Olaisen and Revang (2017) investigate the impact of online technology platforms on knowledge sharing and collaboration within virtual teams. The author contends that virtual teams can effectively achieve knowledge sharing, collaboration, and innovation through these platforms, even without face-to-face interactions. The key to success lies in frequent online interactions and trust in team members' competence, resulting in reduced travel and environmentally sustainable work practices. The study highlights five key strategies: virtual teams can share high-quality knowledge through online platforms, minimizing the need for in-person meetings; valuable knowledge exchange in virtual teams requires regular online interaction, both professionally and socially; trust in team members' competence is essential for fostering knowledge exchange and quality in virtual teams; task-oriented communication can lead to successful knowledge sharing and innovation without face-to-face meetings; and online collaboration facilitates global knowledge sharing, reducing travel requirements and enhancing meaningful work experiences.

Choi et al. (2010), explores the role of information technology in developing Transactive Memory Systems (TMS) and its impact on knowledge sharing and application, which in turn influence team performance. Knowledge sharing is vital to effective knowledge management practices and positively impacts team performance. Aside from knowledge sharing, knowledge application is also crucial for teams to address challenges and make collective decisions. Effective collaboration and integrating existing knowledge are also essential for teams to apply shared knowledge effectively in new contexts, ultimately contributing to team performance. This study underscores the significance of both knowledge sharing and knowledge application. However, knowledge sharing alone is not enough to improve team performance. The shared knowledge must also be effectively applied. Knowledge sharing, application, and collaboration concepts are discussed in the context of team performance.

3.2 Findings

Collaborative knowledge work involves important concepts like cooperation and competition (Ghobadi and D'Ambra, 2012), sharing knowledge, both tacit and explicit, interdisciplinary teams, and technology tools (Wiesner et al., 2016). While some studies view knowledge as a management tool for achieving goals, challenges arise in maintaining, sharing, and reusing knowledge (Precup et al., 2023), especially within the dynamic environment of project-based organizations and the IT industry with its interdependent and fragmented teams (Hetemi et al., 2022b).

In reviewing the selected articles, several key trends and common themes emerge, each shedding light on critical aspects of knowledge sharing in organizational settings.

The first theme, *Communication as a Foundation*, underscores the consistent emphasis on effective communication as a foundational element for knowledge sharing. This spans various face-to-face interactions, emails, meetings, and technology platforms, highlighting the importance of maintaining transparent and open communication channels. McNealy (2017) address how knowledge is transferred and the challenges encountered in managing knowledge.

Within *Training and Development*, a recurring theme emphasizes the significance of investing in training and development for project managers and team members. This encompasses formal training, mentoring, coaching, and web-based resources to enhance skills and knowledge. McNealy (2017) emphasizes the importance of training and development for enhancing knowledge sharing.

In *Technology Facilitation*, technology plays a key role in enabling knowledge sharing and collaboration. This includes intranets, knowledge management systems, social media, and online platforms, all enhancing communication and connecting team members for real-time knowledge exchange. Wiesner et al. (2016) emphasize the necessity for tools and mechanisms to foster collaboration and translate informal content into usable knowledge. Olaisen and Revang (2017) highlight the impact of online technology platforms on knowledge sharing and collaboration within virtual teams.

Teamwork and Collaboration are essential to successful knowledge sharing. The articles consistently stress the importance of teams in sharing knowledge, problem-solving, and achieving project goals. Ghobadi and D'Ambra (2012) provide insights into how cooperation and competition within project teams influence knowledge-sharing quality, which adds to the discussion on different forms of competition affecting knowledge quality. Nambisan and Wilemon (2000) discuss the importance of teamwork and leadership in both software development and new product development, aligning with knowledge work practices. Choi et al. (2010) explores the role of information technology in developing Transactive Memory Systems and its impact on knowledge sharing and team performance.

In *Cross-functional Collaboration*, a particularly relevant aspect of IT projects, there is a positive influence on knowledge quality and sharing. Hetemi et al. (2022a) discuss the role of industry norms and regulations in shaping knowledge-work practices, affecting effective cooperation among different organizational functions.

In *Knowledge Types*, authors recognize that knowledge exists in various forms, encompassing formal (documented information) and informal (skills and know-how) types. Both are deemed crucial for achieving successful project outcomes. McNealy (2017) discuss the different types of knowledge and the resources and processes involved in managing knowledge within project-based organizations. Wiesner et al. (2016) elaborate on the types of knowledge relevant to collaborative product and service design, where tangible and intangible components are interdependent. They also identified the types of knowledge shared, both explicit (e.g., market needs, product specifications) and tacit (e.g., skills, know-how, emotions).

In *Project Characteristics*, aspects like importance and communication medium satisfaction are identified as significant factors affecting knowledge quality and sharing. In Hetemi et al. (2022a) findings, knowledge flows in large-scale projects show the importance of contextual knowledge governance and aligning project setup and knowledge types.

Customizable Frameworks are recommended to address project failure factors and promote collaboration, exemplified by the online collaborative framework tailored for managing large research and development projects developed by Precup et al. (2023). These frameworks can be customized to fit an organization's specific needs.

Social Interaction and Online Platforms are capable of a significant impact on knowledge sharing. Technological platforms, particularly online ones, facilitate knowledge sharing without extensive offline social interactions. Hetemi et al. (2022a) findings expand the understanding of how ICT tools impact knowledge management and the challenges associated with effective knowledge sharing. Newell et al. (2006) advocate for fostering connections and knowledge sharing within groups or networks within organizations, rather than relying solely on ICT for inter-project knowledge exchange.

These themes and trends represent recurring patterns and recommendations or potential areas for further exploration in knowledge sharing and management within project-based organizations and cross-domain projects, particularly in the IT context, as discussed in the selected research articles. However, whether these themes and trends are applicable in all projects will depend on several factors, including the nature of the project, the industry, the organization's culture, and its specific context. Different projects and organizations can prioritize and implement these themes to varying degrees based on their unique needs and circumstances.

3.3 Proposed Best Practices

Based on the research done in the present work, the collaborative work practices and strategies are crucial for improving cross-domain collaboration and knowledge sharing in Information Knowledge projects, as shown in Table II.

4 Discussion

The selected works highlight various facets of knowledge sharing, knowledge management, collaboration, and the challenges of cross-domain collaboration in projects, particularly in IT. This heterogeneity can be attributed to several factors, including differences in research methodologies, sample sizes, geographic locations, and each study's specific focus and objectives. While the heterogeneity among the results of the selected articles poses challenges to drawing uniform conclusions, it also highlights the complex and multifaceted nature of knowledge sharing in project-based organizations and cross-domain projects. It is crucial to consider the organization's and project's specific context and characteristics to derive meaningful insights.

Hetemi et al. (2022b) emphasize the need for in-depth dialogue-based practices and recognizing knowledge work as a situated and evolving activity. Furthermore, the introduction of collaborative project management frameworks and online tools aims to improve collaboration and knowledge sharing in R&D projects and virtual teams (Precup et al., 2023). Additionally, Motta et al. (2022) underscores the similarities between meetings and knowledge management techniques, emphasizing the role of knowledge creation, capture, and reuse, highlighting how managing knowledge generated during meetings can significantly impact process optimization and inform future collaborative endeavors.

The impact of industry norms and regulations on knowledge-work practices is explored in these works, emphasizing the importance of contextual knowledge governance (Hetemi et al., 2022a).

Moreover, articles stress the significance of knowledge management practices in project-based organizations and the risks of neglecting knowledge sharing, proposing specific strategies for improvement (McNealy, 2017). The

Table II. Best Practices for Collaborative Work.

#	Title	Description
1	Open Communication	Promoting open and transparent communication within a team involves actively sharing information, openly discussing ideas, and maintaining clear communication channels.
2	Team Building	Team building activities and strategies are commonly recommended for enhancing collaboration. These activities help team members get to know each other better, build trust, and foster a sense of camaraderie.
3	Training and Development	Emphasizing team member growth, various articles recommend providing skill-building workshops, mentoring programs, and coaching to enhance capabilities.
4	Knowledge Sharing Platforms	Implementing knowledge-sharing platforms and tools is a common strategy. These platforms can include intranets, social media, and knowledge management systems designed to facilitate the exchange of information and expertise.
5	Flexible Work Environments	Creating flexible work environments that allow for remote collaboration is mentioned in multiple articles. This includes using technology to support virtual teamwork and accommodating different work styles.
6	Leadership and Role Clarity	Effective leadership and clearly defined team roles are highlighted as essential. Strong leadership can set the tone for collaboration, while role clarity ensures team members understand their responsibilities.
7	Recognition and Incentives	Recognizing and rewarding individuals and teams for their contributions to knowledge sharing and collaboration is a common practice. Incentives can motivate team members to participate and share their expertise actively.
8	Continuous Improvement	Articles emphasize the need for a continuous improvement culture, urging teams to consistently evaluate processes, learn from experiences, and make collaborative enhancements.
9	Cross-Functional Teams	Creating cross-functional teams composed of members with diverse skills and backgrounds is mentioned to bring different perspectives to problem-solving and innovation.
10	Documentation and Knowledge Capture	Documenting processes, lessons learned, and best practices is a common strategy for preserving and sharing knowledge within teams and organizations.

multi-dimensional competitive model introduced in one study offers insights into effective knowledge sharing in cross-functional project teams (Ghobadi and D'Ambra, 2012). In contrast, another study balances explicit and tacit knowledge in developing Product-Service Systems (Wiesner et al., 2016).

The potential of online technology platforms to support trust, knowledge sharing, and collaboration in professional teams is highlighted, challenging the notion that face-to-face meetings are essential (Olaisen and Revang, 2017). Lastly, the role of IT tools in facilitating TMS development within organizational teams is discussed (Choi et al., 2010), emphasizing their mediating role in knowledge sharing, application, and team performance. These discussions shed light on the evolving landscape of knowledge management and collaboration across diverse organizational settings and industries, especially in IT.

5 Conclusions

Collaborative knowledge work involves diverse individuals or teams pooling expertise for projects, akin to friends sharing study materials before exams. Specialized teams in business and technology must unite, share insights, and solve complex problems collaboratively. In this research, we explore collaborative knowledge work in IT projects, investigating professional interactions, strategies to overcome challenges, and the role of technology in fostering better collaboration.

In this work, we performed a literature review on knowledge work practices, focused on using cross-domain collaboration in IT Projects. The research articles highlighted the importance of effective communication, centralized knowledge repositories, and cross-functional collaboration in successful IT projects. They recognized the diverse forms of knowledge and emphasized the role of technology in facilitating knowledge sharing and improving team performance.

The review synthesizes existing knowledge-sharing and management research in cross-domain IT projects, offering insights into common themes and challenges. It underscores the need for context-specific approaches to knowledge management.

While conducting this literature review, certain limitations should be acknowledged. Firstly, the selection of studies was done in an ad-hoc manner, potentially introducing bias and subjectivity into the process. The lack of a predefined and documented search strategy could impact the transparency and reproducibility of our review, making it challenging for others to replicate the study selection process. Secondly, there is a noticeable heterogeneity among the findings of the selected research articles in this review. While the heterogeneity among the results of the selected articles poses challenges to drawing uniform conclusions, it also highlights the complex and multifaceted nature of knowledge sharing in project-based organizations and cross-domain projects.

In future research, exploring advanced technology solutions, such as AI-driven collaboration platforms, virtual reality environments, and augmented reality tools, is essential to enhance cross-domain collaboration in IT projects. Additionally, there is a need to develop interdisciplinary collaboration models that bridge the gap between IT and other domains, facilitating knowledge sharing and innovation in cross-domain IT projects. Furthermore, investigating the long-term sustainability of knowledge transfer and collaboration efforts in IT projects is crucial to exploring how organizations can maintain effective knowledge-sharing practices over time. These efforts should be complemented by research into training programs that equip IT professionals with the competencies needed for cross-domain collaboration and effective knowledge sharing.

References

Barbosa, C. E., Y. O. de Lima, L. F. C. Costa, H. S. dos Santos, A. Lyra, M. Argôlo, J. A. da Silva, and J. M. de Souza (2022): 'Future of work in 2050: thinking beyond the COVID-19 pandemic'. *European Journal of Futures Research*, vol. 10, no. 1, pp. 25.

Bechky, B. A. (2003): 'Sharing meaning across occupational communities: The transformation of understanding on a production floor'. *Organization science*, vol. 14, no. 3, pp. 312–330.

Choi, S. Y., H. Lee, and Y. Yoo (2010): 'The impact of information technology and transactive memory systems on knowledge sharing, application, and team performance: A field study'. *MIS quarterly*, pp. 855–870.

Edmondson, A. C. and I. M. Nembhard (2009): 'Product development and learning in project teams: The challenges are the benefits'. *Journal of product innovation management*, vol. 26, no. 2, pp. 123–138.

Ghobadi, S. and J. D'Ambra (2012): 'Knowledge sharing in cross-functional teams: a coopetitive model'. *Journal of Knowledge Management*, vol. 16, no. 2, pp. 285–301.

Hetemi, E., J. Ordieres, and C. Nuur (2022a): 'Inter-organisational collaboration and knowledge-work: A contingency framework and evidence from a megaproject in Spain'. *Knowledge management research & practice*, vol. 20, no. 4, pp. 641–653.

Hetemi, E., O. Pushkina, and V. Zerjav (2022b): 'Collaborative practices of knowledge work in IT projects'. *International Journal of Project Management*, vol. 40, no. 8, pp. 906–920.

Lima, Y., C. E. Barbosa, H. S. dos Santos, and J. M. de Souza (2021): 'Understanding technological unemployment: a review of causes, consequences, and solutions'. *Societies*, vol. 11, no. 2, pp. 50.

Majchrzak, A., P. H. More, and S. Faraj (2012): 'Transcending knowledge differences in cross-functional teams'. *Organization science*, vol. 23, no. 4, pp. 951–970.

McNealy, T. L. G. (2017): 'Knowledge management practice strategies in project-based Organizations'. Ph.D. thesis, Walden University.

Motta, R., C. E. Barbosa, A. Lyra, J. Oliveira, G. Zimbrão, and J. M. De Souza (2022): 'Extracting Knowledge from and for Meetings'. In: *2022 12th International Conference on Software Technology and Engineering (ICSTE)*. pp. 82–90.

Nambisan, S. and D. Wilemon (2000): 'Software development and new product development: Potentials for cross-domain knowledge sharing'. *IEEE Transactions on Engineering Management*, vol. 47, no. 2, pp. 211–220.

Newell, S., M. Bresnen, L. Edelman, H. Scarbrough, and J. Swan (2006): 'Sharing knowledge across projects: limits to ICT-led project review practices'. *Management learning*, vol. 37, no. 2, pp. 167–185.

Nicolini, D., J. Mengis, and J. Swan (2012): 'Understanding the role of objects in cross-disciplinary collaboration'. *Organization science*, vol. 23, no. 3, pp. 612–629.

Olaisen, J. and O. Revang (2017): ‘Working smarter and greener: Collaborative knowledge sharing in virtual global project teams’. *International Journal of Information Management*, vol. 37, no. 1, pp. 1441–1448.

Precup, L., D. Mulligan, and D. O’Sullivan (2023): ‘Collaborative Tool to Support Knowledge Sharing and Innovation in an RD Project’.

Wiesner, S., F. Lampathaki, E. Biliri, and K.-D. Thoben (2016): ‘Requirements for cross-domain Knowledge Sharing in collaborative Product-Service System design’. *Procedia CIRP*, vol. 47, pp. 108–113.

Joris, Falip; Nadia, Gauducheau (2024): Do we really want AI answering on our behalf? A study of smart replies usage. In: Proceedings of the 22nd European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies - Exploratory papers, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591), DOI: 10.48340/ecscw2024_ep02

Do we really want AI answering on our behalf? A study of smart replies usage

Joris, Falip; Nadia, Gauducheau
LIST3N/Tech-CICO, Université de Technologie de Troyes, France
joris.falip@utt.fr

Abstract. The goal of this research is to find criteria influencing the use of smart replies in AI-mediated communications and identify the sender's perception of smart replies as a communication tool. We conducted qualitative and quantitative research using surveys and interviews with a population of French native speakers. During our experiment, we shared various communication scenarios using emails and text messages (including both professional and personal contexts) with fifty college students. We offered them the choice between smart replies or their own handwritten reply. We then followed up with interviews with a subset of students to better understand their replies to the survey and their relationship to AI-mediated communication. Analysis of the collected data points toward a broader acceptance of smart replies when the author only intends to acknowledge that the message was received and understood. On the contrary, reply suggestions are often dismissed by the sender as too casual for professional communications and too formal for family or friends.

Introduction

With the ubiquity of information systems came the rise of computer-mediated communication (CMC) (Hohenstein and Jung (2018); Chen et al. (2019)). Advances in machine learning and artificial intelligence as a whole during the last decade paved the way for intelligent systems that can act as agents (i.e., chatbots, virtual assistants) or co-authors by suggesting replies, autocompleting messages, translating or correcting texts (Sundar and Lee (2022)). Users are interacting with these tools daily (Goldenthal et al. (2021)) in what is known as artificial intelligence-mediated communication (AI-MC). AI-MC became omnipresent thanks to both a constant increase in products and devices integrating AI solutions as well as recent breakthroughs in machine learning applied to natural language processing such as translation, autocompletion (Chen et al. (2019)) or generative models for text (Dwivedi et al. (2023)).

Figure 1. Examples of smart replies proposed to users of communication systems. On the left side, smart replies as featured in Gmail online client. On the right side, shorter smart replies offered by Android Messages.

This work focuses on smart replies: reply suggestions generated by an AI so users can quickly answer a message without writing anything themselves, as shown in Figure 1. When receiving a message, many communication tools and platforms offer to choose from pre-written answers that can either be sent as is or manually completed. These responses are mostly intended to replace short messages like the ones exchanged in instant messaging applications (Microsoft Teams, Facebook Messenger), by text message (Android's *Messages* app), or by email (Gmail, Outlook) with a quarter of all emails being shorter than 20 words (Kannan et al. (2016)). We can, for example, point out that 10% of the 300 billion emails sent every day (Pettey (2021)) include AI-generated smart replies (Kannan et al. (2016)). Faced with a growing use of these tools, companies like Google now offer access to advanced smart reply models and text generation algorithms as API so AI can be integrated into third-party software as a co-author and writing assistant.

Related work

The usage of artificial intelligence-mediated communication has been widely studied following the rise in popularity of such technologies (Robertson et al. (2021)). Many research projects focus on the perception by the recipient of messages written by an AI (Liu et al. (2022); Mieczkowski et al. (2021); Angelis and Gonçalves (2020); Jakesch et al. (2019)) even though, in most real-life scenarios, the status of the sender is never disclosed and the recipient in unaware that an AI co-authored the message.

Studies on the perception and usage of authors using AI tools are rare. Few researchers studied the criteria underpinning the acceptance of smart replies (Robertson et al. (2021); Asscher and Glikson (2021)) or their influence on communication (Hohenstein and Jung (2018)) from the sender's perspective. Some studies mention the role of autonomy and agency for the author (Barlas (2019); Candrian and Scherer (2022)) but without accounting for the various usage contexts and their impact on whether the sender will delegate writing to an automated system. Both in computer science (Ribeiro et al. (2016); Schaffer et al. (2019); Cai et al. (2019)) or psychology (Goldenthal et al. (2021)), most of the analyses conducted are quantitative, and few offer a qualitative analysis of such interactions in AI-mediated communication (Hohenstein and Jung (2018); Robertson et al. (2021); Shin et al. (2022)).

Data on the actual usage of these technologies is scarce. In most experimental studies, users are encouraged or forced to use smart replies (Hohenstein and Jung (2020); Mieczkowski et al. (2021)), not taking into account their willingness to use smart replies in their daily communications. Some results and ongoing work from qualitative analysis of interviews point toward a lack of interest regarding the usage of smart replies (Liu et al. (2022); Mieczkowski and Hancock (2022)) without establishing criteria for user adoption.

Our work aims toward both a qualitative and quantitative analysis of how authors perceive smart replies suggested by an AI. Through surveys and interviews with users of such systems, we identify usage criteria for reply suggestions and explore the author's perception of theses communication tools. We specifically emphasize the author's sincerity and its correlation with the usage of smart replies. Existing results underline how the use of AI causes messages to be perceived as less sincere (Glikson and Asscher (2023)) with a lower trust toward the sender (Liu et al. (2022)). These results are focused on the perception of the recipient of those messages. Instead, we focus solely on the author's perception. By conducting two *a priori* analyses and sampling the smart replies used in our surveys, we ensure that smart replies are appropriate to each simulated scenario and that their quality will not impact the usage of AI-generated replies.

We can then formulate the following research questions:

- How often are smart replies used by authors?
- Does the usage of smart replies depend on the context (personal or professional) of the communication?

Methods

Our goal for this study is to offer participants a series of communication scenarios where they have to reply using prewritten AI suggestions or by writing their own replies. To reflect the diversity of use cases for AI-MC, we chose two communication contexts representative of situations where such suggestions are used: one involves communication between colleagues via Gmail, and the other involves communication between acquaintances using the text messaging application Messages. The surveys were conducted with French-speaking students, so all scenarios, messages, and smart replies were in French. Related to professional scenarios, all the students enrolled in this survey had prior professional experience include at least an internship.

Choice of AI-MC tools

Carrying out this study required a pool of AI-generated reply suggestions to design our surveys. Creating such a dataset is made difficult by the complexity and opacity of state-of-the-art models (Arrieta et al. (2020)). Instead of prototyping our own reply suggestion system, we relied on the existing and widely available Smart Reply functionality integrated into Google's ecosystem. We used this feature to generate a pool of context-appropriate smart replies for various communication scenarios. This approach comes with several advantages in our use case: Google Smart Reply is available in French, the native language of all the participants in our study, during both the surveys and interviews. This solution is also embedded into the Gmail email client and the Messages Android application. It provides unified smart replies across our usage scenarios (professional emails and personal texts). Hence, the quality of reply suggestions remains homogeneous across the scenarios and will not influence the rate at which authors select smart replies. Gmail is a widely used email provider with almost two billion monthly users[1] and is frequently used by companies as a professional email solution for their employees. Messages is the default text and instant messaging app on Android, downloaded billions of times[2]. These two tools are representative of the daily habits of billions of users when it comes to AI-mediated communication. Google also provides one of the only smart reply solutions documented by its designers in Kannan et al. (2016), making it easier to gather insights into how our experimental data are generated.

Designing scenarios and gathering smart replies

We created 18 scenarios divided into two main categories (professional and personal). For each category, we designed scenarios that cover various types of speech acts as presented by Searle (1969). As an example of the commissive act, the professional scenario is about planning a business meeting with a colleague,

1 https://blog.google/products/gmail/hitting-send-on-the-next-15-years-of-gmail/
2 https://play.google.com/store/apps/details?id=com.google.android.apps.messaging

and the personal one is about scheduling a dinner with a friend. Every scenario includes a single sentence summary used to give the participant some context and an initial message that the participant will have to reply to using their choice of smart reply or freeform text. All scenarios and messages are available in French as used in our survey (see Appendix A) and translated into English (see Appendix B).

We then gathered examples of smart replies by sending the initial message of each communication scenario through Gmail (for professional scenarios) or Messages (for personal ones) and taking note of the proposed smart replies. We replayed each scenario multiple times to gather 138 smart replies (an average of 8 per scenario).

Pretest survey and filtering smart replies

In our experiment's second step, we selected a sample of smart replies that seemed appropriate to each communication scenario. We removed suggestions of poor quality as they could have dissuaded participants from choosing them, and the aim of this work is not to benchmark the quality of AI smart replies. We conducted an initial analysis to remove ineffective or inappropriate messages from the corpus (such as semantic inconsistencies between the initial message and the suggestion or inappropriate tone). The process reduced the number of smart replies in our dataset from 138 to 78.

Subsequently, we submitted this corpus of suggestions to users to validate our analysis. Specifically, 25 French engineering students (aged 19 to 22) participated in a pretest survey where they read 18 messages along with the AI-generated smart replies, as shown in Figure 2. Note that the mock-ups in this figure are translated to be easily understandable, but the pretest was conducted in French like the rest of this study. They were instructed to circle any smart reply they deemed appropriate. This pretest survey reduced the pool of appropriate smart replies to 59, allowing our final survey to feature an average of 3 smart replies suggested in each scenario. This average matches what is commonly seen in products featuring smart replies like Gmail, Microsoft Teams, Android Messages, or Facebook Messenger.

Survey and interviews

After we retained only appropriate AI suggestions, the 18 communication scenarios were presented to a new sample of 56 participants (also engineering students of the same age) who did not take part in the pretest survey and were asked how they wished to reply to the initial message of each scenario. The survey was carried using paper forms where student had the option to create their own response (handwriting it on the form) or use one of the AI suggestions (by circling it), and if necessary, they could use the suggestion and complete it manually. Figure 3 showcases three examples of questions featured in the survey: in the first one, the participant used a smart reply; the second scenario was answered with a handwritten freeform message; and in the third example the participant used a

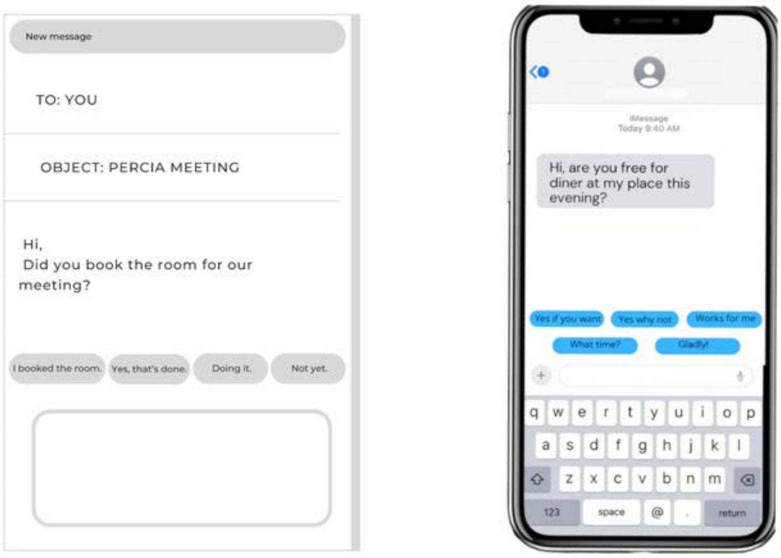


Figure 2. Translated mock-ups of email and text message user interfaces as used for the pretest survey. During this step, participants had to circle smart replies that they deemed appropriate to the initial message.

smart replied supplemented with handwritten greetings ("Hello [smart reply] Regards"). Participants answered 99% of the scenarios, resulting in a dataset of 995 answers.

Subsequently, 13 participants took part in a follow-up semi-structured interview to explain and comment on their choices during the survey and learn more about their usage of smart replies technologies in their daily communications.

Survey and interviews results

scenario	smart reply	free text	both combined	no answer
E1	20	9	25	2
E2	12	15	29	0
E3	17	10	28	1
E4	28	13	15	0
E5	11	28	17	0
E6	33	6	17	0
E7	18	16	22	0
E8	4	27	25	0
E9	1	51	3	1
E10	24	15	17	0

Table I. Results of the quantitative survey for email communication in professional scenarios.

Figure 3. Sample of various answers to our survey. In the first example (left) the participant chose to answer using a smart reply ("*Hi, can you send me the photos from yesterday's party?*" answered with "*Yes no problem*"). Second scenario (middle) showcases the use of free text to answer the initial message ("*I finally got my driver's license!*" answered with "*BRAVOOO!*"). The third example illustrates combined use of a smart reply supplemented with text, the smart reply is displayed as *[...]* in the free text area ("*Hello, Could you send me your notes on yesterday's meeting?*" answered with the smart reply "*Here are my notes*" and the participant added "*"Hello, [smart reply] Regards*").

Quantitative results

Our survey results are available in Table I for professional emails and Table II for personal text messages. We observe that smart replies alone were used in 36% of answers, and free text was also selected by participants in 36% of their answers, with a combination of free text and AI suggestions accounting for the remaining 28%. These results suggest that smart replies, alone or supplemented by free text, are used in more than half of the scenarios in this experiment. However, this usage of smart replies is much higher than expressed during interviews or observed in other studies (Kannan et al. (2016)). This frequency is likely related to the survey protocol, which encourages participants to choose smart replies more often than in a regular setting.

When comparing results between email and text message communication scenarios, we observe that free text alone is similar in both contexts (34% of answers rely on free text alone for emails and 39% for text messages). However, the use of AI suggestions differs between those two contexts: with emails, smart replies alone are used in 30% of the answers, and smart replies supplemented with free text are used in 35% of the answers. With text messages, these rates shift to 43% of smart replies alone and only 16% of smart replies supplemented with free text. When used to reply to an email, smart replies are very often supplemented with text. Analysis of the replies reveals that the opening and closing statements

scenario	smart reply	free text	both combined	no answer
S1	31	15	9	1
S2	18	18	19	1
S3	30	17	8	1
S4	16	22	17	1
S5	23	27	5	1
S6	31	18	6	1
S7	31	18	6	1
S8	11	41	2	2

Table II. Results of the quantitative survey for text messages in personal scenarios.

are often added to make the reply more formal ("Hello" / "Best regards"). Professional email communication encourages participants to use such statements as they are not included in AI-generated smart replies. Participants saw smart replies as more acceptable for text messages with friends and family.

Scenarios that elicited the highest usage of smart replies only are E1, E4, E6, and S3 (see Appendix A and B). These scenarios are all directive speech acts where the participant has to validate or confirm an action. In these cases, short smart replies ("Yes", "Of course", "Understood", or "Thank you") seemed appropriate to participants because, as authors, they want to acknowledge to their recipient that they received and read the initial message. Conversely, situations that prompted the highest use of free text (alone or supplementing a smart reply) are scenarios E9, S2, S4, S5, and S8 (see Appendix A and B). Given the social context, most AI suggestions are inappropriate in these scenarios. For example, message E9 requires apologies or justifications that are unavailable in the pool of smart replies. Some scenarios imply intimacy with the recipient, but all the smart replies lack this intimacy. One of the limitations of AI becomes apparent in these scenarios: the smart replies are often too neutral and lack linguistic markers appropriate to the social distance required by the situation. This inappropriate tone is amplified by suggestions that are very heavily biased toward positive sentiments so that there were no apologies suggested in any of the 138 smart replies we generated, even for situations that were very obviously prompting participants for an apology (e.g. scenario E9 "*I am very disappointed by your absence at yesterday's meeting...*").

Qualitative results

During the semi-structured interviews, all participants were allowed to explain their use or non-use of AI suggestions, and then they were asked about their feelings toward AI assisting them as a co-author. Participants indicate that most of the time, they do not use smart replies because the content of the replies does not correspond to what they would like to communicate. They consider the suggestions unsatisfactory regarding content because it does not fully capture their intent as authors or are insufficiently detailed ("*there wasn't enough information...*

I'd still prefer to specify that he needs to send [the document] to me as soon as possible". Participants also deem the suggestions inappropriate regarding their tone and writing style (too formal, too casual, not displaying enough intimacy) as summarized by one of the participants: "*It's my brother, I am close to him. I am not gonna settle for a somewhat generic message. I really wanna tailor [my reply] to him, to what he's telling me*".

Often, the reasons cited by participants for not using smart replies are linked to acceptability. Users consider that the use of suggestions is hardly compatible with their representation (or model) of interpersonal communication. In particular, participants mention their autonomy as authors and a reluctance to delegate to an AI when they can write the reply themselves ("*write my own reply, so it's my own spontaneous reaction rather than something that I didn't create myself*"). They emphasize the importance of making an effort during communication to ensure a form of reciprocity with their recipient ("*you can't just afford to send a short message, [you have to] spend some time [writing it]*"). The issue of sincerity is also raised by some participants ("*first, it's important to write [yourself]... it's just impersonal to use an automatic message... I'd feel bad to just click on a button and send it if it's in a personal context*"). Finally, we observe that participants anticipate their recipient's negative reaction to an automated reply: "*this kind of message, I think the person receiving it suspects it's somewhat of a canned response. And so it can give the feeling that 'yeah that's cool but I don't really care'*". Users consider both their relationship with the recipient and the context of their own usage. For example, using an AI smart reply may seem inappropriate unless the author is under time pressure or mobility, which prevents them from writing a longer and more personal reply.

These interviews also highlight situations that are compatible with the use of suggestions, at least from the author's perspective: replies that only serve to acknowledge the initial message ("*That's a quick info... The goal is only to give the info nothing more*"), short and casual replies to friends and loved ones or conversely to express disapproval with a cold, short and generic reply ("*So, that's the code to express that I'm angry*") or when the reply is insincere ("*Plus, if I especially don't want to tell them what I'm really thinking, a canned response isn't that bad*").

Conclusion

This exploratory study on the usage of reply suggestions demonstrates that participants, within the framework of fictional scenarios, are rather inclined to select smart replies generated by an AI. However, we remain cautious about the scope of the results as the study setup encouraged participants to use smart replies.

This study underlines that situations involving "acknowledgment" are conducive to the use of suggestions by the author. We also highlight the limitations of AI's smart replies. Despite *a priori* filtering of the replies, suggestions offered to participants are often judged inappropriate or insufficient to be used on their own. The smart replies fail to capture the complexity of exchanges: the variety of communication acts, different types of relationships, and the context of conversations (mobility, conversational history, etc).

Finally, this study identifies that some users have representations of communication that are incompatible with the use of smart replies (reciprocity, delegating authorship to AI, sincerity). These results are part of an ongoing work and need to be confirmed and further explored with additional interviews and new surveys using a protocol closer to the real-life use cases of participants.

References

Angelis, R. D. and M. Gonçalves (2020): 'Contraintes et enjeux de la matérialité numérique: les logiciels d'autocomplétion'. *Semen. Revue de sémio-linguistique des textes et discours*, vol. 49.

Arrieta, A. B., N. Díaz-Rodríguez, J. Del Ser, A. Bennetot, S. Tabik, A. Barbado, S. García, S. Gil-López, D. Molina, R. Benjamins, et al. (2020): 'Explainable Artificial Intelligence (XAI): Concepts, taxonomies, opportunities and challenges toward responsible AI'. *Information fusion*, vol. 58, pp. 82–115.

Asscher, O. and E. Glikson (2021): 'Human evaluations of machine translation in an ethically charged situation'. *new media & society*, vol. 25, pp. 14614448211018833.

Barlas, Z. (2019): 'When robots tell you what to do: Sense of agency in human-and robot-guided actions'. *Consciousness and cognition*, vol. 75, pp. 102819.

Cai, C. J., J. Jongejan, and J. Holbrook (2019): 'The effects of example-based explanations in a machine learning interface'. In: *Proceedings of the 24th International Conference on Intelligent User Interfaces*. p. 258–262.

Candrian, C. and A. Scherer (2022): 'Rise of the machines: Delegating decisions to autonomous AI'. *Computers in Human Behavior*, vol. 134, pp. 107308.

Chen, M. X., B. N. Lee, G. Bansal, Y. Cao, S. Zhang, J. Lu, J. Tsay, Y. Wang, A. M. Dai, Z. Chen, et al. (2019): 'Gmail smart compose: Real-time assisted writing'. In: *Proceedings of the 25th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining*. pp. 2287–2295.

Dwivedi, Y. K., N. Kshetri, L. Hughes, E. L. Slade, A. Jeyaraj, A. K. Kar, A. M. Baabdullah, A. Koohang, V. Raghavan, M. Ahuja, et al. (2023): '"So what if ChatGPT wrote it?" Multidisciplinary perspectives on opportunities, challenges and implications of generative conversational AI for research, practice and policy'. *International Journal of Information Management*, vol. 71, pp. 102642.

Glikson, E. and O. Asscher (2023): 'AI-mediated apology in a multilingual work context: Implications for perceived authenticity and willingness to forgive'. *Computers in Human Behavior*, vol. 140, pp. 107592.

Goldenthal, E., J. Park, S. X. Liu, H. Mieczkowski, and J. T. Hancock (2021): 'Not all AI are equal: exploring the accessibility of AI-mediated communication technology'. *Computers in Human Behavior*, vol. 125, pp. 106975.

Hohenstein, J. and M. Jung (2018): 'AI-supported messaging: An investigation of human-human text conversation with AI support'. In: *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems*. pp. 1–6.

Hohenstein, J. and M. Jung (2020): 'AI as a moral crumple zone: The effects of AI-mediated communication on attribution and trust'. *Computers in Human Behavior*, vol. 106, pp. 106190.

Jakesch, M., M. French, X. Ma, J. T. Hancock, and M. Naaman (2019): 'AI-mediated communication: How the perception that profile text was written by AI affects trustworthiness'. In: *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. pp. 1–13.

Kannan, A., K. Kurach, S. Ravi, T. Kaufmann, A. Tomkins, B. Miklos, G. Corrado, L. Lukacs, M. Ganea, P. Young, et al. (2016): 'Smart reply: Automated response suggestion for email'. In: *Proceedings of the 22nd ACM SIGKDD international conference on knowledge discovery and data mining*. pp. 955–964.

Liu, Y., A. Mittal, D. Yang, and A. Bruckman (2022): 'Will AI console me when I lose my pet? Understanding perceptions of AI-mediated Email writing'. In: *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*. pp. 1–13.

Mieczkowski, H. and J. Hancock (2022): 'Examining Agency, Expertise, and Roles of AI Systems in AI-Mediated Communication'. vol. none.

Mieczkowski, H., J. T. Hancock, M. Naaman, M. Jung, and J. Hohenstein (2021): 'AI-Mediated Communication: Language Use and Interpersonal Effects in a Referential Communication Task'. In: *Proceedings of the ACM on Human-Computer Interaction*, Vol. 5. pp. 1—–14.

Pettey, C. (2021): 'Email Statistics Report, 2021-2025'. https://www.radicati.com/wp/wp-content/uploads/2020/12/Email-Statistics-Report-2021-2025-Executive-Summary.pdf. Accessed: 2024-02-10 and archived in the Internet Archive.

Ribeiro, M. T., S. Singh, and C. Guestrin (2016): 'Why Should I Trust You?: Explaining the Predictions of Any Classifier'. In: *Proceedings of the 22nd ACM SIGKDD International Conference*. p. 1135–1144, ACM.

Robertson, R. E., A. Olteanu, F. Diaz, M. Shokouhi, and P. Bailey (2021): '"I Can't Reply with That": Characterizing Problematic Email Reply Suggestions'. In: *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. pp. 1–18.

Schaffer, J., J. O'Donovan, J. Michaelis, A. Raglin, and T. Höllerer (2019): 'I can do better than your AI - expertise and explanations.'. In: *Proceedings of the 24th International Conference on Intelligent User Interfaces*. p. 240–251.

Searle, J. R. (1969): *Speech acts: An essay in the philosophy of language*, Vol. 626. Cambridge university press.

Shin, D., S. Park, E. H. Kim, S. Kim, J. Seo, and H. Hong (2022): 'Exploring the Effects of AI-assisted Emotional Support Processes in Online Mental Health Community'. In: *CHI Conference on Human Factors in Computing Systems Extended Abstracts*. pp. 1–7.

Sundar, S. S. and E.-J. Lee (2022): 'Rethinking communication in the era of artificial intelligence'. *Human Communication Research*, vol. 48, no. 3, pp. 379–385.

Appendix A - Original scenarios in French

In every scenario, A is the sender, and B is the message's recipient. During the survey, participants answered as B. To keep the table readable, it only displays scenarios' names: the initial message used in the survey may be longer to give participants more context.

	Echanges professionnels par Gmail	**Echanges personnels par SMS**
A demande une confirmation	[E1] As-tu réservé la salle ?	[S1] Es-tu en route pour venir ?
		[S2] Es-tu libre pour venir manger...?
Une demande d'action par A	[E2] Peux-tu m'envoyer le document	[S3] Tu peux m'envoyer les photos...?
A annonce un problème (et n'est pas responsable)	[E3] Je ne pourrais pas venir, je suis malade	[S4] Je ne pourrais pas venir, je suis malade
A annonce un problème (et est responsable)	[E5] Je n'ai pas pu terminer ce que tu m'avais demandé....	[S6] Désolé ne de pas être venu..., j'ai oublié
L'annonce d'une bonne nouvelle pour A	[E4] J'ai terminé en avance. Je te l'envoie	[S5] ...J'ai mon permis !
L'annonce d'un « cadeau » pour B	[E6] Je viens de te faire parvenir les documents..	[S7] J'ai déposé ton cadeau
	[E7] Tu nous accompagnes pour la visite de demain	
Indication d'une faute de B	[E8] Tu n'as pas envoyé les documents	[S8] Tu as oublié de m'envoyer les photos
	[E9] Je suis très déçu de ton absence à la réunion d'hier...	
Demande d'information	[E10] Je suis en groupe de projet avec Daniel, tu le connais ?	

Appendix B - Scenarios translated into English

In every scenario, A is the sender, and B is the message's recipient. During the survey, participants answered as B. To keep the table readable, it only displays scenarios' names: the initial message used in the survey may be longer to give participants more context.

	Professional scenarios via Gmail	Personal scenarios via text message
A asks for confirmation	[E1] Did you book the room?	[S1] Are you on your way?
		[S2] Are you free for dinner...?
A asks B for documents	[E2] Can you send me the report?	[S3] Can you send me the pictures...?
A states a problem (and isn't responsible for it)	[E3] I can't join you, I'm sick	[S4] I can't come, I'm sick
A states a problem (and is responsible for it)	[E5] I couldn't finish what you asked me to do...	[S6] Sorry I wasn't there... I forgot
A shares good news	[E4] I finished it early. I'm sending it to you right now	[S5] ...Got my driver's license!
A is doing a favor to B	[E6] I was able to send you the documents.	[S7] I just mailed your gift
	[E7] You're allowed to join us for tomorrow's visit	
A points a mistake made by B	[E8] You didn't send me the report	[S8] You forgot to share the photos
	[E9] I am very disappointed by your absence yesterday...	
A asks for information	[E10] I'll be working with Daniel, do you know him?	

Schmidt, Michaela; Farshchian, Babak A. (2024): The impact of digitalization on frontline employees' knowledge work – a literature review. In: Proceedings of the 22nd European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies - Exploratory Papers, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591), DOI: 10.48340/ecscw2024_ep03

The impact of digitalization on frontline employees' knowledge work – a literature review

Michaela Schmidt, Babak A. Farshchian
Norwegian University of Science and Technology
Michaela.schmidt@ntnu.no, *babak.farshchian@ntnu.no*

Abstract. Information and Communication Technologies are transforming the public sector, e.g. in the form of self-service solutions, automated decision-making, and case management systems. These technologies change the work practices of frontline employees (FLE) who we conceptualize as knowledge workers as they produce, access, and document knowledge with the aim of making decisions. We analyze how technologies are affecting FLEs by investigating how their roles and work practices change in real-world settings. The research question "How do ICTs affect knowledge workers' roles and work practices in digital public encounters?" is addressed through a systematic literature review of qualitative studies. The main findings are (1) mainly three types of technologies affect FLEs' role and the knowledge required for their work, i.e., self-service, automated decision-making, and case management systems, (2) ICTs affect different aspects of knowledge work, (3) FLEs develop strategies to satisfy systems requirements and apply tacit knowledge as discretion to remain in their role as policy maker. We further discuss our findings and their implications for the CSCW community.

Introduction

Information and communication technologies (ICTs) are widely applied in private and public organizations to improve efficiency, optimize processes, save costs, and improve client or customer participation (Jonathan 2020; Castro and Lopes 2022). Digitalization transforms organizational structures, the way services are provided, as well as governance systems (Liva et al. 2020). These changes in the environment are shown to affect employees, who may experience negative control over work which can lead to physical and mental health problems (Peña-Casas et al. 2018), or reduced meaningfulness of work (Stein 2017). Other negative consequences may include changing social structures, work group dynamics, and worker safety and health (Bailey 2022). We further explore this problem by investigating the impact of ICTs on frontline employees (FLE) in the public sector who play an important role in citizens' interaction and satisfaction with their government.

Public organizations have been a focus in IS and CSCW research for a long time, including research on health and welfare technologies and digital innovations for public sector service delivery (Fitzpatrick and Ellingsen 2013; Aaen 2021), ICTs implications on accountability, trust, and transparency in the public sector (Smith et al. 2010; Flügge et al. 2020), and IT-systems not supporting user autonomy in public service provision (Bratteteig and Verne 2012). We add to this research by focusing on the *public encounter*, which is the interaction between the public organizations and the citizens, as Goodsell (1981) says "where state and citizen meet". The public encounter, which was traditionally a face-to-face interaction, is being replaced, supported, or mediated by ICTs such as self-service, automated decision-making, and case management systems.

While ICTs change the interaction between citizens and public administration, we want to specifically investigate the impact of these technologies on the role of frontline employees (FLE) whom we conceptualize as knowledge workers. Knowledge workers are people who rely on personal knowledge in their work. Aspects of knowledge work include acquiring knowledge, designing knowledge output, decision-making, and communicating the designed output (Davis and Naumann 1999). The CSCW literature has mainly focused on how ICTs support knowledge work (Borchorst and Bødker 2011; Fitzpatrick and Ellingsen 2013; Boulus-Rødje 2018), we add to this knowledge by investigating how ICTs can affect the roles and work practices of FLE as knowledge workers.

We draw evidence from the social and welfare services, such as unemployment benefits or financial support, where FLEs face complex cases. They use their experiences and tacit knowledge to make decisions and exercise discretion (Lipsky 2010). In this way, FLEs working with social services constitute an important but understudied example of knowledge workers.

We conducted a systematic literature review, focusing on qualitative studies investigating digital public encounters in welfare and social services. Our research question is: *How do ICTs affect knowledge workers' roles and work practices in digital public encounters*?

With this research, we contribute to CSCW literature by pointing towards potentially unintended consequences of ICTs on FLEs' roles and work practices. To design the best possible ICT solutions, it is important to understand how they are used 'on the ground' and the implications they have for FLEs. The upcoming sections will include relevant background literature, an overview of data collection and analysis methods, a presentation of results, and conclude with a discussion, limitations, and future research opportunities.

Background

The concept of knowledge work was first introduced in 1979, referring to organizational knowledge that represents a firm's "intellectual capital" (Kelloway and Barling 2000). It has since been used across many fields, leading to three main perspectives of knowledge work (1) as a profession, (2) as an individual characteristic, and (3) as an individual activity. Kelloway and Barling (2000) propose to define knowledge work as discretionary behavior focused on the use of knowledge.

Davis and Naumann (1999) define knowledge work as mental work performed by humans to generate useful information. Knowledge workers therefore access data, use knowledge, analyze information, design solutions, make decisions, and communicate information.

The CSCW research community has mainly focused on the collaborative aspects of knowledge work – the sharing of knowledge and information. Ackerman et al. (2013) distinguish between knowledge sharing and expertise sharing. While knowledge sharing is enabled or embodied by computational or information technology artifacts or repositories (artifact-centered), expertise sharing is based on discussions among knowledgeable actors and less supported by artifacts (communication-centered). Sharing expertise is closely linked to tacit knowledge which can be learned only through experience and therefore requires contact with others. Research in CSCW has focused on systems that can support knowledge sharing and expertise sharing. Cabitza and Simone (2012) outline that ICT devices can be knowledge-management systems as they support the creation and sharing of knowledge, or knowledge-based systems where knowledge is stored in the system to support decision-making and problem-solving. While this CSCW research has focused on how knowledge workers share knowledge and expertise with their colleagues and peers (e.g. in a team), in our research on FLEs knowledge work we include other aspects of knowledge work such as accessing and analyzing information, decision-making, and knowledge possession.

FLE in the public sector work at the intersection between the citizens and the administration – i.e., the public encounter. They perform knowledge work as they answer citizen requests, handle cases, and make decisions that have the potential to impact people's lives. Lipsky (2010) describes the role of FLE as that of policy-makers which is built upon a high degree of discretion and relative autonomy from organizational authority. This relates to Kelloway and Barling's (2000) definition of knowledge work as discretionary behavior. In social- and welfare services, FLE often deal with complex citizen narratives. They build upon personal experience and use discretion to deliver the best possible solutions for citizens (Lipsky 2010). For instance, FLEs might adjust dates to protect citizens' financial benefits, strategically categorize citizens' needs to make them eligible for benefits, or adjust demands posed on citizens in order to receive benefits fitted to their life situation (Raso 2017; Gustafsson and Wihlborg 2019). These examples show how FLE apply knowledge about policies and regulations to individual citizens' situations when making decisions. Discretion is also discussed by Petersen et al. (2020) who investigate how social workers exercise discretion cooperatively, based on consultations and skills. They argue that discretion should not be undermined by technology but rather be integrated within it. This aligns with the CSCW perspective on knowledge and expertise sharing and the ongoing debate on how systems can support these practices.

To exemplify, FLE are knowledge workers as they (1) possess specialized knowledge, e.g. administrative rules and regulations, (2) access knowledge, e.g. information on the citizen's life situation, (3) document and share knowledge, e.g. documenting information on citizens, and (4) make decisions, e.g. on a citizen's eligibility for certain benefits. These processes are complemented by FLEs experiences and discretionary practices.

In CSCW, the research on knowledge work has mainly focused on practices such as healthcare (Fitzpatrick and Ellingsen 2013), manufacturing (Hoerner et al. 2023), or IT-teams (Spence and Reddy 2012), leaving FLE as knowledge workers in the public administrations and especially social welfare agencies relatively understudied. Borchorst and Bødker (2011) investigate knowledge-sharing and collaborative activities between citizens and the government, drawing on the three cases of parental leave, citizen service offices, and municipal plans. Verne and Bratteteig (2016) present a study of citizens' calls to the tax authorities requesting help in filling out their tax forms. Both studies focus on the transfer of knowledge between citizens and FLE. Boulus-Rødje (2018) focuses on frontline employees and knowledge practices within the organization. They identify characteristics of caseworker's knowledge work and discuss implications for the design of ICTs that support these knowledge practices. Dolata et al. (2020) investigate how case and knowledge management systems may disturb the service provision when they are used as a collaborative resource during a service encounter with citizens. We build on this valuable research and extend it with our contribution towards framing FLEs' role as knowledge workers and how ICTs affect their knowledge work practices.

Methodology

This is a research-in-progress paper that presents first results of a systematic literature review with the aim to comprehensively explore the various aspects of digital public encounters. We specifically concentrated on qualitative research studies, as these studies provide valuable insights into people's emotions, opinions, and behaviors. The research question discussed in this paper emerged as part of the coding process.

We searched for three terms Digital, Public, and Encounter and their synonyms. The SPIDER tool proposed by Cooke et al. (2012) was used as inspiration for combining the terms. See Figure 1 for an overview of the search terms. The search terms were derived from an initial set of studies and tested throughout several iterations to develop a search string that returned the most relevant results. The final search string was checked against the list of an initial set of studies. We searched in Title, Abstract, and Keywords in Web of Science and Proquest.

AND

OR

Digital	Public /NEAR service	Encounter	Empirical
Electronic	Public sector	Discretion	Case study
Technolog*	Public authorit*	Public value	Focus group
ICT	Public administration	Interaction	Mixed method
AI	Public official	Citizen	Qualitative
Chatbot	Government	Accountability	Interview
Robot	Social work	Self-service	Observation
Automat*	frontline	Service delivery	Ethnography
"automated-decision-making"		Fact-to-face	Action-design-research

Figure 1 Overview of search terms for the query.

Several exclusion criteria were added to the search string. These included only peer-reviewed papers and publications from 2015 - now (2023). The time frame is based on the theoretical problem analysis carried out prior to the literature review. To refine the search results the following exclusion terms were added to the search string: inter-organizational, open data, data warehouses, big data, adoption, cloud computing, education, health, blockchain, Covid-19. These terms emerged during the testing and evaluation of the search string, and studies including these terms were considered non-relevant.

A total of 2420 studies were returned from the databases and saved to the reference management software Zotero. After removing duplicates and studies that were not published in English, Norwegian, or German (languages understood by the authors), 2124 studies were included in the screening process.

The screening process was based on pre-defined inclusion-exclusion criteria (see Table I). The inclusion criteria were derived from the study's aim to understand how technologies are applied to the context of a public encounter within social service provision, and the impacts on citizens as well as employees.

Table I. Overview of inclusion and exclusion criteria

Inclusion	**Exclusion**
Studies investigating means of digital interaction between citizens and public administrations	Full-text not available (i.e. not available in the university's subscription package)
Studies investigating the impact of ICTs and automation on discretion, accountability, and/or the work processes of public officials;	not within the context of social service provision
Studies investigating the impact of ICTs and automation on the role of citizens and/or frontline employees.	Non-empirical research
	Published before 2015

The screening process had three iterations where studies were included based on (1) title, (2) abstract, and (3) full text. The three iterations resulted in respectively 484, 91, and the final sample of 20 studies. An overview of the final sample is presented in the Appendix.

The final sample was imported and analyzed using the Dedoose app for analyzing qualitative and mixed-method research. Following a grounded theory coding approach, the final sample was analyzed using open coding, axial coding, and selective coding "in an intertwined fashion" (Wolfswinkel et al. 2013).

The open coding serves the identification of different concepts that emerge from the literature. Through axial coding, these concepts are grouped into different categories. The process of identifying concepts and categories is iterative in nature and requires revisiting papers, concepts, and categories based on new insights. Selective coding is further used to identify and develop relations between the main categories (Wolfswinkel et al. 2013).

The open coding resulted in 71 codes including concepts such as accountability, barriers, collaboration, control, emotion, flexibility, language, and responsiveness, among others. Through axial coding, we identified *Technologies* as a main category. The category *Technology* contains the sub-categories *self-services, automated decision-making / robotic process automation, and case management systems.* These sub-categories include codes related to work practices and the roles of FLE.

As this is a research-in-progress, the axial and selective coding will be continued to identify further categories and their relations to one another.

Results

In the following, we will present how ICTs affect the roles and work practices of FLE. The findings are structured along three technology categories emerging from our sample. These are (1) self-services (SS) (2) automated decision making (ADM) / robotic process automation (RPA), and (3) case management systems (CMS). Each of these has the potential to affect different aspects of knowledge work.

Self-services

Self-service solutions have the potential to change different aspects of knowledge work conducted by FLEs, leading to changes to current roles, the creation of new roles and duties, and the elimination or outsourcing of traditional roles.

Firstly, the application of self-service solutions can transfer knowledge work from the FLE to the citizen or others helping the citizen. With self-services the citizen has to find information about benefits and services themselves, they have to understand eligibility criteria, and possess general knowledge of how the public sector works (Heggertveit et al. 2022). At the same time, FLEs are changing their role from giving specialized guidance to helping citizens become self-sufficient in using digital solutions, which is shaped by "digital first" policies (Pors 2015; Schou and Pors 2019; Jorgensen and Schou 2020; Bernhard and Wihlborg 2022; Pedersen and Pors 2023). Changing roles also means changing how knowledge work is practiced. FLEs who take on this new role need to be familiar with several areas of service provision and focus more on communication, interaction, and creating a learning environment, rather than principles of law and public administration regulations (Pors 2015). In addition, they often have limited access to citizens' information and records and thus limited ability to help (Bernhard and Wihlborg 2022; Heggertveit et al. 2022). While bound to their new role of guiding citizens to use self-service, many FLEs still use discretion to provide the best possible service within the boundaries of their new role. Based on personal experience and social competence, rather than expertise and professional training, they assess a citizen's digital skills and decide how they can help them (Pedersen and Pors 2023). In some cases, this leads to the FLE taking over, doing the task for the citizen, even though it is against the official policy (Pors 2015; Schou and Pors 2019; Jorgensen and Schou 2020; Heggertveit et al. 2022; Pedersen and Pors 2023). Their new role may hinder them from giving more specialized advice as it is focused on helping to use the technology (Pedersen and Pors 2023).

Giest and Samuels (2022) describe how the role of helping citizens may also be outsourced to volunteers, e.g. library employees, and not performed by FLE. These volunteers are not allowed to give advice or confirmation about eligibility criteria but feel pressure to undertake additional steps to help citizens given the often vulnerable situation they are in. These steps can include calling other services and hotlines for them and checking compliance with services.

Several studies show that FLE’s core tasks as specialized decision-makers are replaced with the task of making citizens capable of using digital solutions (Pors 2015; Schou and Pors 2019; Pedersen and Pors 2023). They are further seen as complementing the self-service (Bernhard and Wihlborg 2022).

Another aspect of self-service solutions regards the processing of online applications. Information received through self-services can be “simplified, often binary formats, fragmented and incomplete” (Loberg 2023). This produces two main challenges for the FLE, (1) a cohesive citizen narrative is deconstructed into pieces, and (2) the information is incoherent with conflicting answers. The FLE will then “search for additional information and use previous experience to recontextualize the case and reconstruct the client narrative” (Loberg 2023).

Automated decision-making and Robotic process automation

Automated decision-making and Robotic process automation (ADM/RPA) are tools that generate decisions based on data input and streamline routine work processes. Similar to self-service solutions, does the deployment of the RPA lead to changing roles for the FLE who are no longer social workers that prove eligibility criteria but now focus on other tasks, such as the reintegration of the citizen into the labor market (Ranerup and Henriksen 2019). While their primary role as decision-makers has diminished (Ranerup and Henriksen 2022; Ranerup and Svensson 2023), FLEs consider it as part of their professionalism to validate data in the decision-making process.

Their changing role allows FLEs to have more time for non-routine tasks such as reviewing citizen's activity plans and appeals against decisions, as well as personal contact with citizens. Some FLEs point out that the ADM improves their capacity to make judgments (Ranerup and Svensson 2022). Other FLEs pointed to the individual micro-assessments they make based on interaction with the citizen which they don’t see can be done by ADM. During such micro-assessments, the FLE uses discretionary power to make decisions (Gustafsson and Wihlborg 2019). Another case concerns the deployment of a “fully automated service-delivery model that produces its own legal decisions after caseworkers have input […] client information” (Raso 2017). In this case, the decision-making behavior of the tool is seen as unpredictable which creates additional tasks for the FLE. FLEs often have to correct errors generated by the ADM which redirects their attention away from the citizen and toward the tool. They describe it as being overwhelmed with administrative work that takes away time they'd rather spend with the citizens. They had to learn "its [the tools] language" so that they could more effectively manipulate the system and produce wanted outcomes (Raso 2017).

Case management systems (CMS)

Case management systems (CMS) are widely used in public administration. Løberg and Egeland (2023) describe how the use of a CMS "that enables counselors to find information about the client and supports formal decision-making" can lead to an incomplete perception of the citizen. The system cannot always display the full picture of the citizen, as one FLE pointed out that it can be useful to see the citizen as "this tells us something about the person we can lose sight of when everything is digital…" (Loberg and Egeland 2023). The authors argue that this fragmentation can lead to alienation that can rob the work of its meaning (Loberg and Egeland 2023). Fragmentation is also addressed by Devlieghere and Roose (2019) who investigated the case of standardized forms in child welfare protection. Here, FLEs point out that the tool makes it "almost impossible for them" to create a nuanced and complete overview of the citizens' life history. They also point to the system's linguistic structure that lacks narrative. As the FLEs were expected to use the system they developed workarounds such as contacting other services before completing the form, exaggerating a citizen problem or withholding positive information on the citizen's situation, and using certain text fields for unintended purposes (Devlieghere and Roose 2018; Devlieghere and Roose 2019). Other FLEs working with the same tool, appreciated the structure of the IS in providing clear aims, a path to follow during consultations, and helping to structure the thoughts. They considered the IS as a tool to create a single and uniform language that leads to more objective assessments (Devlieghere et al. 2020; Devlieghere et al. 2021). The IS was further seen as helpful in reconstructing citizens' care trajectories (Devlieghere and Roose 2019).

A CMS for social benefits in Canada forced FLEs to develop several workarounds. They enter placeholder data to satisfy the need to fill all fields, adjust dates forward and backward to moderate the system's exacting interpretation of dates, and categorize citizens' needs so that the system will find them eligible for benefits. The FLEs learned to creatively enter client data so that the system generates outcomes that better fit the FLE's perception of the citizens' needs (Raso 2017). Dolata et al. (2020) investigated a CMS that is designed for sharing information, orchestrating processes within the agency, and checking information. It further has embedded regulatory obligations and technical limitations that define the FLEs work but doesn't support citizen consultation very well. As such the FLEs develop strategies for better consultation and information sharing with clients while having to satisfy the requirements of the system. These strategies include being selective about their documentation and the effort put into documentation depending on the citizen’s needs (Dolata et al. 2020). Some FLE reuse frequently used paragraphs or just use keywords to make notes and complete the documentation after the consultation. Another strategy to share information with the citizen includes turning the computer screen toward the citizen. The system itself is designed as a single-user desktop software and has no specific screen-sharing option to be used during consultations (Dolata et al. 2020).

In several of the presented cases, FLEs see the CMS as a control instrument that creates a conflict between satisfying the systems' needs and being responsive to the citizens (Raso 2017; Devlieghere et al. 2020; Dolata et al. 2020).

Discussion and Conclusion

The findings show how the different technologies self-services, ADM/RPA, and case management systems affect the roles and practices of frontline employees concerning knowledge work as defined by Davis and Naumann (1999) and Kelloway and Barling (2000).

We first relate our findings to the four aspects of knowledge work as presented in the background section: (1) possessing specialized knowledge, (2) accessing knowledge, (3) documenting and sharing knowledge, (4) decision making, as well as the FLEs use of tacit knowledge within those aspects. Subsequently, we discuss the findings with the CSCW perspective on knowledge work.

(1) Possessing specialized knowledge: The findings show that specialized administrative knowledge may be transferred to the citizens using self-service, or volunteers helping citizens to use self-services (e.g. Heggertveit et al. 2022; Giest and Samuels 2022). Knowledge of regulations and eligibility criteria may be transferred to the ADM and FLEs are often assigned a new role in which their main task is to guide citizens to use self-services. In that role, they need more general knowledge of the services and the use of the technology. They further need to be able to assess a citizen’s digital skills and create a supportive learning environment (e.g. Pors 2015). While their roles changed completely, FLEs still apply tacit knowledge when deciding how much support a citizen needs and whether they might have to ‘take over’ for the citizen. FLEs who work with case management systems and ADM also develop knowledge of the functionality of the system to use it more effectively. This can also mean manipulating the system to produce a wanted outcome (e.g. Raso 2017).

(2) Accessing knowledge: FLEs who take on the role of helping citizens to use self-services often experience limited access to citizens' information and records (e.g. Bernhard and Wihlborg 2022). They are bound to certain rules, such as not being allowed to see sensitive information when assisting a citizen, or simply not

having access to the administration's case management systems. This limits their ability to help the citizens. Yet, FLE may bend these rules when they perceive it as the only way to help the citizen (e.g. Schou and Pors 2019; Jorgensen and Schou 2020).

Self-services and case management systems can cause fragmentation of citizen information. In those cases, the FLE applies tacit knowledge and engages in further knowledge production based on other sources to re-construct the narrative (Loberg 2023).

(3) Documenting and sharing knowledge: Case management systems can support but also limit the documentation and sharing of knowledge. They may help to structure a consultation, thoughts, and re-construct citizens' service history, but are also often seen as too standardized and rigid to allow for a nuanced representation of the citizen's narrative (e.g. Devlieghere et al. 2020). In those cases, the FLEs develop ‘creative’ documentation practices by entering placeholder data, using text fields for unintended purposes, or engaging in selective documentation practices to satisfy the system (e.g. Raso 2017; Devlieghere and Roose 2018). To better share knowledge with the citizens, they may turn the screen towards the citizen when the system does not provide a special function for sharing (e.g. Dolata et al. 2020). Here, the FLE uses discretion to overcome the limitations perceived by the system.

(4) Decision making: Self-services and ADM can remove the FLEs core task of specialized decision-making and leave them with the task of complementing the system. They may still validate citizen data and control the decisions generated by the tool. When the tool takes a supportive role, i.e. the decision must be approved by the FLE, some FLEs state that the tool can improve their capacity to make judgments (e.g. Ranerup and Svensson 2022). Additionally, FLE may correct the tool's decision if it differs from theirs. While the tool is basing its decision solely on data input, the FLE makes use of tacit knowledge and discretion to develop its decision. When the ADM is fully automated and FLEs cannot correct its decision, they will correct it by changing the data input to the system. This includes adjusting dates, exaggerating problems, or withholding positive information (e.g. Raso 2017). Thus, despite the full automation of the decision-making process, FLEs try to remain in control over the decision.

Across all four aspects, we can identify elements of artifact-centered knowledge sharing as defined by Ackerman et al. (2013). Especially ADM and RPA are precisely designed to have knowledge (e.g. regulations, rules, and policies) embodied within them and carry out a task based on that knowledge. They are what Cabitza and Simone, (2012) call knowledge-based systems. These systems, although designed to support decision-making, can cause challenges for the FLE when the system's decision differs from theirs. Case-management systems can be considered knowledge-management systems (Cabitza and Simone

2012) as they allow for documentation and knowledge sharing. As outlined above they often come with limitations regarding documentation and knowledge sharing, especially in complex client trajectories. It can therefore be assumed that they support knowledge sharing rather than expertise sharing. To what degree these systems can support expertise sharing remains unknown from the findings.

As presented above, ICTs affect knowledge work in different ways. However, one aspect of knowledge work, the use of tacit knowledge and discretion, remains present and even dominant across all aspects. This is in coherence with Kelloway and Barling (2000) who suggest that discretionary behavior is at the core of knowledge work. It further agrees with Lipsky (2010), who states that FLE will use discretion to deliver the service they consider best suitable for the citizen, thus taking on the role of policy-makers. It further agrees with Petersen et al. (2020) who argue that attempts to reduce discretion through automation can cause damages. Our findings reveal that automation does not necessarily reduce discretion, as FLEs manipulate the system to create the decisions they deem suitable. Automation may thus create more challenges for FLEs than relieving them of tasks. To conclude, the findings show that while ICTs change how knowledge work is practiced and what role the FLE takes in the public encounter, they cannot fully replace knowledge workers in the public service provision.

Implication and Future Research

Our study demonstrates that ICTs affect different aspects of knowledge work in the context of a public encounter. As this is an exploratory study, we want to further explore CSCW literature and investigate how ICTs can support all aspects of knowledge work and especially consider discretionary behavior as an essential part of knowledge work. Additionally, the findings presented here constitute only one aspect of the digital public encounter, the impact of technologies on FLE roles and their knowledge work practices in the delivery of welfare and social services. The overarching aim of this research project is to develop a holistic understanding of the digital public encounter and highlight its importance for the CSCW community. Our future research activity will therefore include further analysis of the data from this literature review and develop a framework that captures the different aspects of the digital public encounter, adding citizens and other actors within the public encounter and its service-ecosystem.

The findings have further implications for practice and system designers. To design systems that support knowledge work at the frontline it is important to understand the roles of different actors, how they use the system, and how they are affected by a system. Ill-designed systems that fail to recognize the range of knowledge work practices can lead to negative consequences for workers. Although our findings show some positive effects of ICTs on FLE's work practices, most research addresses negative effects. Administrations that utilize ICTs in their public encounters should therefore identify clear metrics that help them identify positive as well as negative effects.

Limitations

The findings of this study are based on a literature review which presents limitations to the data gathering and analysing process. The search string and databases may not have returned all relevant studies, despite testing in several iterations. The data analysis is susceptible to researcher's bias. To reduce bias, the authors discussed codes and findings throughout the process.

Acknowledgements

This project is conducted as part of the project SustainDiT (Sustainable Digital Transformations) at the Norwegian University of Science and Technology. We thank project members for feedback and discussions related to the topic of the paper. We also thank the anonymous reviewers for their fruitful and constructive comments.

References

Aaen J (2021) Competing Concerns on Emerging Welfare Technologies. A review of eight prevailing debates in current literature. Scandinavian Journal of Information Systems 33(1)

Ackerman MS, Dachtera J, Pipek V, Wulf V (2013) Sharing Knowledge and Expertise: The CSCW View of Knowledge Management. Comput Supported Coop Work 22(4):531–573. https://doi.org/10.1007/s10606-013-9192-8

Bailey DE (2022) Emerging Technologies at Work: Policy Ideas to Address Negative Consequences for Work, Workers, and Society. ILR Review 75(3):527–551. https://doi.org/10.1177/00197939221076747

Bernhard I, Wihlborg E (2022) Bringing all clients into the system - Professional digital discretion to enhance inclusion when services are automated. INFORMATION POLITY 27:373–389

Borchorst NG, Bødker S (2011) "You probably shouldn't give them too much information" – Supporting Citizen-Government Collaboration. In: Bødker S, Bouvin NO, Wulf V, Ciolfi L, Lutters W (eds) ECSCW 2011: Proceedings of the 12th European Conference on Computer Supported Cooperative Work, 24-28 September 2011, Aarhus Denmark. Springer, London, pp 173–192

Boulus-Rødje N (2018) In Search for the Perfect Pathway: Supporting Knowledge Work of Welfare Workers. Comput Supported Coop Work 27(3):841–874. https://doi.org/10.1007/s10606-018-9318-0

Bratteteig T, Verne G (2012) Conditions for Autonomy in the Information Society: Disentangling as a public service. Scandinavian Journal of Information Systems 24(2)

Cabitza F, Simone C (2012) Affording Mechanisms: An Integrated View of Coordination and Knowledge Management. Comput Supported Coop Work 21(2):227–260. https://doi.org/10.1007/s10606-011-9153-z

Castro C, Lopes C (2022) Digital Government and Sustainable Development. J Knowl Econ 13(2):880–903. https://doi.org/10.1007/s13132-021-00749-2

Cooke A, Smith D, Booth A (2012) Beyond PICO: The SPIDER Tool for Qualitative Evidence Synthesis. Qual Health Res 22(10):1435–1443. https://doi.org/10.1177/1049732312452938

Davis GB, Naumann JD (1999) Knowledge Work Productivity. Emerging Information Technologies: Improving Decisions, Cooperation, and Infrastucture," in Knowledge Work Poductivity" In Emerging Information Technologies: Improving Decisions, Cooperation, and Infrastucture :343–357

Devlieghere J, Bradt L, Roose R (2021) Electronic information systems as means for accountability: why there is no such thing as objectivity. EUROPEAN JOURNAL OF SOCIAL WORK 24:212–223

Devlieghere J, Roose R (2019) Documenting practices in human service organisations through information systems: When the quest for visibility ends in darkness. SOCIAL INCLUSION 7:207–217

Devlieghere J, Roose R (2018) Electronic Information Systems: In search of responsive social work. JOURNAL OF SOCIAL WORK 18:650–665

Devlieghere J, Roose R, Evans T (2020) Managing the electronic turn. EUROPEAN JOURNAL OF SOCIAL WORK 23:767–778

Dolata M, Schenk B, Fuhrer J, Marti A, Schwabe G (2020) When the system does not fit: Coping strategies of employment consultants. COMPUTER SUPPORTED COOPERATIVE WORK-THE JOURNAL OF COLLABORATIVE COMPUTING AND WORK PRACTICES 29:657–696

Fitzpatrick G, Ellingsen G (2013) A Review of 25 Years of CSCW Research in Healthcare: Contributions, Challenges and Future Agendas. Comput Supported Coop Work 22(4):609–665. https://doi.org/10.1007/s10606-012-9168-0

Flügge AWA, Hildebrandt T, Møller NH (2020) Algorithmic Decision Making in Public Services: A CSCW-Perspective. In: Companion Proceedings of the 2020 ACM International Conference on Supporting Group Work. Association for Computing Machinery, New York, NY, USA, pp 111–114

Giest S, Samuels A (2022) Administrative burden in digital public service delivery: The social infrastructure of library programs for e-inclusionPalabras Clave(sic)(sic)(sic). REVIEW OF POLICY RESEARCH

Gustafsson MS, Wihlborg E (2019) `It is always an individual assessment': A case study on challenges of automation of income support services. ELECTRONIC GOVERNMENT (EGOV 2019) 11685:45–56

Heggertveit I, Lindgren I, Madsen CO, Hofmann S (2022) Administrative burden in digital self-service: An empirical study about citizens in need of financial assistance. ELECTRONIC PARTICIPATION, EPART 2022 13392:173–187

Hoerner L, Schamberger M, Bodendorf F (2023) Using Tacit Expert Knowledge to Support Shop-floor Operators Through a Knowledge-based Assistance System. Comput Supported Coop Work 32(1):55–91. https://doi.org/10.1007/s10606-022-09445-4

Jonathan GM (2020) Digital transformation in the public sector: Identifying critical success factors. Information systems: 16th european, mediterranean, and middle eastern conference, EMCIS 2019, dubai, united arab emirates, december 9–10, 2019, proceedings 223–235

Jorgensen B, Schou J (2020) Helping or intervening? Modes of ordering in public sector digitalization. JOURNAL OF ORGANIZATIONAL ETHNOGRAPHY 9:265–279

Kelloway EK, Barling J (2000) Knowledge work as organizational behavior. International Journal of Management Reviews 2(3):287–304. https://doi.org/10.1111/1468-2370.00042

Lipsky M (2010) Street-Level Bureaucracy, 30th Anniversary Edition: Dilemmas of the Individual in Public Service. Russell Sage Foundation

Liva G, Codagnone C, Misuraca G, Gineikyte V, Barcevicius E (2020) Exploring digital government transformation: a literature review. 13th international conference on theory and practice of electronic governance (ICEGOV 2020) 502–509

Loberg IB (2023) Assessments of digital client representations: How frontline workers reconstruct client narratives from fragmented information. JOURNAL OF PUBLIC ADMINISTRATION RESEARCH AND THEORY 33:19–29

Loberg IB, Egeland C (2023) `You get a completely different feeling' - an empirical exploration of emotions and their functions in digital frontline work `Du far en helt annen feeling' - en empirisk undersokelse av folelser og deres funksjon i digitalt forstelinjearbeid. EUROPEAN JOURNAL OF SOCIAL WORK 26:108–120

Pedersen KZ, Pors AS (2023) Discretionary responses in frontline encounters: Balancing standardization with the ethics of office. JOURNAL OF PUBLIC ADMINISTRATION RESEARCH AND THEORY 33:80–93

Peña-Casas R, Ghailani D, Coster S (2018) THE IMPACT OF DIGITALISATION ON JOB QUALITY IN EUROPEAN PUBLIC SERVICES THE CASE OF HOMECARE AND EMPLOYMENT SERVICE WORKERS

Petersen ACM, Christensen LR, Hildebrandt TT (2020) The Role of Discretion in the Age of Automation. Comput Supported Coop Work 29(3):303–333. https://doi.org/10.1007/s10606-020-09371-3

Pors AS (2015) Becoming digital – passages to service in the digitized bureaucracy. Journal of Organizational Ethnography 4(2):177–192. https://doi.org/10.1108/JOE-08-2014-0031

Ranerup A, Henriksen HZ (2019) Value positions viewed through the lens of automated decision-making: The case of social services. Government Information Quarterly 36:101377 [1–13]

Ranerup A, Henriksen HZ (2022) Digital discretion: Unpacking human and technological agency in automated decision making in Sweden's social services. Social Science Computer Review 40:445–461

Ranerup A, Svensson L (2023) Automated decision-making, discretion and public values: a case study of two municipalities and their case management of social assistance. EUROPEAN JOURNAL OF SOCIAL WORK

Ranerup A, Svensson L (2022) Discretion, automated decision-making and public values: Background and test of an approach for unpacking human and technological agency. ELECTRONIC GOVERNMENT, EGOV 2022 13391:291–306

Raso J (2017) Displacement as Regulation: New Regulatory Technologies and Front-Line Decision-Making in Ontario Works. Canadian Journal of Law and Society 32(1):75–95. https://doi.org/10.1017/cls.2017.6

Schou J, Pors AS (2019) Digital by default? A qualitative study of exclusion in digitalised welfare. SOCIAL POLICY & ADMINISTRATION 53:464–477

Smith M, Noorman M, Martin A (2010) Automating the Public Sector and Organizing Accountabilities. Communications of the Association for Information Systems 26(1). https://doi.org/10.17705/1CAIS.02601

Spence PR, Reddy M (2012) Beyond Expertise Seeking: A Field Study of the Informal Knowledge Practices of Healthcare IT Teams. Comput Supported Coop Work 21(2):283–315. https://doi.org/10.1007/s10606-011-9135-1

Stein EA (2017) Are ICTs democratizing dictatorships? New media and mass mobilization. Social Science Quarterly 98:914–941

Verne G, Bratteteig T (2016) Do-it-yourself services and work-like chores: on civic duties and digital public services. Pers Ubiquit Comput 20(4):517–532. https://doi.org/10.1007/s00779-016-0936-6

Wolfswinkel JF, Furtmueller E, Wilderom CPM (2013) Using grounded theory as a method for rigorously reviewing literature. European Journal of Information Systems 22(1):45–55. https://doi.org/10.1057/ejis.2011.51

Appendix

Author (Year)	Title	Publication Title	Technology and Context
Ranerup and Svensson (2023)	Automated decision-making, discretion and public values: a case study of two municipalities and their case management of social assistance	European Journal of Social Work	RPA, income support, Sweden
Giest and Samuels (2022)	Administrative burden in digital public service delivery: The social infrastructure of library programs for e-inclusion	Review Of Policy Research	Self-services, libraries, and community centers, Netherlands
Loberg (2023)	Assessments of digital client representations: How frontline workers reconstruct client narratives from fragmented information	Journal Of Public Administration Research And Theory	Self-service application, needs assessment unemployment, Norway
Pedersen and Pors (2023)	Discretionary responses in frontline encounters: Balancing standardization with the ethics of office	Journal Of Public Administration Research And Theory	Self-services, Citizen service centers, Denmark
Bernhard and Wihlborg (2022)	Bringing all clients into the system - Professional digital discretion to enhance inclusion when services are automated	Information Polity	Self-services, Contact centres, Sweden
Heggertveit et al. (2022)	Administrative burden in digital self-service: An empirical study about citizens in need of financial assistance	Electronic Participation, Epart 2022	Self-services, financial assistance application, Norway
Ranerup and Svensson (2022)	Discretion, automated decision-making, and public values: Background and test of an approach for unpacking human and technological agency	Electronic Government, Egov 2022	RPA, income support, Sweden
Loberg and Egeland (2023)	`You get a completely different feeling' - an empirical exploration of emotions and their functions in digital frontline work `Du far en helt annen feeling' - en empirisk undersokelse av folelser og deres	European Journal Of Social Work	CMS, income support/unemploymen t, Norway

	funksjon i digitalt forstelinjearbeid		
Devlieghere and Roose (2021)	Electronic information systems as means for accountability: why there is no such thing as objectivity	European Journal Of Social Work	CMS, Child-Welfare-protection, Belgium
Ranerup and Henriksen (2022)	Digital discretion: Unpacking human and technological agency in automated decision-making in Sweden's social services	Social Science Computer Review	RPA, income support, Sweden
Devlieghere et al. (2020)	Managing the electronic turn	European Journal Of Social Work	CMS, Child-Welfare-protection, Belgium
Dolata et al. (2020)	When the system does not fit: Coping strategies of employment consultants	CSCW-The Journal Of Collaborative Computing And Work Practices	CMS, employment agency, Germany
Jorgensen and Schou (2020)	Helping or intervening? Modes of ordering in public sector digitalization	Journal Of Organizational Ethnography	Self-services, Citizen service centers, and tax call center, Denmark
Ranerup and Henriksen (2019)	Value positions viewed through the lens of automated decision-making: The case of social services	Government Information Quarterly	RPA, income support, Sweden
Schou and Pors (2019)	Digital by default? A qualitative study of exclusion in digitalised welfare	Social Policy & Administration	Self-services, Citizen service centers, Denmark
Devlieghere and Roose (2019)	Documenting practices in human service organisations through information systems: When the quest for visibility ends in darkness	Social Inclusion	CMS, Child-Welfare-protection, Belgium
Gustafsson and Wihlborg (2019)	`It is always an individual assessment': A case study on challenges of automation of income support services	Electronic Government (Egov 2019)	ADM, income support, Sweden
Devlieghere and Roose (2018)	Electronic Information Systems: In search of responsive social work	Journal Of Social Work	CMS, Child-Welfare-protection, Belgium

Raso (2017)	Displacement as Regulation: New Regulatory Technologies and Front-Line Decision-Making in Ontario Works	Canadian Journal of Law and Society	CMS with integrated ADM, financial income support, Canada
Pors (2015)	Becoming digital – passages to service in the digitized bureaucracy	Journal of Organizational Ethnography	Self-services, Citizen service centres, Denmark

Le Song and Zhegong Shangguan (2024): The Moment That The Driver Takes Over: Examining Trust in Full-Self Driving in A Naturalistic and Sequential Approach. In: Proceedings of the 22nd European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies - Exploratory papers, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591), DOI: 10.48340/ecscw2024_ep04

The Moment That The Driver Takes Over: Examining Trust in Full Self-Driving in A Naturalistic and Sequential Approach

Le Song
Department of SES
i3 Lab (CNRS)
Telecom Paris
Institut Polytechnique de Paris
Palaiseau, France
le.song@telecom-paris.fr

Zhegong Shangguan
Autonomous Systems and Robotics Lab/U2IS
ENSTA Paris
Institut Polytechnique de Paris
Palaiseau, France
zhegong.shangguan@ensta-paris.fr

Abstract

In this paper, we have documented the challenges that drivers with autopilots experience on real-world roads by focusing on the practices of humans taking over. Using a conversation analytic approach, we analyze data of full self-driving cars selected from third-party YouTube videos. We have shown how drivers treat the car's moment-by-moment motion as actions that are projectable for potentially relevant risky outcomes and how they take over the full self-driving system in situ and in vivo, with continuous situated monitoring. We have demonstrated four typical situations in which drivers take over in the unfolding course of driving action: going too close to the front car, inappropriate speed in the local context, wrong recognition of lanes, and pedestrian priority. We argue that the achievement of human takeovers is inextricably connected to the situated organization and accountability of the course of action.

Keywords: Trust, full self-driving, human assisting, multimodal conversation analysis

1 Introduction

1.1 Human and self-driving car interaction from the conversation analysis perspective

Autonomous vehicles (AVs) are already commonly seen on the roads. In the foreseeable future, smart cars with L2 and above functionalities will become mainstream. Currently, the majority of technical challenges lie in artificial intelligence (AI) algorithms, path planning, etc. However, the interaction between drivers and automated systems, especially the conflicts encountered among human-machine interactions (HMI) in natural driving, is an area that desires further research.

The interaction between humans and self-driving vehicles presents a multifaceted challenge, as underscored by recent research. Traditional nonverbal cues utilized by human drivers to convey awareness and intent to pedestrians are absent in autonomous vehicles, necessitating the development of alternative interfaces. Mahadevan et al. (2018) emphasize the importance of multi-modal interfaces beyond vehicle movement, which can aid pedestrians in understanding the vehicles' intentions, particularly in crosswalk scenarios. Drawing from cross-cultural analyses of human traffic interaction, Brown et al. (2022) identify fundamental movement elements crucial for safe maneuvering on roads, such as gaps, speed, position, indicating, and stopping. These insights suggest opportunities for designing vehicle motion to enhance understandability within traffic contexts, thus improving overall safety and efficiency.

However, autonomous vehicles still struggle with the complex social dynamics of traffic, as evidenced by Brown et al. (2023), who found shortcomings in their ability to navigate yielding situations. This highlights the challenges in designing autonomous vehicles to effectively communicate intentions and respond appropriately to other road users' actions. As a higher manifestation of intelligent behavior, social behavior is still difficult for current AVs to handle these social interactions.

Moreover, the challenges drivers face when using GPS navigation systems, as Brown & Laurier (2012) investigated, underscore the need for technology to support "instructed action" by fostering a better understanding of how drivers interact with navigation systems. This insight is relevant for designing interfaces that facilitate seamless collaboration between human operators and automated systems. Similarly, the analysis of public videos of assisted and autonomous driving by Brown and Laurier (2017) emphasizes the importance of transparency in vehicle actions to enhance mutual understanding among drivers and improve overall road safety. This highlights the need for vehicle systems to communicate their intentions and actions effectively to human drivers and other road users.

Overall, these studies underscore the complexities inherent in human-vehicle interaction (HVI) and suggest avenues for designing interfaces and motion behaviors that facilitate clear communication of vehicle intentions while ensuring safety and efficiency on the roads. Future research should continue to explore innovative solutions to address these challenges and facilitate the integration of autonomous vehicles into existing traffic ecosystems.

1.2 Trust in human-machine interaction study

Trust plays a pivotal role in shaping human interaction with machines (Harper & Odom, 2014; Ivarsson & Lindwall, 2023), particularly in the context of human-robot interaction (HRI) and human-agent interaction (HAI). Plurkowski et al. (2011) highlight the significance of interactional repair mechanisms in human-robot interactions, drawing insights from card-game activities to inform the design of autonomous social robotic systems. Their study employs a conversation analytic (CA) approach to examine how humans identify and manage interactional trouble within activities, offering implications for future autonomous robot design. Rieger et al. (2023) look into the dynamics of trust formation in human-agent interactions, comparing trust attitudes towards automated systems and human experts. Their findings suggest that trust attitude and perceived reliability are higher for human experts than for AI, emphasizing the importance of considering agent expertise in HAI scenarios. This underscores the existence of an imperfect automation schema, indicating potential challenges when introducing novel AI support agents. González-Martínez & Mlynář (2019) introduce the concept of "practical trust," emphasizing the continuous practical work involved in trust formation within interpersonal interactions. They advocate for empirical research to identify the specific practices that constitute trust as an interactional phenomenon, highlighting its strong link to the organization of action and accountability. Watson (2014, 2009) revisits Garfinkel's notion of trust (Garfinkel, 1963; Turowetz & Rawls, 2020), emphasizing trust as a background condition for mutually intelligible action. Through an ethnomethodological lens, Watson (2014) underscores the importance of understanding trust within the context of constitutive practices and everyday sense-making activities. Eisenmann et al. (2023) examine Garfinkel's research on human-machine interaction, particularly with ELIZA and LYRIC programs from 1967 to 1969. They argue that successful human-machine interaction relies on exploiting human sense-making practices rather than solely on machine characteristics. This historical perspective has implications for contemporary AI design, suggesting a need to integrate human social practices into computational systems. Ivarsson and Lindwall (2023) examine the issue of trust and suspicion in conversational agents and human interaction. By departing from ethnomethodology and conversation analysis, they illustrate how parties in a conversation understand their interactional partners. When suspicion is roused, shared understanding is disrupted. They claim that the proliferation of conversational systems, fueled by artificial intelligence, may have unintended consequences, including impacts on human–human interactions.

In summary, past related works highlight the multifaceted nature of trust in human-machine interaction, emphasizing its role in shaping intersubjectivity and interobjectivity (Latour, 1996), informing design considerations, and enacting trust as a social reality (Lewis & Weigert, 1985). Ethnomethodological approaches offer valuable insights into the practical work involved in trust formation, while historical perspectives provide context for understanding the evolving nature of human-machine interactions.

1.3 The ‘Zero Takeovers’ Challenge in full self-driving mode

Figure 1. FSD Youtubers are doing “zero takeovers” testing on self-driving cars, usually by keeping their hands off the steering wheel

Some full self-driving (FSD) testing Youtubers would like to take the so-called ‘zero takeovers’ challenge (figure 1). They try to put no hands on the steering wheel and the touchpad (Jung et al., 2020) and keep the vehicle driving by itself as long and as much as possible, even if it is conditions like night, snow, or hill roads.

The following case is an example showing how the tester tries to keep the car turned by itself at an intersection in a moment-by-moment way. Although trying to keep his hands off the steering wheel, the driver holds his two hands just above the wheel and monitors the car’s motions all the way, trying to achieve the accomplishment of “don’t hit anything.” He narrates and describes every essential action of the car and the road conditions, appearing to decide to touch and control the wheel at any time.

Figure 2: "Don't hit anything". Driver doing "zero takeover challenge" in FSD mode. I use a comic fashion visualization for the transcription of moment-by-moment interactions. Video from Marques Brownlee YouTube channel, Dec 15, 2022

Keeping the hands at a close distance from the wheel or even holding the hands on the wheel is a way of dealing with the issue of trust in FSD. Here is another case that shows the driver always holding his hands on the steering wheel because "I didn't trust there" in his narrative of the video. The driver claims the car does not manage so well in some situations, even for the Enhanced Autopilot.

Figure 3. A driver chooses to "always have to hold your hand on the steering wheel" in FSD mode.

The issue emerges as how drivers deal with situations in which they do not trust self-driving cars and how they take over by adopting human assisting actions (Brown & Laurier, 2017) in situ and in vivo (Cahour et al., 2012). In this paper, we aim to examine how human drivers' taking over actions occur as situated and multimodal practices in full self-driving mode by investigating "why take over now" from the perspective of EMCA. We will check some of the typical situations in which the drive takes over.

2 Method and data

2.1 Public online FSD testing videos

Online collections of third-party videos offer a valuable source of information on human interactions and technology use in various settings, especially with the advent of new technologies. YouTube is currently the most extensive repository of third-party videos in the world. However, it is essential to exercise caution when searching for, organizing, and reusing videos on the platform. Raw data from online self-driving car testing videos adhere to the naturally occurring principle of conversation analytic video analysis (Deppermann et al., 2018). For this study, we collected 12 hours of video from YouTube. In our data corpus, there are altogether 50 clips that come from 24 YouTubers.

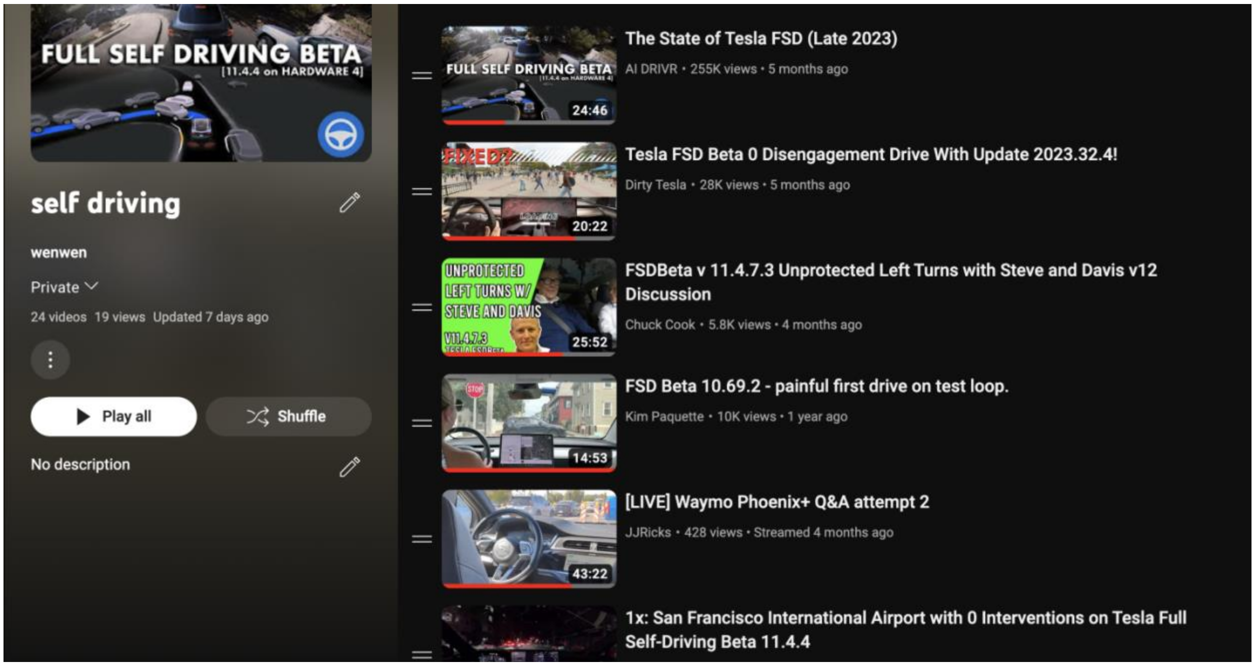


Figure 4. Screenshot of part of our selected self-driving testing channels

2.2 Multimodal conversation analysis

We employ multimodal conversation analysis (Hazel et al., 2014; Schegloff, 2007) as the research method. Our analysis aims to identify, describe, and explain the orderly and recurrent practices adopted by participants during the driving activities. We closely examine the multimodal resources that emerge within the technologized contextual configurations, including gestures, gaze, body postures, and the embodied manipulation of all devices.

The next-turn proof procedure by Sacks, Schegloff, and Jefferson (1974) is an essential guide for the conversation analytic approach. To gain insights into the question "Why that now" (Schegloff & Sacks, 1973: 299), analysts can examine how a turn is related to the previous turn and how it is responded to. In other words, people display their understanding of the preceding turn in their next turn, which can be used for analysis.

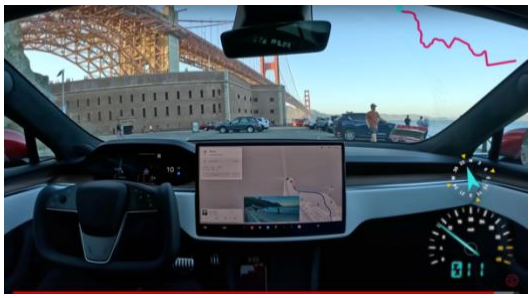
There are two main ways of transcribing the data. The first is the typical way of combining screenshots of critical actions and verbal interactions (Extracts 1, 3, and 4). The second is we use a comic style visualization (Brown et al., 2023) with the driver(s)’ narratives or dialogues superimposed on the screenshots for the transcription of the unfolding naturally-occurring interactions (Extract 2, and the “don’t hit anything” case above).

3 Analysis: Human Assisting As Situated And Multimodal Practices In Full-Self Driving

3.1 Turning the steering wheel: “feeling a little bit too close to that car there”

Extract 1
(from “Whole Mars Catalog” YouTube channel,
https://www.youtube.com/watch?v=sqDsdYq39cI)

D: I think (.) the more you're able to monetize the software
(1.0) the more you can (1.0) bring down the price of the cars.
it actually (.) makes sense to hook them with a low-priced
car#1.1(.) so that you can then (.) hook them onto#1.2(.)
so#1.3ftware services#1.4.


(1.1 driving using FSD, with hands off the wheel)


(1.2 starting taking over)


(1.3 turning the wheel)


(1.4 finishing the taking over)

feeling a little bit too close to that car there#1.5,(.) .h so
that's why I took over. (2.5) B/ut you can see it did pretty
well (.) navigated all the way here,


(1.5 continuing the FSD mode)

In this case, the Tesla car in FSD mode reaches almost the end of the trip under the Golden Gate Bridge in San Francisco when the driver talks about self-driving cars' business modes. In line 4, he starts taking over (image 1.2). He turns the wheel (image 1.3), making the car head leftwards. In his later narratives, he accounts for his action (lines 6-7), saying that he feels too close to the car ahead and takes over. He also produces a positive assessment of the FSD mode that "but you can see it did pretty well (.) navigated all the way here".

In this case, the driver treats the car's move/action as going too close to a car/almost hitting the car. He responds by switching the car's direction before the assumed "hitting." This case reflects a conflict between the machine's decision and the human driver's decision/judgment (Park et al., 2020).

3.2 Giving a little accelerator press: "Very slowly and cautiously. Maybe a little too cautiously"

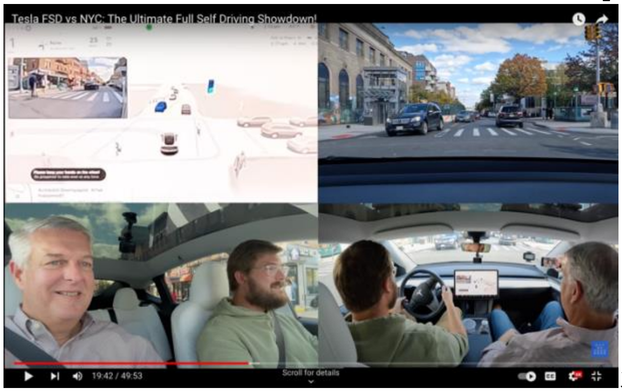
Extract 2
(from the "Whole Mars Catalog" YouTube channel)

The driver is in an FSD Tesla, and one of his friends sits beside him as a front passenger. The car is going through a construction zone at the moment. The car moves very slowly. The driver treats this action as being cautious and "maybe a little too cautiously." The car even finally stopped. Confusion about intent, particularly when driving at speed, could easily cascade into collisions or other problems on the road (such as holding up traffic) (Brown et al., 2023). It is at this conjuncture that the driver narrates and gives it a little accelerator press.

3.3 Changing lanes: "It just turned down the oncoming lane"

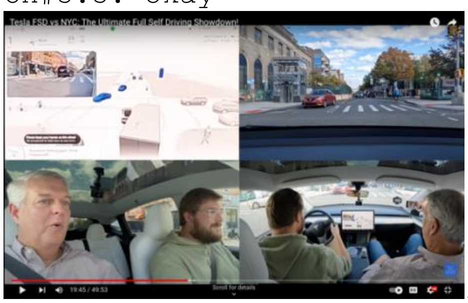
Extract 3
(From "Out of Spec Dave" YouTube channel,
https://www.youtube.com/watch?v=XDxjB6bFLRg)
(D means 'driver'; C means 'co-pilot' as front passenger)

01 D: Let's put it on the FSD#3.1 beta now, here in the middle of
02   the intersection, now it's back [up-



3.1

03 C: [Whoa#3.2
04 D: Oh#3.3: okay



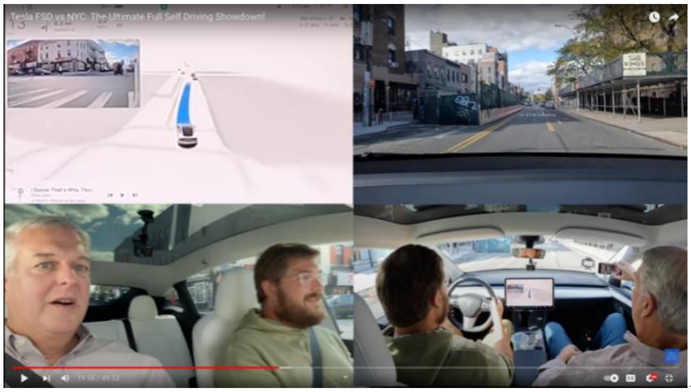
3.2

3.3

05 D: .hh I'm covering the [brake,
06 C: [There was a red Ver[sa,
07 D: [WHoa#3.4 I'm
08   covering the brake

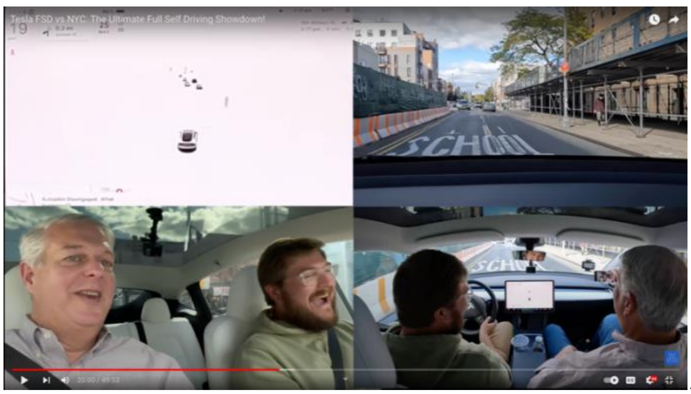
3.4

09 C: it knew it was a red Ver[sa-
10 D: [It's like-
11 C: your most hated car.
12 D: but now there's no room GO/
13 C: Go
14 D: hahahaha
15 C: There we go.
16 D: Whoa, we're on the#3.5-[oncoming-
17 C: [OH:: this is not good.



3.5

```
18 D: HAHAHAHA#3.6
```



3.6

```
19 C: #3.7TH/at was not good. THa:t was not good.
```

3.7

```
20 D: .hh it just turned down the oncoming lane.
```

In this case, the self-driving Tesla makes a mistake after turning left and goes to the oncoming lane. The drivers observe this and make the lane change (Laurier et al., 2012). Trust in self-driving cars as an observable phenomenon of order requires continuous local work even in the most commonplace situations, not to say on complicated roads. From the extract of in-car and out-car interaction, we examine the gestalt of projectable aspects of road trips, car motions, and driver talks that come to be combined with the task at hand.

3.4 Yielding for a pedestrian: "It doesn't stop so you have to do that"

Extract 4

4.1

4.2

4.3


(4.4, waits for the pedestrian to pass)

4.5

4.6

The last case deals with and relates to the driving rules, that is, to yield proactively for pedestrians. Since it is still hard for a self-driving car to judge whether a pedestrian is just standing by the roadside or going to pass the road, it is not easy for it to decide whether it should stop for the pedestrian (Brown et al., 2023). Therefore, a human driver needs to take over at such moments when necessary. This extract is a typical case illustrating this. The driver is driving a Tesla in FSD mode in Switzerland, and the car does not stop for a wheelchair pedestrian, and the driver has to take control of that. The two actions pair together and produce a joint activity–yielding and going on the social road (Brown & Laurier, 2017).

4 Implications

Based on the four cases we have discussed, we propose that implementing practical improvements in self-driving cars, particularly focusing on maintaining a safe following distance, adjusting speed dynamically, ensuring accurate adherence to road rules, and prioritizing pedestrian safety, holds significant implications for enhancing road safety and efficiency.

Safe Following Distance: Incorporating advanced sensors and algorithms to ensure self-driving cars maintain safe distances from other vehicles is crucial. Educational initiatives should emphasize the importance of safe following distances for AV operators.

Adaptive Speed Control: AV technology should dynamically adjust speed based on real-time traffic conditions and environmental factors. Training for AV operators should emphasize compliance with local speed regulations.

Enhanced Road Rule Adherence: Improving the accuracy of AVs' understanding and interpretation of road rules is essential. Developers should refine algorithms to recognize and respond to road signs and signals accurately.

Pedestrian Priority: Programming self-driving cars to prioritize pedestrian safety through advanced detection technologies and predictive algorithms is vital. Public awareness campaigns should promote mutual respect between AV operators and pedestrians.

Integrating these practical implications into the design and operation of self-driving cars can significantly improve road safety, traffic efficiency, and overall transportation experience.

5 Discussion and conclusion: the road towards “normal natural driving”

The journey towards achieving "normal natural driving" with self-driving cars traverses through intricate pathways of trust, the symbiotic collaboration between human operators, and sophisticated technological systems.

Road Towards “Normal Natural Driving”: As self-driving technology advances, the aspiration to emulate the natural and intuitive driving behaviors exhibited by human drivers becomes increasingly palpable. The concept of "normal natural driving" embodies the seamless integration of autonomous vehicles into the existing fabric of road traffic, where interactions mirror those of human-operated vehicles.

Hierarchy of Trust: Central to the successful integration of self-driving cars into the transportation ecosystem is the establishment of a hierarchy of trust between humans and autonomous systems. This hierarchical structure delineates the roles, responsibilities, and decision-making authority of human operators and automated systems.

Combining Brain with the System: The symbiotic fusion of human cognition with artificial intelligence represents a paradigm shift in the interaction between humans and autonomous systems. By harnessing the complementary strengths of human intuition, adaptability, and moral reasoning alongside the computational prowess and efficiency of AI algorithms, we can cultivate a synergistic relationship that transcends the capabilities of either entity in isolation.

In conclusion, in this paper, we have documented the challenges drivers with autopilots experience on real-world roads by focusing on the practices of humans taking over. Using videos of full self-driving cars selected from third-party YouTube videos, we have shown how drivers treat the self-driving car's moment-by-moment motion as projectable for potentially relevant risky outcomes and take over the full self-driving system by assisting action in situ and in vivo, with continuous situated monitoring. We have demonstrated four typical situations in which drivers take over in the unfolding course of driving action: going too close to the front car, inappropriate speed in the local context, wrong recognition of lanes, and pedestrian priority.

APPENDIX. TRANSCRIPT CONVENTIONS

This paper's transcription conventions mainly adopt Gail Jefferson's (2004) conventions for talk and Lorenza Mondada's (2018) conventions for embodied actions. Courier New font is used for the transcripts. The main convention symbols involved in this article are as follows:

, means intonation continuation;
. means downward intonation;
\ and / represent the falling and rising intonation, respectively;
(.) means inconspicuous short pauses of the driver's talk (usually less than 0.2 seconds);
(2.0) means the silence time of the driver's talk when more than 0.2 seconds;
*--->
---->* asterisk marks the moment and the phase (when the action continues longer than just a moment) of the action;
# indicates where the screenshot appears;
= indicates the connection of two turns;
(( )) indicates non-verbal behavior.

References

Brown, B., & Laurier, E. (2012). The normal natural troubles of driving with GPS. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. https://doi.org/10.1145/2207676.2208285

Brown, B., & Laurier, E. (2017). The trouble with autopilots. Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems. https://doi.org/10.1145/3025453.3025462

Brown, B., Broth, M., & Vinkhuyzen, E. (2023). The halting problem: Video analysis of self-driving cars in traffic. Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems. https://doi.org/10.1145/3544548.3581045

Brown, B., Laurier, E., & Vinkhuyzen, E. (2022). Designing motion: Lessons for self-driving and robotic motion from human traffic interaction. Proceedings of the ACM on Human-Computer Interaction, 7(GROUP), 1–21. https://doi.org/10.1145/3567555

Cahour, B., Nguyen, C., Forzy, J.-F., & Licoppe, C. (2012). Using an electric car. Proceedings of the 30th European Conference on Cognitive Ergonomics. https://doi.org/10.1145/2448136.2448142

Deppermann, A., Mondada, L., & Laurier, E. (2018). Overtaking as an interactional achievement: Video analyses of participants' practices in traffic. Gesprachsforschung: Online-Zeitschrift zur verbalen Interaktion, 19, 1-131.

Eisenmann, C., Mlynář, J., Turowetz, J., & Rawls, A. W. (2023). “machine down”: Making sense of human–computer interaction—Garfinkel’s research on Eliza and lyric from 1967 to 1969 and its contemporary relevance. AI & SOCIETY. https://doi.org/10.1007/s00146-023-01793-z

González-Martínez, E., & Mlynář, J. (2019). Practical trust. Social Science Information, 58(4), 608–630. https://doi.org/10.1177/0539018419890565

Garfinkel, H. (1963) 'A Conception of, and Experiments with, "Trust" as a Condition for Stable Concerted Actions', pp. 187–238 in O.J. Harvey (ed.) Motivation and Social Interaction. New York: Ronald Press.

Hazel, S., Mortensen, K., & Rasmussen, G. (2014). Introduction: A body of resources – CA studies of Social Conduct. Journal of Pragmatics, 65, 1–9. https://doi.org/10.1016/j.pragma.2013.10.007

Harper, R., & Odom, W. (2014). Trusting oneself: An anthropology of digital things and personal competence. Trust, Computing, and Society, 272–298. https://doi.org/10.1017/cbo9781139828567.017

Ivarsson, J., & Lindwall, O. (2023). Suspicious minds: The problem of trust and conversational agents. Computer Supported Cooperative Work (CSCW), 32(3), 545–571. https://doi.org/10.1007/s10606-023-09465-8

Jefferson, G. (2004). Glossary of transcript symbols with an introduction. Conversation Analysis, 13–31. https://doi.org/10.1075/pbns.125.02jef

Jung, J., Lee, S., Hong, J., Youn, E., & Lee, G. (2020). Voice+tactile: Augmenting in-vehicle voice user interface with tactile touchpad interaction. Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems. https://doi.org/10.1145/3313831.3376863

Kaneyasu, M., & Iwasaki, S. (2017). Indexing 'entrustment': An analysis of the Japanese formulaic construction [n da yo n]. Discourse Studies, 19(4), 402–421. https://doi.org/10.1177/1461445617706592

Latour, B. (1996). On interobjectivity. Mind, Culture, and Activity, 3(4), 228–245. https://doi.org/10.1207/s15327884mca0304_2

Laurier, E., Brown, B., & Hayden, L. (2012). What it means to change lanes: Actions, emotions and wayfinding in the family car. Semiotica, 2012(191). https://doi.org/10.1515/sem-2012-0058

Lewis, J. D., & Weigert, A. (1985). Trust as a social reality. Social Forces, 63(4), 967. https://doi.org/10.2307/2578601

Lindholm, C., & Stevanovic, M. (2022). Challenges of trust in atypical interaction. Pragmatics and Society, 13(1), 107–125. https://doi.org/10.1075/ps.18077.lin

Mondada, L. (2018). Multiple temporalities of language and body in interaction: Challenges for transcribing multimodality. Research on Language and Social Interaction, 51(1), 85–106. https://doi.org/10.1080/08351813.2018.1413878

Mahadevan, K., Somanath, S., & Sharlin, E. (2018). Communicating Awareness and intent in autonomous vehicle-pedestrian interaction. Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems. https://doi.org/10.1145/3173574.3174003

Park, S. Y., Moore, D. J., & Sirkin, D. (2020). What a driver wants: User preferences in semi-autonomous vehicle decision-making. Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems. https://doi.org/10.1145/3313831.3376644

Plurkowski, L., Chu, M., & Vinkhuyzen, E. (2011). The implications of interactional "repair" for human-robot interaction design. 2011 IEEE/WIC/ACM International Conferences on Web Intelligence and Intelligent Agent Technology. https://doi.org/10.1109/wi-iat.2011.213

Rieger, T., Kugler, L., Manzey, D., & Roesler, E. (2023). The (im)perfect automation schema: Who is trusted more, automated or human decision support? Human Factors: The Journal of the Human Factors and Ergonomics Society. https://doi.org/10.1177/00187208231197347

Sacks, H., Schegloff, E. A., & Jefferson, G. (1974). A simplest systematics for the organization of turn-taking for conversation. Language, 50(4), 696. https://doi.org/10.2307/412243

Schegloff, E. A. and Sacks, H. 1973. Opening Up Closings. Semiotica 8: 289–327.

Schegloff, E. A. (2007). Sequence Organization in interaction: A Primer in conversation analysis. Cambridge University Press.

Turowetz, J., & Rawls, A. W. (2020). The development of Garfinkel's 'Trust' argument from 1947 to 1967: Demonstrating how inequality disrupts sense and self-making. Journal of Classical Sociology, 21(1), 3–37. https://doi.org/10.1177/1468795x19894423

Watson, R. (2009). Constitutive practices and Garfinkel's notion of trust: Revisited. Journal of Classical Sociology, 9(4), 475–499. https://doi.org/10.1177/1468795x09344453

Watson, R. (2014). Trust in interpersonal interaction and cloud computing. Trust, Computing, and Society, 172–198. https://doi.org/10.1017/cbo9781139828567.012

Barra, Paola, Cantone, Andrea Antonio, Francese, Rita, Giammetti, Marco, Sais, Raffaele, Santosuosso, Otino Pio, Sepe, Aurelio, Spera, Simone, Tortora, Genoveffa, Vitiello, Giuliana (2024): A Task-oriented Multimodal Conversational Interface for a CSCW Immersive Virtual Environment. In: Proceedings of the 22nd European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies - Exploratory papers, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591), DOI: 10.48340/ecscw2024_ep05

A Task-oriented Multimodal Conversational Interface for a CSCW Immersive Virtual Environment

Paola Barra[1], Andrea Antonio Cantone[2], Rita Francese[2], Marco Giammetti[2], Raffaele Sais[2], Otino Pio Santosuosso[2], Aurelio Sepe[2], Simone Spera[2], Genoveffa Tortora[2], and Giuliana Vitiello[2]

[1]Department of Science and Technology, University of Naples Parthenope, Italy
[2]Department of Computer Science, University of Salerno, Italy

Abstract. In CSCW immersive Virtual Reality environments, users may be uncomfortable when interacting with a two-dimensional menu. Multimodal conversational interfaces may enhance the interaction enabling users to communicate with the system in different modalities. In this paper, we investigate the use of an embodied multimodal chatbot for improving interaction in a Virtual Reality (VR) environment simulating a working context. In particular, we adopt a User-Centered Design approach to build a multimodal conversational interface, named Muxi, in which a task-oriented voice avatar is enhanced with an interactive board for supporting meeting organization in VR. Users were involved in all the development phases, from task definition to iterative user testing. To assess the usability of the proposed interface, we conducted a controlled experiment involving 32 participants to compare the use of Muxi with a traditional menu-based interface in a CSCW environment. We performed quantitative analysis, concerning efficiency and effectiveness assessment, and qualitative analysis, related to participant cognitive load and perceived usability. Results revealed that our multimodal interface increases usability by greatly alleviating cognitive load and improving user performance, representing a good alternative to a menu-based interface.

1 Introduction

Since the advent of the Graphical User Interface (GUI), menus have been recognized as essential tools for computer users. They help users navigate through various items and select one of them. They are also adopted in 3D VR environments, where they require the user to select the menu item by using gestures or controllers to indicate the object and confirm the selection (Mundt and Mathew, 2020; Wang et al., 2021).

In VR, however, the user is immersed in a three-dimensional, spatial environment, and it may be uncomfortable to have to interact with a two-dimensional menu. Multimodal conversational interfaces may enable the user to communicate with the computer in different modalities, such as speech, text, gesture, image, video, and sound. Introducing them in VR environments may improve the system's usability. VR voice assistants are generally implemented by using an avatar (Zhao et al., 2022) to increase the presence perception and engagement of the users by providing a more realistic interaction.

The design of a multimodal conversational interface is not an easy task (Crovari et al., 2020; Francese et al., 2022). It requires the choice of the most appropriate interaction modalities for the user, the task, and the context. In addition, multiple modalities have to be integrated coherently and consistently, providing clear and intuitive feedback to the user (Sebillo et al., 2009). In multimodal conversational interfaces, interaction may also depend on the chatbot type, ranging from service chatbot useful for customer support (Mohamad Suhaili et al., 2021), to task-oriented chatbot helping users complete tasks in specific domains, to Personal Assistants, serving the user continuously, to general purpose chatbots (Følstad et al., 2019). Chatbots are also adopted to support collaborative work and learning in VR environments (Trappey et al., 2022; David et al., 2019; De Lucia et al., 2009).

In this paper, we equipped the multi-user VR CSCW Environment MetaCUX (Barra et al., 2023a,b) with a multi-modal conversational interface, named Muxi, for helping users in tasks related to the setting of a working environment, such as creating a meeting room.

The main contributions of the paper are the following:

- We describe the User-Centered Design (UCD) approach we followed to design a multi-modal task-oriented CSCW conversational interface.
- The proposed interface enhances the vocal interaction provided by an embodied avatar with a board GUI.
- We conduct a user study involving 32 participants aiming at assessing the impact of the use of a multimodal task-oriented chatbot versus a menu-based interface on user performance and perception when interacting in an immersive virtual environment.

The paper is structured as follows: Section 2 discusses related work. Section 3 describes the MetaCUX system and Section 4 describes the UCD methodology used for the development of the multimodal conversational interface Muxi. Section 5 describes the experimental user study while in Section 6 results are reported and discussed. Finally, Section 7 concludes the paper.

2 Related work

In this section, we discuss the research efforts that have been devoted to the use and assessment of menu-based and Chatbot interfaces in VR environments, and the support offered by task-oriented chatbots in VR CSCW environments.

2.1 Menu-based interface in VR environment

Das and Borst (2010) compared different types of design choices for Menu in VR: layout (pie vs. linear list), placement (fixed vs. contextual), and pointing method (ray vs. pointer-attached-to-menu) reporting the pros and cons of each of them. They involved 34 participants and compared time and errors. Mundt and Mathew also assessed the use of several types of pie-menu (Mundt and Mathew, 2020) with 24 participants, assessing usability, user experience, presence, error rate, and selection time.

The authors in (Lipari and Borst, 2015) integrated touch menus into a cohesive smartphone-based VR controller. Users transitioned between the menu interaction area and the other for spatial interactions such as VR object navigation areas. The study involved 20 participants and compared touch menu selection and ray-based selection by measuring time, errors, and user satisfaction. Results showed that both techniques have advantages and disadvantages.

Wang et al. (2021) assessed the use of handled menus in VR that follow the users to move, without obstructing their vision. They compared two types of menu interfaces (fixed menu and handheld menu) and three selection techniques. The choice of the solution depends on the contexts of use and end-users.

2.2 Chatbot in VR environment

The amount of experiments on chatbot usability has increased in the literature. Generally, it is assessed with experiments measuring usability based on effectiveness, efficiency, and satisfaction (Ren et al., 2022). The study proposed in (Nguyen et al., 2022) investigated disparities in user satisfaction between a chatbot and a menu-based interface system related to a mobile app. The research findings reveal that the use of the chatbot results in a decreased level of perceived autonomy and increased cognitive load compared to menu-based interface systems, ultimately leading to lower user satisfaction. This study suggests that advanced technology may not always be the optimal solution to organizational problems, which could lead to unintended negative consequences if user concerns are not adequately addressed.

Concerning the usability assessment of chatbots in VR, few works performed this kind of analysis. Indeed, Trappey et al. (2022) introduced a VR chatbot trained to answer frequently asked questions (FAQs) from a power transformer manufacturer. They assessed only the performance of the NLP models, which achieved an accuracy rate exceeding 91%. No user study has been conducted. In (Xie et al., 2023), chatbots are integrated into a university platform to assist both students and teachers with various tasks. Also in this study, no user study has been conducted.

Pick et al. (2017) compared speech-based and pie-menu-based interaction for the control of complex VR applications. They conducted a user study with 20 participants and assessed their performance in terms of time and errors and perceived usability. It resulted that on one side, speech is faster but on the other side pie menus are less error-prone.

2.3 Supporting CSCW with task-oriented chatbots

Task-oriented chatbots in VR are designed with specific purposes. They focus on assisting users in achieving well-defined tasks within the working VR environment. Examples include managing virtual meetings, coordinating complex projects, or providing real-time information.

Wang et al. (2023) provided guidance for online retailers to design chatbots with appropriate communication styles for effective service recovery in electronic commerce. Trappey et al. (2022) considered the context of industrial equipment manufacturing, involving customized design, assembly, installation, and maintenance services for electric power transformers. These services cater to the specific needs of customers. They proposed a VR-Enabled Chatbot for intelligent engineering consultation. The chatbot provides VR users with highly interactive and realistic graphical views during engineering counseling sessions.

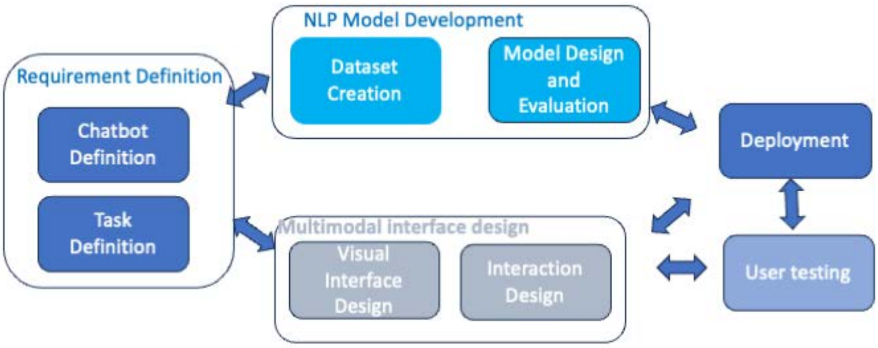


Figure 1: The adopted development process.

Unlike previous works that investigated the use of chatbot or menu-based interfaces, we propose a multimodal conversational interface enhancing a vocal chatbot represented by a virtual avatar with an interactive board. The novelty of this paper lies also in adapting UCD principles to chatbot development in a CSCW VR meeting environment, ensuring that these AI-driven interfaces truly enhance user experiences and seamlessly integrate into their daily interactions. We also assess the multimodal interface usability by comparing it with an already existing menu-based interface.

3 The MetaCUX system

The MetaCUX system is a multi-user CSCW VR immersive environment (Barra et al., 2023b,a). It allows users to choose a customized avatar, offered by Meta, for navigating different virtual rooms.

A user can play two roles: *the organizer*, enabled to create a new public or private room, select the scenario, and manage the creation and scheduling of various activities, such as meetings, interviews, etc. or *the participant*, enabled to enter rooms and perform activities organized by other users. Whenever the organizer changes the room scenario, all users in the room can view the change in real-time. The new scenario is automatically loaded for everyone.

4 Enhancing MetaCUX through a UCD approach

The goal of introducing a multimodal assistant into MetaCUX is to try to simplify the interaction. To this aim, we adopted a UCD methodological approach consisting of the steps summarized in Fig.1. We involved the users in the various development phases.

4.1 Requirement definition

Muxi is expected to assist the user in performing the meeting management inside the MetaCUX environment.

4.1.1 Chatbot definition

The chatbot is task-oriented (*chatbot type definition*) to be used in a CSCW VR environment. For this type of chatbot, we select a user-driven dialogue (*dialog type definition*): the chatbot has to identify the user intent, serve it, and provide feedback on the result. The relation is short-term (*relation-type definition*): the chatbot considers the user as a newcomer, it does not remember the past interactions (Følstad et al., 2019).

4.1.2 Task definition

To identify the tasks that require greater support we performed a preliminary study on the management of a meeting in MetaCUX, involving three HCI experts. We first let them freely use the original system and then asked them to use the features for creating rooms, changing the scenarios, scheduling and participating in a meeting, writing on the whiteboard, and so on. Then, immediately after leaving the experience, we conducted a focus group (Kontio et al., 2008) by following a discussion template previously prepared by the authors of this paper (Cassell et al., 2004). During the focus group meeting, which lasted 30 minutes, participants had to reveal the positive and negative aspects of their experience. From the discussion it emerged that the most critical interaction aspects were found for the following tasks:

- Creating a new room;
- Scheduling a new meeting;
- Changing the room scenario.

4.2 NLP model development

In this study, targeted data collection was conducted to develop two Deep Learning models: one for intent recognition and the other, Named Entity Recognition (NER), capable of understanding and interpreting users' intentions and recognizing named entities within a voice request. We associated each interaction task with an intent Muxi has to detect to accomplish the task.

4.2.1 Dataset creation

To create a dataset for training the NLP model implementing the chatbot Muxi, we first studied possible human-based dialogues for performing those tasks. Thus, we conducted a survey, which provides an example of the three intents the chatbot has to execute and requires two sentences for each of them. This small number of sentences has been chosen to avoid overloading the user. A group of 31 volunteer users (Computer Science students) were involved. They were asked to simulate the inquiry of a voice assistant for performing the considered tasks and fill out the form with their requests. We collected 186 sentences.

4.2.2 Data Augmentation

We removed the duplicated sentences. Then, the original dataset, consisting of 157 sentences collected with their corresponding intent labels was input to ChatGPT which was required to generate similar sentences. It was also tasked with altering the structure of existing sentences. This approach resulted in the generation of a new dataset consisting of *900 sentences*, divided into 300 sentences for each of the three intents.

To create a training dataset for intent detection the data collected were pre-processed as follows.

1. *Data Cleaning*, consisting in removing duplicate and inconsistent sentences.
2. *Tokenization*, the method of splitting a large text into tokens, which are shorter texts.
3. *Stopwording*, consisting in the removal of commonly used terms, such as "a", "an", and "the".
4. *Lemminization*, consisting in reducing the words to their root, e.g., "running" is reduced to "run".
5. *Vectorization and Transformation*, the text data were converted into a numeric format so that it can be used as input for NLP tasks for BERT.

4.2.3 NER dataset creation

The tagging of the datasets of NER models was done manually. In particular, we defined the tags for intent as follows:

- *Create rooms*:
  - Scenario type: B_TYPE_SCEN;
  - Number of participants: B_NUM_PART;
  - Room name: B_NAME
- *Create meeting*:
  - Name meeting: B_NAME-MEETING;
  - Meeting description: B_DESCR;
  - Day: B_DAY;
  - Month: B_MONTH;
  - Start time: B_HOUR-START;
  - Finish time: B_HOUR-END;

- *Change scenario*:
  - Scenario name: B_NAME_SCEN;

The dataset was divided into sentences and words, along with their respective named entity labels. Additionally, missing labels were filled using the forward-fill method to ensure dataset consistency. The labels were converted to uppercase for uniform formatting.

4.3 Model development

For *intent recognition*, we adopted the pre-trained BERT model[1]. In particular, we adapted the BERT model for the specific task of intent recognition by including a dropout layer to prevent overfitting, and an output layer for the three intent classifications. Also, the *NER model* is based on BERT, utilizing the implementation provided by the "simpletransformers" library[2].

Both models were validated with K-fold cross-validation, for K=5. Their performance was assessed by using on the test set standard multiclass evaluation metrics, such as Macro Average Precision (MAPrecision), Macro Average Recall (MARecall), and Macro Average F1 (MAF1) (Berger and Guda, 2020), reported in Table I for both the models and computed as follows, where p_i and r_i are precision and recall computed on the multiclass Confusion Matrix on the i-th class, for $i = 1 \ldots 3$. These measures are computed by assessing the Task Completion Success.

$$MAPrecision = \frac{\sum_{i=1}^{3} p_i}{3}, MARecall = \frac{\sum_{i=1}^{3} r_i}{3})$$

$$MAF1 = 2 * \left(\frac{MAPrecision * MARecall}{MAPrecision + MARecall} \right)$$

Table I: Model performance

Model	**MAPrecision**	**MARecall**	**MAF1**
Intent rec.	92.72	91.52	92.12
NER	89.24	88.07	88.65

When the accuracy of all three intents is lower than 75% we consider that the chatbot does not understand the question or it is inappropriate.

4.4 Multimodal interface design

The design phase is concerned with both the visual appearance of the interface and the interaction modality the interface offers.

[1] https://huggingface.co/docs/transformers/index
[2] https://simpletransformers.ai/

Table II: The adopted usability guidelines (Crovari et al., 2020)

ID	Guideline
P1	Show, don't tell.
P2	Separate feedback from support
P3	Show information only when necessary
P4	Design a light interface — emphasize content
P5	Show one modality at a time
P6	Do not overload multiple modalities beyond user preferences and capabilities
P7	Use multi-modality to resolve ambiguities

4.4.1 Visual Interface design

To make the user experience more engaging and realistic in a task-oriented interaction, we decided to represent the chatbot with an avatar. In some cases, visual interaction may be preferred to the vocal one, e.g., when a list of the available actions is provided. Thus, we decided to offer a multimodal interface consisting of the chatbot avatar equipped with an interactive board. The appearance of the avatar and the board should be appropriate for the type of environment in which they are introduced, a working setting in our case. The final result is shown in Fig. 2, where the user is on the left (with the label of his name) and the avatar is on the right, near the board. We animated the avatar with movements that resemble a person gesturing while speaking.

4.4.2 Interaction design

There is a need to design how the different communication approaches have to combine the two elements (chatbot and board) to avoid overloading or confusing the user, also considering the wide space of the virtual environment. We followed the design guidelines (Crovari et al., 2020) summarized in Table II while Table III describes how the guidelines have been applied to the Muxi design.

As shown in Fig. 2, the user avatar starts the interaction with the chatbot by pressing the "Ask me" button on the board. In particular, the P1 guideline is related to providing the user feedback on what the chatbot has understood of the user request. The user may pronounce a sentence, such as *"Create a meeting room for twenty people called job interviews."* Visual feedback is provided on the higher part of the board, where the text of the user command is displayed. This is useful to permit the user to give again the command in case of misunderstanding. In the case the conversation is out of the three individuated topics the chatbot vocally specifies that it does not understand the question and shows on the board a description of the task it may perform (P2).

Figure 2: The multimodal conversational interface.

Table III: Application of the usability guidelines to the Muxi interface design

ID	Guideline application
P1	Use the visual interface to display the user sentence after the pronunciation.
P2	Feedback on the performed operation is vocally provided, while support (e.g., what the user can or should do in the next interactions) is visually shown.
P3	The GUI changes according to the conversation.
P4	The vocal interface provides only essential information.
P5	One modality at a time is adopted to provide information.
P6	Feedback is vocally provided, list of actions is provided in the support visual interface.
P7	Both the conversational and the visual interfaces produce a message when a task is successfully executed.

4.5 Deployment

The multimodal conversational interface is deployed on a client-server system and communicates with the client via an API call. The interaction between the user and the bot has been implemented as follows.

- **Speech-To-Text:** for Speech-To-Text (STT) we adopted the *wit.ai*[3] NLP platform, which provides various tools and services to build conversational interfaces.
- **Bot intent elaboration**: the translated text is sent to the trained NLP models that recognize the intent of the sentence and the related attributes.
- **Text-To-Speech Result:** the opensource TTS engine eSpeak[4] has been selected.
- **Avatar implementation**: The Muxi avatar performs the required action and provides feedback to the user. It was created using the ready player sdk[5] and has lip and body movements synchronized with the bot's voice during conversation. It is included in MetaCUX.

4.6 Pilot user testing

We performed two iterations. In the first, we involved three users (the same participating in the task definition phase) to experiment with the first Wizard-of-Oz prototype, in which the avatar speech was pronounced by one of the authors, and another author managed the room changes and the display. One of the participants suggested better highlighting the "Ask me" button. In the first iteration, the avatar was a futuristic man with a head-mounted display. An avatar more appropriate to a working setting was preferred, such as the man dressed formally shown in Fig. 2.

We performed a second iteration with the same users and a running prototype. Participants suggested displaying the user sentence (see the top of the board in Fig. 2) and adding the Chatbot feedback when the intent is not understood. We enhanced the final prototype with these last suggestions and then performed a user study with real users, as described in the following.

5 Evaluation Planning and design

The experimental design and other measures were approved by Computer Science Ethics Board of the University of Salerno. Participants joined the study voluntarily, and they could leave at any time without having to justify their decision.

[3] https://wit.ai/
[4] https://espeak.sourceforge.net
[5] https://readyplayer.me/

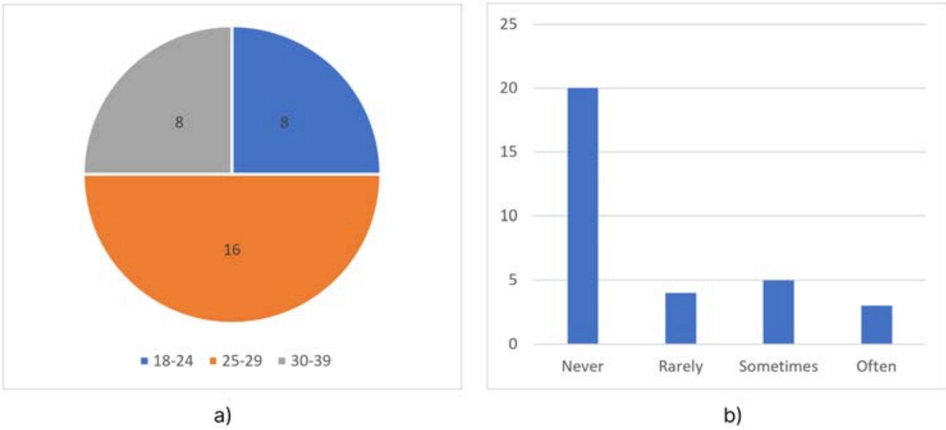


Figure 3: (a) Age and (b) experience with VR device of participants

5.1 Goal

The goal of the study is the following (Basili and Rombach, 1988):

Experiment with the interaction in a CSCW VR environment **in order** to evaluate the impact of the use of a task-oriented multimodal conversational interface when compared with a menu-based interface **with respect to** usability **from the point of view** of end-users **in the context of** a meeting management setting.

Starting from this goal we formulated the following Research Question (RQ):

RQ

When immersing in a virtual environment, is there a difference in usability whether using a multimodal conversational interface or a menu-based interface?

5.2 Participants

We involved 32 participants from the University of Salerno. There were 22 males and 10 females. Their age was distributed according to Fig.3(a) while their previous experience with the use of VR with head-mounted devices is summarized in Fig.3(b).

5.3 Tasks

We identified the following two tasks:

- *T1*: create a new room and change the scenario room;
- *T2*: schedule a meeting.

In particular, for task T1, we asked participants to perform these activities: "Create an interview room for 20 people called Job Interview" and "Change the environment in a meeting room"; for task T2: "Schedule a meeting with the development team on December 17th from seven to eight o'clock".

5.4 Study design

Participants performed two tasks, namely T1 and T2 described in the previous section. They were randomly grouped into two groups named Group1 and Group2, except for participants experts in VR use, who were equally distributed. All performed two tasks T1 and T2, and were exposed to two treatments: Menu, when the user interacts with a menu-based interface, and Chatbot, when the interaction occurs with Muxi. To avoid bias due to task ordering we adopted a crossover design (Vegas et al., 2016), where the Menu treatment is provided in T1 for Group1 and in T2 for Group2. Vice versa for the Chatbot treatment. Figure 4 shows the study design.

5.5 Variables and Measurements

As *independent variable*, we considered the two treatments Menu and Chatbot.

To assess the two considered interaction modalities we measured the following *dependent variables* representing usability, grouped in performance measures and user perceptions.

Performance measures, measuring performance in terms of:

- *Efficiency*: Time. It measures the time to perform a task.
- *Effectiveness*: Errors. It measures the number of errors committed during the execution, e.g., the number of times the chatbot failed in the Chatbot treatment and the number of user errors in the Menu treatment.

Users' perceptions, measuring user satisfaction in terms of:

- *Cognitive load*, measured through the NASA Task Load Index (NASATLX) questionnaire (Hart, 2006). It consists of six subscales representing the following factors: Mental, Physical, and Temporal Demands, Frustration, Effort, and Performance. To make it simple, the NASA (raw) TLX version was applied (Hart, 2006), where each sub-scale can get a score that goes from 0 (low) to 100 (high), except Performance that goes from 0 (Good) to 100 (Poor). The final score is the mean of the individual scores; a smaller score means lower cognitive load experienced by people performing a task.
- *Perceived usability*, measured through the System Usability Scale (SUS) questionnaire (Bangor et al., 2008), a usability tool based on a ten-item survey, a widely used method. The SUS was evaluated following the standard approach: all items were rated on a 1–5 Likert scale, all items with positive wording were transformed as (xpos-1) (adjusting them to 0–4) while all items with negative wording were transformed as (5-xneg) (reversing the scale and adjusting to 0–4). The SUS score was then computed by summing all items and multiplying them by 2.5, resulting in a final score on a scale of 0–100.

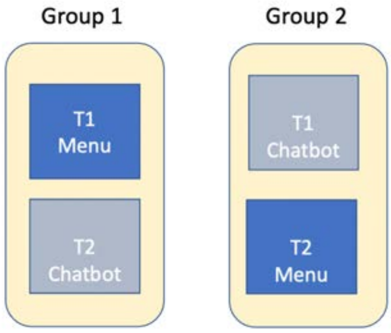


Figure 4: Study Design

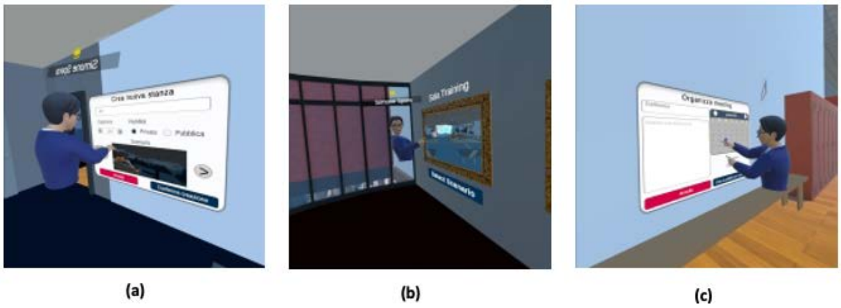


Figure 5: The MetaCUX interface for the Menu treatment

5.6 Experimental objects

The Chatbot and Menu treatments are conducted in a virtual environment ad-hoc developed and hosted on the MetaCUX platform, exposing the two interfaces depicted in Fig. 2 and 5, respectively. To interact with the former interface users have to speak with the avatar while they have to adopt controllers for performing the tasks when using the latter.

5.7 Procedure

During the experiment, we followed this procedure:

- *Recruitment.* Participants were recruited at the University of ***. After collecting their consensus form, they filled in a pre-test questionnaire, collecting their demographic information and their experience concerning of use of VR technology.
- *Assignment.* Considering the results of the pre-test we randomly distributed the participants with and without previous experience in VR use in the two groups (Wohlin et al., 2012).
- *Training.* Participants received training on how to use the Meta Quest 2 device and its controllers to engage with the virtual environment. The duration of this training session was twenty minutes.

- *Operation.* The participants individually performed the two tasks according to the study design in Fig.4. At the end of each task, they filled in the questionnaires described in Section 5.5. A Post-task single open question is also proposed: *What are the positive and negative aspects of this mode of interaction?*

5.8 Analysis procedure

We aim to assess the effect of one factor - the interaction modality - on the dependent variables Effectiveness and Efficiency. For quantitative variables, a t-test for normally distributed data or, otherwise, a Wilcoxon Signed Rank Test may be adopted as our factor has only two levels. We also measure the effect size by using Cohen's distance in the case of normally distributed data and Cliff's (Cliff, 2014) effect size, otherwise. We fixed the significance level (α) at 0.05.

Concerning the user perception analysis related to cognitive load and perceived usability, since all questions are measured on a Likert ordinal scale we analyze the questionnaire results by analyzing the median and adopting nonparametric tests.

6 Results

6.1 Performance analysis

Descriptive statistics of the dependent variables by Treatment are reported in Table IV. It is possible to see that the Chatbot-based interaction modality reached better time performance (Median=40.5 sec.) when compared to the menu-based interaction (Median=61 sec.). This is confirmed by the statistical analysis: Time was not normally distributed, thus, we applied the Wilcoxon Signed Rank Test and it resulted in a statistically significant difference with a large negative effect size (see Tab. V). Similarly, results are also reached by Errors. The boxplot in Fig.6 shows the boxplots of the time by analyzing the two tasks, which confirms this trend for both tasks. A similar trend occurs also for Errors, see Fig.7.

Table IV: Some descriptive statistics for the dependant variables

Variable	**Treatment**	**Mean**	**SD**	**Min**	**Median**	**Max**
Time (sec.)	Chatbot	43.63	16.25	27	40.5	99
	Menu	59.69	15.52	31	61	98
Errors	Chatbot	0.59	1.01	0	0	4
	Menu	2	1.19	0	2	4

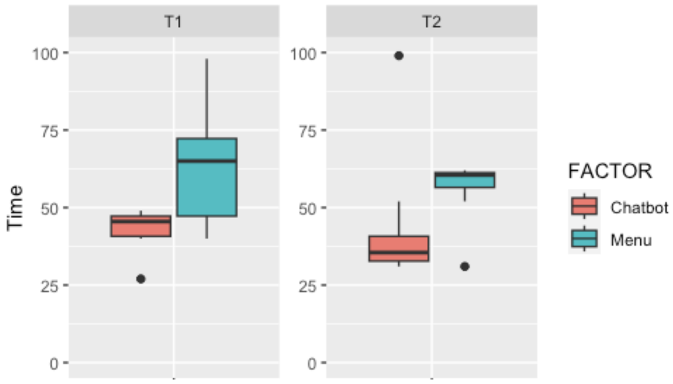


Figure 6: Boxplot of the Times to accomplish the two tasks

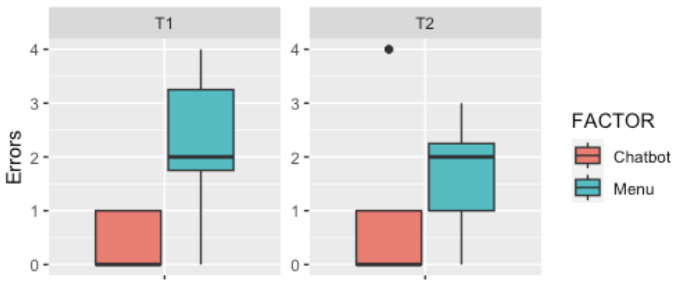


Figure 7: Boxplot of the Errors to performed during the two tasks

Table V: Results of statistical analysis of quantitative variables

Variable	p-value	Cliff's delta
Time	8.303e-06	-0.6484375 (large)
Error	2.69e-06	-0.6484375 (large)

Table VI: Median for NASA-TLX questionnaire (Lower values have less load and best performance)

Variable	Chatbot	Menu
Mental Demand	35	70
Physical Demand	20	65
Temporal Demand	25	50
Frustration	15	35
Performance	15	70
Effort	30	60
NASA TLX total score	33.33	58.33

Table VII: SUS Score

Variable	Chatbot	Menu
SUS score	82.5	48.75

6.2 User perception analysis

6.2.1 Cognitive load

As shown in Table VI, all the median of the NASA-TLX scales related to the Chatbot treatment always outperforms the Menu treatment ones. This is confirmed by the statistical analysis (Table VIII): users perceived less cognitive load in all the scales when using chatbots with a large negative effect size.

6.2.2 Perceived usability

We assessed the SUS score for each participant and treatment. Fig. 8 shows the results of the single questions. Globally, the Chatbot interface is always better perceived (note that questions with pair numbers have been reversed). The SUS score is 54.06 and 82.19 for the Menu and Chatbot treatments, respectively, as shown in Table VII.

Table VIII: Results of statistical analysis of user perception variables (Chatbot vs Menu)

Variable	p-value	Cliff's delta
Mental Demand	3.168e-08	-0.79 (large)
Physical Demand	1.635e-07	-0.75 (large)
Temporal Demand	3.646e-11	-0.9492188 (large)
Frustration	1.49e-05	-0.6152344 (large)
Performance	6.007e-07	-0.71875 (large)
Effort	2.535e-07	-0.7363281 (large)
Total	6.695e-10	-0.8955078 (large)
SUS score	1.573e-07	0.7617188 (large)

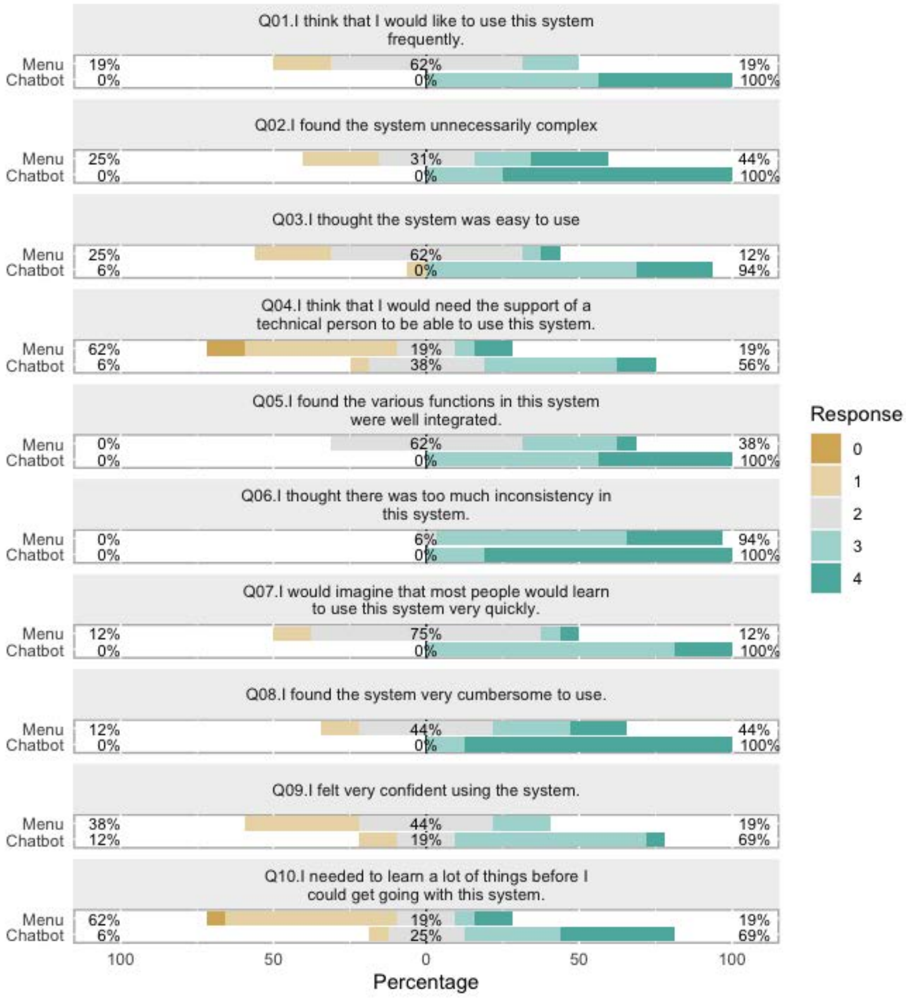


Figure 8: SUS Likert scores summarized for both the treatments (negative answers are reversed)

6.3 Discussion

Performance measures revealed that to support task-oriented activities in a CSCW VR environment a multimodal conversational interface may represent a good alternative to the menu-based interface based on controllers. Indeed, the new interface performed better in both tasks, as shown in Figures 6 and 7.

According to Bangor et al. (2008), a SUS score higher than 77.8 is in the fourth quartile. This indicates that Muxi, which scored 82.5, has no relevant usability problem when compared with the menu approach of the previous version of the system, which scored 48.75.

NASA TLX scores highlight that the cognitive load was significantly lower for all the subscales. In particular, Physical and Mental demand, and Performance seem more affected by the different interaction types.

The performance of NLP models has been further assessed in the experiment obtaining good results: Muxi user performance and perceptions were far better than the menu ones with a large effect size. This may suggest that the proposed UCD development approach has successfully met the users' needs.

Concerning the open questions related to the chatbot experience, an expert participant wrote: *"Using an avatar allowed me to do what was asked of me quickly and in a short time. In this way, however, I had less interaction with the virtual environment in general."*. A non-expert user commented *"It was easier to use your voice rather than the headset controllers to experiment. I did the task much faster."*

Comment of an inexpert user related to the menu interface: *"The negative aspect is that this mode of interaction, for those who are less accustomed to the use of viewers or technology in general, can cause frustration."*

These comments may indicate that interfaces based on chatbots may be particularly useful for non-expert users to start to familiarize themselves with the environment. Only two experts participated in the experiment, which had the same trend for all the factors except for Performance and Physical effort: they both scored better on the menu Performance than Chatbot and signaled a reduced Physical effort in the Menu case.

6.4 Threats to validity

To address the threats that may affect the validity of our findings we follow the recommendations by Wohlin et al. (2012).

External validity. We conducted our experiment with a few participants having different abilities in the use of the technology, which may pose a threat to the interaction of selection and treatment (i.e., the findings may not apply to all the people with the same skills). We tried to limit this threat by uniformly distributing the most skilled participants between the two groups. Furthermore, the adopted multimodal conversational interface was designed to be appealing and easy to use, but we acknowledge that our findings may not apply to a different setting *interaction of setting and treatment*. The selected tasks were also associated specifically with the MetaCUX environment. We formulated the two tasks in such a way as to have about the same duration, to avoid different cognitive loads in the Menu treatment.

Internal validity. The voluntary participation may introduce a *selection threat* because volunteers are usually more motivated than the whole population.

Construct validity. We mitigated the social threats. In particular, participants have not evaluated (*evaluation apprehension*), and we did not communicate the experiment's aim to avoid influencing their opinion (*Experimenter expectancy*).

Conclusion validity. The threat of violated assumptions of statistical tests may exist. To mitigate this threat we adopted non-parametric tests and distances for data that was not normally distributed and qualitative data.

7 Conclusion

In this paper, we described the User Centered Design process we adopted to create the task-oriented multimodal conversational interface in a CSCW VR environment named MetaCUX. A vocal chatbot embodied by an avatar is enhanced by an interactive board for supporting meeting management by easing interaction concerning the original menu-based interface and showing additional content. The empirical investigation involving 32 users aimed to compare the usability of a menu-based interface with the proposed multimodal interface. Both the performance and user perception analyses revealed that performance and user perceptions of the multimodal modalities obtained better results in all the considered aspects. Thus, the proposed multimodal interface may constitute a valid solution for designing task-oriented chatbots in CSCW VR environments.

References

Bangor, A., P. T. Kortum, and J. T. Miller (2008): 'An empirical evaluation of the system usability scale'. *Intl. Journal of Human–Computer Interaction*, vol. 24, no. 6, pp. 574–594.

Barra, P., A. A. Cantone, R. Francese, M. Giammetti, R. Sais, O. P. Santosuosso, A. Sepe, S. Spera, G. Tortora, and G. Vitiello (2023a): 'MetaCUX-a multi-user, multi-scenario environment for a cooperative workspace'. In: *Proceedings of the 15th Biannual Conference of the Italian SIGCHI Chapter*. pp. 1–3.

Barra, P., A. A. Cantone, R. Francese, M. Giammetti, R. Sais, O. P. Santosuosso, A. Sepe, S. Spera, G. Tortora, and G. Vitiello (2023b): 'MetaCUX: Social Interaction and Collaboration in the Metaverse'. In: *IFIP Conference on Human-Computer Interaction*. pp. 528–532.

Basili, V. R. and H. D. Rombach (1988): 'The TAME Project: Towards Improvement-Oriented Software Environments'. *IEEE Transactions on Software Engineering*, vol. 14, no. 6, pp. 758–773.

Berger, A. and S. Guda (2020): 'Threshold optimization for F measure of macro-averaged precision and recall'. *Pattern Recognition*, vol. 102, pp. 107250.

Cassell, C., G. Symon, and N. King (2004): *Using Templates in the Thematic Analysis of Text*, pp. 257 – 270. SAGE Publications London.

Cliff, N. (2014): *Ordinal methods for behavioral data analysis*. Psychology Press.

Crovari, P., S. Pidó, F. Garzotto, and S. Ceri (2020): 'Show, don't tell. reflections on the design of multi-modal conversational interfaces'. In: *International Workshop on Chatbot Research and Design*. pp. 64–77.

Das, K. and C. W. Borst (2010): 'An evaluation of menu properties and pointing techniques in a projection-based VR environment'. In: *2010 IEEE Symposium on 3D User Interfaces (3DUI)*. pp. 47–50.

David, B., R. Chalon, B. Zhang, and C. Yin (2019): 'Design of a collaborative learning environment integrating emotions and virtual assistants (chatbots)'. In: *2019 IEEE 23Rd international conference on computer supported cooperative work in design (CSCWD)*. pp. 51–56.

De Lucia, A., R. Francese, I. Passero, and G. Tortora (2009): 'Development and evaluation of a system enhancing Second Life to support synchronous role-based collaborative learning'. *Softw. Pract. Exp.*, vol. 39, no. 12, pp. 1025–1054.

Følstad, A., M. Skjuve, and P. B. Brandtzaeg (2019): 'Different chatbots for different purposes: towards a typology of chatbots to understand interaction design'. In: *Internet Science: INSCI 2018 International Workshops, St. Petersburg, Russia, October 24–26, 2018, Revised Selected Papers 5*. pp. 145–156.

Francese, R., A. Guercio, V. Rossano, and D. Bhati (2022): 'A Multimodal Conversational Interface to Support the creation of customized Social Stories for People with ASD'. In: P. Bottoni and E. Panizzi (eds.): *AVI 2022: International Conference on Advanced Visual Interfaces, Frascati, Rome, Italy, June 6 - 10, 2022*. pp. 19:1–19:5, ACM.

Hart, S. G. (2006): 'NASA-task load index (NASA-TLX); 20 years later'. In: *Proceedings of the human factors and ergonomics society annual meeting*, Vol. 50. pp. 904–908.

Kontio, J., J. Bragge, and L. Lehtola (2008): *Guide to Advanced Empirical Software Engineering*, Chapt. The Focus Group Method as an Empirical Tool in Software Engineering, pp. 93–116. Springer.

Lipari, N. G. and C. W. Borst (2015): 'Handymenu: Integrating menu selection into a multifunction smartphone-based VR controller'. In: *2015 IEEE Symposium on 3D User Interfaces (3DUI)*. pp. 129–132.

Mohamad Suhaili, S., N. Salim, and M. N. Jambli (2021): 'Service chatbots: A systematic review'. *Expert Systems with Applications*, vol. 184, pp. 115461.

Mundt, M. and T. Mathew (2020): 'An evaluation of pie menus for system control in virtual reality'. In: *Proceedings of the 11th Nordic Conference on Human-Computer Interaction: Shaping Experiences, Shaping Society*. pp. 1–8.

Nguyen, Q. N., A. Sidorova, and R. Torres (2022): 'User interactions with chatbot interfaces vs. Menu-based interfaces: An empirical study'. *Computers in Human Behavior*, vol. 128, pp. 107093.

Pick, S., A. S. Puika, and T. W. Kuhlen (2017): 'Comparison of a speech-based and a pie-menu-based interaction metaphor for application control'. In: *2017 IEEE Virtual Reality (VR)*. pp. 381–382.

Ren, R., M. Zapata, J. W. Castro, O. Dieste, and S. T. Acuña (2022): 'Experimentation for Chatbot Usability Evaluation: A Secondary Study'. *IEEE Access*, vol. 10, pp. 12430–12464.

Sebillo, M., G. Vitiello, and M. De Marsico (2009): *Multimodal Interfaces*, pp. 1838–1843. Boston, MA: Springer US.

Trappey, A. J., C. V. Trappey, M.-H. Chao, and C.-T. Wu (2022): 'VR-enabled engineering consultation chatbot for integrated and intelligent manufacturing services'. *Journal of Industrial Information Integration*, vol. 26, pp. 100331.

Vegas, S., C. Apa, and N. Juristo (2016): 'Crossover Designs in Software Engineering Experiments: Benefits and Perils'. *IEEE Transactions on Software Engineering*, vol. 42, no. 2, pp. 120–135.

Wang, S., Q. Yan, and L. Wang (2023): *Task-oriented vs. social-oriented: Chatbot communication styles in electronic commerce service recovery*, pp. 1–33. Springer.

Wang, Y., Y. Hu, and Y. Chen (2021): 'An experimental investigation of menu selection for immersive virtual environments: fixed versus handheld menus'. *Virtual Reality*, vol. 25, pp. 409–419.

Wohlin, C., P. Runeson, M. Höst, M. C. Ohlsson, B. Regnell, and A. Wesslén (2012): *Experimentation in software engineering*. Springer Science & Business Media.

Xie, Q., W. Lu, Q. Zhang, L. Zhang, T. Zhu, and J. Wang (2023): 'Chatbot Integration for Metaverse - A University Platform Prototype'. In: *2023 IEEE International Conference on Omni-layer Intelligent Systems (COINS)*. pp. 1–6.

Zhao, Y., J. Jiang, Y. Chen, R. Liu, Y. Yang, X. Xue, and S. Chen (2022): 'Metaverse: Perspectives from graphics, interactions and visualization'. *Visual Informatics*, vol. 6, no. 1, pp. 56–67.

Oskarsen, Johanne Svanes & Bratteteig, Tone (2024): "We kind of have to do our job alongside the digitalization" – on working with continuously changing tools. In: Proceedings of the 22nd European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies - Exploratory papers, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591), DOI: 10.48340/ecscw2024_ep06

"We kind of have to do our job alongside the digitalization" – on working with continuously changing tools

Johanne Svanes Oskarsen and Tone Bratteteig
Department of Informatics, University of Oslo
Contact Author: johansos@ifi.uio.no

Abstract. Most public organizations are engaged in digtialization to achieve efficiency and innovation. Today, most software is developed, implemented and continuously improved following an agile software development methodology. In this exploratory paper we highlight an understudied aspect of digitalization, emphasizing the need for a deeper understanding of how it affects the day-to-day work in the organization. By examining the experiences of advisors in a public welfare agency, the paper sheds light on the challenges and complexities arising from digitalization on work in practice. The findings reveal a discrepancy between the idealized view of digitalization and the practical realities faced by workers, leading to fragmented work conditions and continuously changing tools. This paper seeks to contribute to a nuanced understanding of the impact of digitalization on work practices.

Introduction

Digitalization is often expedient to increase the efficiency in public administration with regard to case handling, while simultaneously ensuring more correct handling of cases in light of the current regulations. In the context of public administration, digitalization is about "renewing, simplifying and improving" the existing services and facilitating for increased value creation and innovation (Ministry of Digitalisation and Public Governance, 2014). Digital transformation in the public sector is seen as "an important endeavour that is instrumental in public administration effectiveness as well as the promotion of democratic values and mechanisms" (Jonathan, 2020, p. 224). Often, the overarching goal of digitalization is to become a digitally transformed organization that is better equipped to withstand the stresses of a constantly changing society (Byremo and Fjellanger, 2024). Digitalization can be understood as a continuous organizational development process, i.e., a constant and never-ending process (Ribes, 2022).

Most IT development in public sector organizations uses agile methods (Jørgensen, 2024). While agile development is "relative to each organization" (Tendedez et al., 2018, p. 2), what distinguishes agile development from traditional, plan-based development models is the aim to "address the challenge of an unpredictable world by relying on people and their creativity rather than on processes" (Dybå and Dingsøyr, 2008, p. 835). As such, agile development generally refer to approaches that emphasize flexibility, collaboration, and iterative improvements (Agile Manifesto, 2001). Projects are broken down into smaller, more manageable tasks to handle changing requirements and feedback from users (Dybå and Dingsøyr, 2008; Dingsøyr et al., 2012).

In an empirical study of 14 "heavily digitalized" public organizations in Norway, Bygstad and Iden (2024) found that the most "mature" digitalized organizations "focus less on strategy and more on continuous development (...) based on the premise that the organization has a digital infrastructure in production, which is extended with new products and services, responding continuously to customer demands and new digital options" (Bygstad and Iden, 2024, p. 6). One of their informants stated that "our focus is on continuous innovation of services, I am particularly focused on exploiting windows of opportunity when they open", while another informant argued, "our job is to digitalise despite the existing technical and organizational structures. Continuous and agile development requires that we cannot wait for the old structures to change; rather we must build new structures on top of the old ones." (Bygstad and Iden, 2024, p. 7).

Both in academia and in business, agile approaches to development processes are preferred. It is pointed out that increased flexibility and more autonomous teams will achieve the goals for digitalization in the best possible way: "It seems that the emphasis on delivering value for customers through learning along the way, earlier and frequent deliveries, better utility management along the way and more flexibility in what is delivered, are flexible elements that have a good effect on digitalization" (Jørgensen, 2024, p. 80).

In this paper we focus on the work that is done in the organization. We particularly want to understand how the people who carry out the work experience the digitalization. We aim to add to the prevailing understanding of agile development processes by showing how the continuous development is experienced by those who use the continuously changing systems to support their everyday work practice. Our aim is to suggest how CSCW can contribute to a debate on how organizational change is carried out.

The paper is structured as follows. First we briefly present our empirical case and methods for data collection, before we present our findings, focusing on how digitalization affects the work that is carried out, how workers cope with the changing conditions for carrying out their work, and how digitalization is experienced as an additional part of their work. Finally, we discuss our findings, focusing on what CSCW as a research field can contribute to the prevailing discourse on digitalization.

Empirical case and methods

The Labour and Welfare Administration (WA) aims to contribute to social and economic safety for the citizens, with a focus on the citizens' employment and activity. The WA seeks to help citizens maintain a sustainable life in times of economic challenges by offering a variety of services and financial benefits related to unemployment, sickness, disability, pension, and so on. As such, their areas of administration requires collaboration and data sharing with a large number of other actors, both public and private. WA's organizational structure includes a large central Directorate where the IT department is located, and over 250 local offices distributed in the municipalities all over the country. Most services and welfare benefits are handled at a governmental level, except for social welfare, i.e., 'the last security net' for citizens, which is handled by the municipalities.

The front-line workers who follow up on citizens are generally referred to as 'advisors' as they manage the clients' cases over time, with a focus on helping the clients find or keep employment, or assess if they need financial benefits due to loss of work ability. Hence, the advisors predominantly work with helping people who are in difficult life situations with navigating their situation and the WA. The advisors in local offices have a portfolio of clients they are responsible for. In our fieldwork, we encountered advisors whose portfolio consisted of approximately 15 cases, and others who had up to 200. As a general rule, the smaller the portfolio, the more complex each case is. The advisors' job description thus focus on helping clients get the help they need within the context of WA. Their daily tasks involve meetings with clients, answering inquiries from clients or other actors related to a case (e.g., doctors, employers, and other WA units) and other case handling tasks.

To do their work, the advisors must use a number of IT systems (see Figure 1). Due to organizational change over time, the number of systems have grown, and they regularly use up to 6 different systems to handle their work tasks, in addition to other tools such as Microsoft Word, Teams, e-mail and the Intranet. *Old CMS* is a case handling system that was implemented at the beginning of the 2000s. The advisors we have interviewed state that this system is used mainly for tasks related to 'work-oriented follow-up,' e.g., registration for activation measures, case handling of applications, and reporting from meetings. In this system, there is a lot of necessary information about the clients, as well as CVs, vacancies, information on measures, etc. *Archive System* is referred to by the advisors as an archiving system that should contain all documents that belong to the client's cases. In addition, they can find information on payments and other information related to the client here. This system is also used for internal communication in the WA where the advisors can send inquiries to other WA units. *New CMS* is used by the advisors mainly as their 'view' of the client's page online. Thus, this is the system the advisors use to interact with the clients digitally, e.g., through the Digital Dialogue (messaging service) or the Activity Planner (the client's 'pathway to employment'). *Ancient CMS* is a case handling system that was developed in the late 70s and has been in use ever since. Today, this is rarely used by advisors, but in certain cases parts of a case handling process must be done here. To handle the separation between governmental and municipal services and benefits, all cases related to social welfare is handled in a separate IT system: *Municipal CMS*. Furthermore, a *Communication system* has been implemented in recent years. This system is described as an off-the-shelf communication tool that allows for communication both internally and with actors external to WA, such as employers.

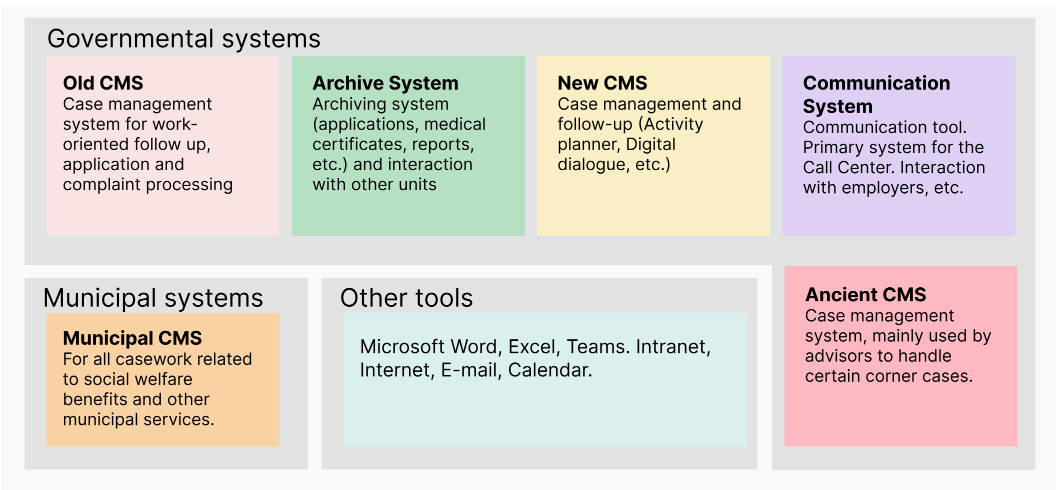


Figure 1. An overview of the systems in use on the front-line.

Methods for data collection

The data we build on in this paper are mainly from interviews and observations of advisors working on the front-line, conducted between 2019-2023. In addition, our overall understanding of their work situation is based on interviews with the other groups of employees, e.g., people who work with IT-support or training in the local offices. In total we have interviewed 7 advisors and 7 employees in other roles. We have conducted semi-structured interviews where we have focused on asking questions related to the employee's role and tasks in WA, particularly on how the employee uses the digital systems in their everyday work. Some of these interviews have included groups of employees. The interviews have been transcribed and analyzed for problems and themes relating to changes in the work practice. All participants have been made aware of the study's content and signed a consent form, and the audio recordings have been stored according to the current guidelines for research data.

The observations of advisors working were made at the participant's workplace. The length of the observations varied depending on what the individual advisor had time and opportunity for, but we estimate that each of the observation sessions lasted between 2-6 hours. The researcher who made the observations sat with the advisors while they carried out their tasks, asked questions, and talked about the work along the way. In addition, the researcher was allowed to participate in certain meetings attended by the advisor. The data from the observations are documented in the researcher's field notes. As the advisors most often work in an open office environment, we considered it unethical to make audio recordings of these.

Digitalization in practice

This section presents our analysis of the collected data.

Fragmentation of work

> "If I am to process a complaint on [the refusal of a financial benefit], I find the actual complaint and GP's documentation in the Archive system, and then there are conversation reports in New CMS, and then I have to go through Municipal CMS to see if the client has received social welfare benefits, and then I do the actual casework in Old CMS."

The digitalization in WA has made it possible to more efficiently cooperate with external actors such as medical professionals and employers with regard to the documentation that is needed in the handling of each individual case. Furthermore, in recent years, online self-services has made it easier for clients to, e.g., send applications, send inquiries to the WA, and manage their cases. Such developments have contributed to the growing number of IT systems in use at the front-line, as new functionality has required technology that was not available in the older systems. Additionally, when cases are handled digitally, i.e., are made up of bits and pieces of digital information and documentation, it has become more convenient for WA to distribute the decision-making power between WA units. For instance, their 'second-line' units mostly make the final decisions on granting or refusing citizens financial benefits.

For the advisors on the front-line, this fragmentation of their work has lead to changes in practice. Throughout their day, they work with clients' cases in increments, e.g., by answering an inquiry from one client before registering a complaint from a different client. However, to make the right decisions and guide their clients successfully, they depend on maintaining an overview of individual clients' cases. To accommodate the fragmented nature of cases and work tasks, one advisor kept a Word document as a 'living documentation' for each of her clients, where she kept her notes regarding the case for easy access and a better overview. Similarly, due to the many different systems, their work tasks are also fragmented in themselves: while doing one single task they regularly navigate between several different systems and tools, as exemplified in the quote above.

Change is fast-paced and continuous...

> "It's problematic if you think you have learned a routine, and just do it as you remember because it can be wrong as the routines change so often."

The daily work on the front line is characterized by IT systems that are constantly changing. We were told that in a given month, the IT department performed 1400 'production settings'. While most of these are 'under the hood', it illustrates the pace of development. Most changes made to the IT systems are small, but they occur in an already complex environment. An important focus for the software development in WA is phasing out the older case handling systems, i.e, Old CMS and Ancient CMS as they are built on technologies that are 'dying'. The goal of getting rid of the old systems dictates the kinds of changes that face the advisors: information and functionality are moved to newer systems.

The advisors experience the development as fast-paced. From one day to the next, functionality and information can be moved from one system to another, or there is a new routine to do a process. An example of a type of functionality that has recently been moved to a different system are what is called 'case handling notes', i.e., forms and text that the advisors write to supplement the input in a case handling process. Earlier, these notes were made in Old CMS, but now they are mainly found in Archive System. To make sure that the advisors store the notes correctly, they have access to an overview of which notes should go into what system. According to one advisor, the process of moving the notes have caused confusion beyond the location. She explained that some of the functionality has also been re-named: "Before, there was something called 'letter menu' and that was what we used when we wrote these notes. But now we have something called 'note menu' *and* something called 'letter menu', and these are different things. 'Letter menu' is not 'letter menu' as it used to, but for sending outgoing letters. So if I write a case handling note in the 'letter menu' (...) it will get sent to the client." By the looks of it, the scope of the change is not easy to understand. Some changes may cause uncertainty and complications for the advisors in practice.

Even though there is generally more resistance to certain changes among employees who have been working in the agency for many years, the more recently employed advisors experience the changes as cumbersome, as there is 'always something new'. The IT department are apparently aware of how the continuously changing IT systems can cause frustration and difficulties for users. An example on how they attempt to inform the users of recent changes is through an easily accessible overview in New CMS, where the users can read about changes and how it may affect their routines. When observing an advisor navigating in this system, she accidentally clicked the button and was presented with a list of recent changes. She immediately exclaimed, "what is this?" and said that she was not aware that the button existed.

A different example that illustrates the ever-changing systems is from an advisor who was doing a routine task that spanned several different systems. Even though she does this task regularly in her work, she used what she termed a 'recipe' for the task, i.e., internal documentation describing the workflow, including what needs to be done in each system, which buttons to press, and which text fields need to be filled in. While executing the task, she occasionally returned to check that she was doing everything as described by the recipe. She explained that she prefers using the recipes, as the systems change so often that she does not care to learn routines by heart. Similarly, a different advisor mentioned how, when a database of routine descriptions were moved from one system to another, he needed to learn new techniques for finding the information he was looking for. In the old database, he used his visual memory when looking for entries, but when the new system was implemented, he was required to search for the entries by means of text. As such, he needed to know which keywords to use instead of remembering what the list of entries looked like visually.

Several of the advisors illustrated the large number of system changes by imagining going on holiday for a few weeks. They said they would be "bewildered" upon their return, and that coming back to work would be "a complete crisis, because then you are so far behind" with the developments. While the changes themselves are not always difficult to grasp, it is the totality of changes over time that seem to be challenging for the users.

...but improvements are slow

While the experience of digitalization generally suggests a fast-paced development, the advisors simultaneously express that larger changes and new (innovative) functionality takes a long time before they are implemented in practice. They have an understanding of the overall plan for the digitalization efforts that will affect their work in practice. For instance, they know about the eventual phasing out of the older systems and other, larger bits of functionality that are planned.

Since the beginning of our fieldwork, the advisors have awaited a technical solution that makes writing a certain kind of case handling document simpler. The new solution will delegate some of the tasks in the current process to the clients, while the advisor is supposed to have a supervising role in the process, i.e., checking if the client's inputs are correct, and approving the document before it is used in further case processing. Such a solution would make extensive changes to their work in practice, as the way they do it today require them to, e.g., gather information from a variety of systems, having conversations with the client beforehand, and store it in the correct system.

In 2019, one of the advisors explained that "They [i.e., managers and the IT department] have talked for a long time about how, when we write this [document], we will no longer do it the way we do it today. It will change (...) and they have talked about this for a long time, but for the time being, nothing has happened." In 2020, a different advisor said that "This [document] will be made by the client himself. It will come in New CMS but it has been postponed indefinitely. We will probably receive it little by little." In 2023, we were told that "There will come a new way to make these [documents], but they have talked about it for, what.. ever since I started [in 2018] about how there will be an easier way to make these [documents] and that the client will do it directly from their Activity Planner (...) They have worked on this for years and years, but it still has not happened. There was a solution, but it was taken down as it was not quite right in terms of privacy".

Similarly, in recent years the agency has developed a new deviation handling system, i.e., a system used to report on, e.g., issues with privacy, and for reporting cases where clients behave in threatening or discriminatory manners. The old deviation system was 'really difficult' to use, and it was suggested that deviations were under-reported due to the system. One of the advisors exclaimed that, "They have talked about this for a hundred years and finally it is happening", suggesting that this has been a long-awaited system. As such, digitalization is simultaneously experienced as a perpetual process, and as a process where the advisors may wait for years for changes that they hope will make their work more efficient.

Juggling work and digitalization

> "The development is going so fast. There are probably things that are good, but we don't know how to use them. The digital things take the focus away from a lot of other things — we kind of have to do our job alongside the digitalization"

The advisors' work days are largely governed by how many clients they follow up, how complex the cases are, or how much managerial responsibility they have. There are constant inquiries from clients, employers and doctors, and questions that need to be assessed are sent from other WA units. The advisors at the local offices say that "inquiries come through all channels" all day, and that "it feels like it never stops", meaning that they always have something to do at work.

At the same time, they must constantly deal with changes in the IT systems, learn new or changed functionality or which work routines they must change. In the previous sections, we have provided examples of both small and larger changes. Generally, the smaller changes comes with information from the IT department or managers on how to use the new or changed functionality. One advisor expressed that, "We get information from so many places about new things or things that disappear. There's either an e-mail, or information at a regional level, or news on the Intranet, or... it can be so many places", suggesting that keeping an overview of the changes is difficult.

In cases of major system changes, the training is often more extensive. In such cases, they may have groups of advisors involved at various stages of the process, and employees may need to attend full-day courses to learn the new systems. However, when it comes to all the less extensive changes, the advisors themselves have to set aside time for training, sign up for courses and become familiar with the new functionality. This is in stark contrast to how digitalization was carried out some years ago: "Earlier we went to courses for every new screenshot and every new process. Now we just get a message that 'this is new' and we have to use it", explained an experienced advisor. The individual responsibility for training was an ongoing challenge: "When you work on the front-line and you advise up to 200 clients, you don't have a lot of time to sit down and read about what has happened to the IT systems, and that may be an issue on a daily basis".

Discussion

Tokkonen et al. (2023) note that the drivers for digitalization as a means to introduce changes to work practices are regulation-driven and therefore mandatory, or they are technology-driven and represent more radical changes. These drivers can be seen as pressure for certain changes, or as opportunities to the organization — in WA we see both types. In the introduction we referred to the government's rationale for digitalization of public organizations like the WA as creating a better and efficient administration that is more accessible to citizens, has better IT systems, and aligns with societal developments in general (Ministry of Digitalisation and Public Governance, 2014; Bygstad and Iden, 2024). We also referred to research in software development arguing for agile development as a way to continuously renewing the organization through iterative improvements (Jørgensen, 2024; Tendedez et al., 2018; Dybå and Dingsøyr, 2008). The drivers for change in WA are both imposed by government and made possible by technical development, and are also in line with technically driven changes in other organizations in contemporary society both concerning the aims and the methods.

In this paper we have wanted to describe a side of the digitalization which is both understudied and relevant to CSCW as a research field. CSCW has traditionally been concerned with studying work practices, i.e. how people actually do their jobs (Grudin, 1994; Button and Harper, 1995; Suchman, 1987; Schmidt, 2011). We believe this perspective is missing in a discourse that constantly praises digitalization managed by organizations where IT development teams are increasingly autonomous and flexible (Byremo and Fjellanger, 2024; Jørgensen, 2024; Bygstad and Iden, 2024). WA is an example of a public organization that follows the principles of agile IT development, and where the changes made to the systems hit their users accordingly. Keeping up with digitalization is perceived as a process that must be done while simultaneously doing the work they are employed to do.

Our empirical studies of advisors' work practices have enabled us to analyze digitalization from the point of view of the front-line of WA, i.e., employees whose job it is to realize the public welfare services. We have seen that there is a difference between the prevailing understanding of digitalization and how it is best carried out and the understanding of the work of the front-line advisors in the WA. Their everyday work practices are characterized by complex work tasks that are (supposed to be) supported by a large number of IT systems, and where the systems are changed in partly unpredictable — and important — ways. We have shown how the digitalization over time have led to work conditions characterized by fragmentation, both in terms of tasks, case information, and cooperation. We see a parallel to the classic example by Bowers et al. (1995) where the new system in a printshop is analyzed. The new system is designed for accounting purposes, and it turns out that the workflow suggested by the accounting perspective differs from the printshop workers' view of a smooth "workflow from within". Their workflow would allow them to divide jobs and utilize the printing machines' capacity and schedule breaks without stopping the machines. This is not possible in the workflow "from without". We see a similar difference in the view of digitalization "from without", i.e., outside of the advisors' work, and digitalization "from within". A similar discussion is found in Verne and Bratteteig (2016): they suggest that automation efforts should depart from the work processes instead of what is easy and/or possible to automate.

Tokkonen et al. (2023) shows that the activities concerned with designing changes in work practices, like software development, is usually done at an organizational level. The people at the work practice level of the organization — the advisors — can be seen as "mere subjects to change, expected to adopt and support it" (Tokkonen et al., 2023, p. 820). Even if the agile software development processes involve actual user representatives throughout the process, the experience of the advisors still reflects the feeling of being subjects to change; they can identify with the overall goals of the digitalization (e.g., getting rid of old systems), but in practice, their work tools are rapidly and constantly changing and they have little power over when and how the changes will be implemented. Bråten and Andersen (2023) confirms that the flexibility and fragmented nature of large agile software development projects lead to less involvement and influence by users and trade union representatives (see, e.g., Åkesson et al. (2023); Thomsen and Åkesson (2013)).

The organization of software development as a number of agile teams each focusing on one theme or "product" leads to introduction of changes when they are ready from the agile teams and not when they fit with the advisors' work. The different systems change at different rates, i.e., rates that fits the development teams. We argue that the way the development processes are organized has led to a fragmentation of the work on the front-line in WA. However, the changes that are made may not fit with the work practice of the employees who are carrying out the work, i.e., those who put WA's policy into practice (Lipsky, 2010). The fragmentation of work can lead to a feeling of incompetence and vulnerability because they are dependent on using the systems to do their work. They also worry about coming changes in their work and of unemployment (Åkesson et al., 2023, p. 8). The advisors are expected to deal with and learn most of the changes by keeping up with the news, but in their busy everyday work, they do not always have the time to keep track of the changes until they affect their work explicitly.

In large public organizations, an aspect that increases complexity is often that the systems are used by employees in many different roles, at many organizational levels. Developing systems that take everyone's work activities into account is indeed challenging, but as we know that digitalization is a continuous, possibly ever-lasting process, should we not try to shed light on digitalization from several perspectives, and aim to maintain the workers' control of their work? Digitalization is not going to finish (Ribes, 2022). A debate on how organizational change should happen and what digitalization is for will benefit from more studies of the work practices that are affected by the changes introduced by digitalization.

References

Agile Manifesto (2001): 'Manifesto For Agile Software Development'.

Bowers, J., G. Button, and W. Sharrock (1995): 'Workflow From Within and Without: Technology and Cooperative Work on the Print Industry Shopfloor'. In: H. Marmolin, Y. Sundblad, and K. Schmidt (eds.): *Proceedings of the Fourth European Conference on Computer-Supported Cooperative Work ECSCW '95: 10–14 September, 1995, Stockholm, Sweden*. Dordrecht: Springer Netherlands, pp. 51–66.

Bråten, M. and R. K. Andersen (2023): 'Digitalisering, personvern og tillitsvalgtes medvirkning'. Technical report, Fafo.

Button, G. and R. Harper (1995): 'The relevance of 'work-practice' for design'. *Computer Supported Cooperative Work (CSCW)*, vol. 4, no. 4, pp. 263–280.

Bygstad, B. and J. Iden (2024): 'Digital Management in the Public Sector - a Framework'. *Electronic Government, an International Journal*, vol. 20, no. 1, pp. 1.

Byremo, H. and B. Fjellanger (2024): 'To vanlige digitaliseringsfloker'. *Magma*, vol. 27, no. 1. Number: 1.

Dingsøyr, T., S. Nerur, V. Balijepally, and N. B. Moe (2012): 'A decade of agile methodologies: Towards explaining agile software development'. *Journal of Systems and Software*, vol. 85, no. 6, pp. 1213–1221.

Dybå, T. and T. Dingsøyr (2008): 'Empirical studies of agile software development: A systematic review'. *Information and Software Technology*, vol. 50, no. 9, pp. 833–859.

Grudin, J. (1994): 'Computer-supported cooperative work: history and focus'. *Computer*, vol. 27, no. 5, pp. 19–26. Conference Name: Computer.

Jonathan, G. M. (2020): 'Digital Transformation in the Public Sector: Identifying Critical Success Factors'. In: M. Themistocleous and M. Papadaki (eds.): *Information Systems*. Cham, pp. 223–235, Springer International Publishing.

Jørgensen, M. (2024): 'Smidigere oppstart av smidig IT-utvikling i offentlig sektor'. *Magma*, vol. 27, no. 1. Number: 1.

Lipsky, M. (2010): *Street-level bureaucracy: dilemmas of the individual in public services*. New York: Russell Sage Foundation, 30th anniversary expanded ed edition. OCLC: ocn503596064.

Ministry of Digitalisation and Public Governance, K.-o. (2014): 'Digitalisering i offentlig sektor'. Publisher: regjeringen.no.

Ribes, D. (2022): 'Digitize Again Forever'. In: *Interrogating Datafication: Towards a Praxeology of Data*, Vol. 3. Bielefeld, Germany: transcript Verlag, 1 edition.

Schmidt, K. (2011): 'The Concept of 'Work' in CSCW'. *Computer Supported Cooperative Work (CSCW)*, vol. 20, no. 4, pp. 341–401.

Suchman, L. A. (1987): *Plans and Situated Actions: The Problem of Human-Machine Communication*. Cambridge University Press. Google-Books-ID: AJ_eBJtHxmsC.

Tendedez, H., M. A. M. Ferrario, and J. Whittle (2018): 'Software Development and CSCW: Standardization and Flexibility in Large-Scale Agile Development'. *Proceedings of the ACM on Human-Computer Interaction*, vol. 2, no. CSCW, pp. 171:1–171:23.

Thomsen, M. and M. Åkesson (2013): 'Understanding ISD and Innovation through the Lens of Fragmentation'. In: Y. K. Dwivedi, H. Z. Henriksen, D. Wastell, and R. De' (eds.): *Grand Successes and Failures in IT. Public and Private Sectors*. Berlin, Heidelberg, pp. 467–480, Springer.

Tokkonen, T., A. Kinnula, M. Kinnula, and K. Kuutti (2023): 'Work practice view to digitalization – A literature review'. *Procedia Computer Science*, vol. 219, pp. 815–823.

Verne, G. and T. Bratteteig (2016): 'Do-it-yourself Services and Work-like Chores: On Civic Duties and Digital Public Services'. *Personal Ubiquitous Comput.*, vol. 20, no. 4, pp. 517–532.

Åkesson, M., M. Thomsen, and J. Johansson (2023): 'AI i byråkratins tjänst - förändrad digital arbetsmiljö när robotkollegor blir en del av vardagen'. Technical report, Afa Försäkring.

Zhenyu Wu, Zhiyang Ding, Yu Zhang, Yanqin Mao (2024): The Importance of Multimodal Interactions for Enhancing Cooperations in Dynamic Social Groups. In: Proceedings of the 22nd European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies - Exploratory papers, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591), DOI: 10.48340/ecscw2024_ep07

The Importance of Multimodal Interactions for Enhancing Cooperations in Dynamic Social Groups

Zhenyu Wu, Zhiyang Ding, Yu Zhang, Yanqin Mao
Nanjing University of Posts and Telecommunications, Nanjing, China
zhenyu.wu@njupt.edu.cn, 1222077423@njupt.edu.cn, 1221077131@njupt.edu.cn, yqmao@njupt.edu.cn

Abstract. Multimodal interactions have the potential to enhance cooperation performance in dynamic social groups considerably. Despite this, previous researches have overlooked the possibility of leveraging multimodal interaction data to identify valuable patterns and experiences that can assist future group behavior. In this paper, a multimodal human-machine interaction architecture is proposed to capture and analyze such data. The proposed model employs hardware devices such as cameras and microphones to collect multimodal interaction data, and the machine learning model processed data is further recommended to help group members. This iterative process is expected to improve the overall performance of the groups. Furthermore, a dynamic social graph model has been adopted to process the multimodal interaction data in this paper. Finally, the proposed method is evaluated using the AMI corpus. The experimental results illustrate that group members with different roles could be identified, and passive members encouraged based on the analysis results. These findings provide new strategies to enhance learning in educational scenarios. The effectiveness of modelling multimodal interactions with dynamic social graphs has been demonstrated.

Introduction

Social groups are commonplace in our daily lives. For example, corporate teams hold project meetings, and school classes hold group discussions. In social groups, how to effectively communicate, interact and cooperate among members so as to form group effectiveness is the issue concerned in this paper. In general, individuals within social groups engage in multimodal interactions with one another through various means, including voice, hearing, observation, and touch. This collection of interactions is known as multimodal interaction (Turk, 2014). An example of such multimodal interaction is the act of teaching and learning in a classroom. Previous researches have demonstrated that the use of multimodal teaching modes can significantly improve student learning initiatives (Moreno and Mayer, 2007; Love, 2008; Deutsch et al., 2009; Leeuwen, 2015). These findings are based on the theory of multimodal discourse analysis, which shows that students with different characteristics can better understand and memorize information when it is presented through different sensory organs. Therefore, capturing and analyzing multimodal interaction data, such as text, images, voices, and gestures, offer a comprehensive view of the status of a group during the process of dynamic social group activities.

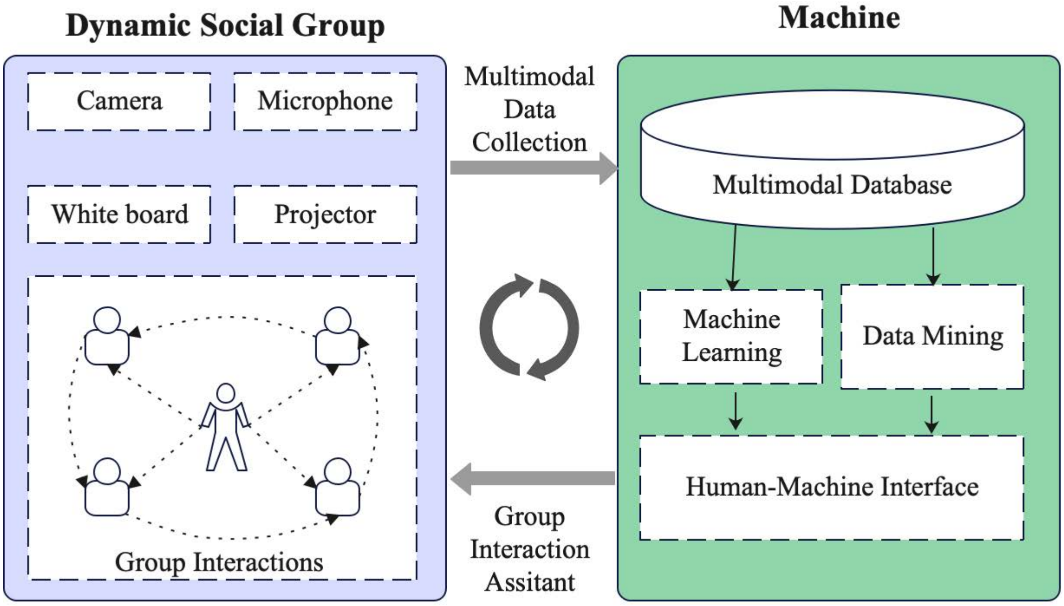


Figure 1. Multimodal human-machine interactions in dynamic social group.

Multimodal interaction data can be captured using hardware devices such as cameras and microphones and stored in a multimodal database housed within a computer server. By applying the popular machine learning and data mining models, important insights can be discovered and utilized through interfaces between humans and machines. Such a continuous process can improve group performance by collecting and processing multimodal data in the database in real time. The proposed system architecture, as shown in Figure 1, comprises the dynamic social group on the left and the machine components on the right. In machine component, a computer server running dedicated software can communicate with hardware devices via the local networks. In dynamic social group component, the cameras and microphones can directly upload their captured data to the server through the communication networks. As the machine learning models process the uploaded data in real time, the results can be quickly returned to social group members through interfaces between humans and machines, thereby improving their decision-making capabilities. As hardware devices continuously recapture multimodal interaction data of social groups, the valuable results would continuously provide to social groups for the improvement of their further interactions. In this way, the performance of social groups could be improved.

Therefore, one of the important tasks is to model and analyze social groups and their interactions. In fact, members in a social group form a temporal social network. That is, social network mining and analysis technologies could be applied to study multimodal interactions in social groups. Since graph models are commonly used to identify relationships among individuals, they are utilized to model and analyze the multimodal interactions in social group interactions. Due to the dynamic characteristics of the social group interactions, a dynamic interaction graph is proposed for studying the multimodal interactions. Finally, a dataset on group meetings has been selected to assess the proposed method.

The main contributions of the paper are the following: First, a multimodal interaction architecture between humans and machines is proposed to improve groups' learning performance. Second, a dynamic interaction graph is proposed for modelling multimodal interactions in group learning. Third, based on the experimental results and analyses, a digital member is proposed to provide a theoretical vision for integrating group interaction intelligence in the future.

Related Works

Multimodal Interaction Analysis

Multimodal interactions between individual members can facilitate knowledge transfer during dynamic group activities. Speakers can utilize various communication methods, including voice, text, gestures, and movements to delivery information. Meanwhile, listeners can acquire information through auditory and visual means. Moreover, each person's facial expressions can also indicate their level of comprehension. The objective of multimodal interaction analysis is to analyze human communication patterns comprehensively by using various data mining and analysis techniques, including image processing and text analysis (Martinez-Maldonado et al., 2018). Like traditional social network analysis, multimodal interaction analysis summarizes the regularities of interpersonal relationships through calculating the interaction statuses between individual members. In such settings, the analysis results could be further used to enhance the efficiency of social groups.

Jewitt (2008) emphasized the importance of multimodal communication with integration of images, actions, and voices, studying its relationships with classroom teaching. Their findings highlighted the significance of multimodal data for understanding in reading, writing, and learning. Similarly, Hassett and Curwood (2009) studied the significance of multimodal text in early teaching stages, stating that teachers are responsible for providing valuable multimodal resources. Barton and Ryan (2014) examined feedback teaching in high school based on multimodal interactions, arguing that teacher instructions to students involved language, gestures, and actions. Additionally, students could better understand their learning performance with multimodal feedback. Yuan (2021) developed a multimodal interaction assistant system, utilizing the integration of speech recognition, image recognition, gesture recognition, and natural language understanding with linear regression algorithm. This system greatly assisted the teaching process of teachers and improved college English composition scoring. Papakostas et al. (2021) used social robots to evaluate the participant degrees of students with learning disabilities, as these students often exhibit deficiencies in task completion and learning efficiency (Swanson, 2011). Their studies concluded that multimodal interactions greatly improved students' participant degrees.

The utilization of multimodal interaction analysis in interpersonal communication can enhance the efficiency of communication by providing an abundance of interaction data. Nevertheless, this article intends to investigate the potential of iterative interaction between humans and machine algorithms in interpersonal communication. This research direction centers on the creation of human-machine intelligence, which is a significant area of research in artificial intelligence and collective learning. Such multimodal interaction can revolutionize communication patterns between individuals and open up new possibilities for interactive technologies.

Dynamic Graph Model

Dynamic graphs, which are graph theory structures built on top of static graphs, focus on studying the application scenarios that change over time and possess dynamic properties (Harary and Gupta, 1997). These structures are highly valuable in the field of computer science. Dynamic graphs offer numerous benefits. Firstly, they expand static graphs to the dynamic domain, meaning that dynamic graphs incorporate all the theories of static graphs. Secondly, they enable the description of the evolving properties of graph objects, facilitating the clear and intuitive capture of graph changes over time. Finally, many real-world occurrences possess real-time and complex characteristics, making dynamic graph models a valuable framework for modelling and analyzing (Zaki et al., 2016). Dynamic graph models can be utilized to model the intricate and dynamic nature of interpersonal communication. Pedagogy is a form of communication that relies on teachers and students discussing and exchanging ideas to attain mutual understanding. Through iterative communication, they augment their knowledge, ultimately achieving common progress.

Mihoub et al. (2016) proposed a multimodal behavioral model that is based on a Dynamic Bayesian Network (DBN). The model was developed by training it with nonverbal interaction data collected from two participants. Their ultimate goal, through the application of this model to humanoid robots, is to detect, predict, and guide humans in performing a variety of tasks, including shopping, exercising, and rehabilitation. Zhang et al. (2022) developed the Siamese Spatial and Temporal Dynamic Network (SSTDN) to predict future social events across different countries. They utilized multimodal global historical data containing text, images, and various dynamic features. Their model incorporates the time and spatial dynamic graph representations of events, and predicts the evolution of social events while determining their positive or negative character. Ding et al. (2021) employed dynamic graph models for detecting multiple intents and filling slots related to them. They employed a dynamic interaction graph between intents and slots to model their correlation. This graph can be dynamically updated to minimize error propagation. Chang et al. (2020) proposed a method that utilizes dynamic network graphs to learn continuous-time dynamic embeddings for joint encoding of time and structural information. They defined a time-evolving dynamic graph as a graph that changes dynamically between its nodes due to a series of events over time. By using this graph, they captured user interactions and analyzed their behavior, thereby combining node and interaction attributes during specified time intervals. Feng et al. (2020) designed a meeting summarization technique called the Dialogue Discourse-Aware Meeting Summarizer (DDAMS) using a dynamic graph model. They modelled various discourse relations based on speech interactions among members during a meeting and reflected dynamic interaction patterns among them. Additionally, the graph is continuously updated over time, improving the comprehensiveness of the meeting summary.

Dynamic graph models have been proven to effectively reflect changes and interactions between nodes in social network graphs. This study aims to utilize dynamic graph models to model teacher-student interactions throughout the entire course in the classroom and analyze communication patterns. This provided effective information for teachers to understand students' learning progress and offer targeted help based on their individual learning situations, thus offering new insights into student learning evaluations.

Social Group Cooperation

Cooperative behavior can effectively improve the working efficiency of social groups (Malone, 2018).

Alvarez-Rodriguez et al. (2021) studied the interaction evolution in social groups by extracting the key factors in social groups. Xu et al. (2020a) used WeChat data to study group interaction behavior in online classroom discussion.

Experimental games method were used to study decision making and cooperation in social groups (van Dijk and De Dreu, 2021). Henrich and Muthukrishna (2021) reviewed the major evolutionary mechanisms that have been proposed to explain human cooperation, including kinship, reciprocity, reputation, signaling, and punishment. In order to understand group changes relating to cooperation in public good provision, Otten et al. (2022) analyzed a dataset comprising approximately 1.5 million contribution decisions made by about 135 thousand players in about 11.3 thousand groups. Xu et al. (2020b) studied the effect of non-cooperative behaviors in dynamic social groups using social network analysis method. Subburaj et al. (2020) carries out multi-modal modelling for the interaction of members in the social group, and sets different weight values for different modal data.

Recently, with the development of artificial intelligence, Seebera et al. (2020) studied the possibility of adding artificial intelligence as a member to social groups. Cooperation between humans and computers has also been applied in fields such as medicine (Tschandl et al., 2020).

Modelling Multimodal Interactions in Group Learning

Research Gaps

Research on social group cooperation has received increasing attention (Turner, 2010; Hughes et al., 2018). In terms of application areas, most of the current researches focus on group cooperation in teaching and learning (Gillies, 2004; Foldnes, 2016; Abramczyk and Jurkowski, 2020). Methodologically, social network approaches have been used to study social group cooperation and have taken into account the multimodal nature of the interaction process (Apicella et al., 2012; Fowler and Christakis, 2010).

In this paper, we argue that the following research questions need further elucidation in social group multimodal interaction.

- RQ1: In social groups, the interactions between members are multimodal and dynamic, in order to better analyze the cooperation process between members of social groups, how to accurately model members with different identities and role information and their interaction process becomes the primary problem to be solved.
- RQ2: Multimodal interactions among members in social groups affect members' attitudes, opinions, decisions, actions, etc., which ultimately lead to changes in overall cooperation efficiency. What is the relationship between types of multimodal interactions and group cooperation efficiency? What types of interactions are the main factors affecting the efficiency of group cooperation?

- RQ3: Most of the existing researches focus on analyzing social group interactions and their cooperation effectiveness in the field of teaching and learning, what are the common findings in other types of datasets?

Problem Definitions

The multimodal interaction data should be accurately modelled and deeply analyzed so that the hidden patterns should be discovered. The discovered patterns could be further used to assist future behavior in social groups.

Assuming there are n members in a dynamic social group, the group could be defined as follows:

$$LG = \{M_1, M_2, ..., M_n\} \tag{1}$$

The multimodal interactions MI could be defined as follows:

$$MI = \{Dialog, Gesture, Movement\} \tag{2}$$

Where $Dialog$ represents the voice response of M_i to M_j, R means the relationship between M_i and M_j, and it could be defined as follows:

$$Dialog =< M_i \quad R \quad M_j > \tag{3}$$

$Gesture$ includes hand gesture and head gesture of social group members. $Movement$ represents the actions of member during group activities.

Obviously, multimodal interactions in social group have dynamic characteristics. That is, they are changing with time. The dynamics of multimodal interactions should be modelled, which could be represented as follows:

$$DMI = \{MI_1, MI_2, ..., MI_T\} \tag{4}$$

Where T is the time period, and $0 \leq t \leq T$ is a time slice. In this way, the dynamics of multimodal in group learning could be studied.

Dynamic Interaction Graph

Generally, graph models are natural to represent individual entities and their complex relationships. Therefore, graph models are used in this paper to represent members in group learning and multimodal interactions among different members. An interaction graph G could be defined as follows:

$$G = \{V, E\} \tag{5}$$

Where V and E are respectively the list of nodes and the list of edges in G. Each element in $v \in V$ represent an individual member. The attributes of v represent the actions of member during multimodal interactions such as head gestures, hand gestures and movements. Each element in $e \in E$ represents the interactions between to members. In the case of group learning, if member 1 replies member 2 with natural language, there would be a directed edge between them. The weights of the edges represent the interaction frequencies between two members. In this way, multimodal interactions among members in group learning could be represented.

In order to represent the dynamics in group learning, the dynamic interaction graphs are proposed, as shown in Figure 2. It is obvious that the numbers of nodes and edges are changing with time. Therefore, the dynamic interaction graph DG could be represented as follows:

$$DG = \{G_0, G_1, ..., G_T\} \quad (6)$$

Where G_t $(0 \leq t \leq T)$ represent a snapshot of G at time t. That is, G could be divided into successive time slices to study its dynamics changed with time.

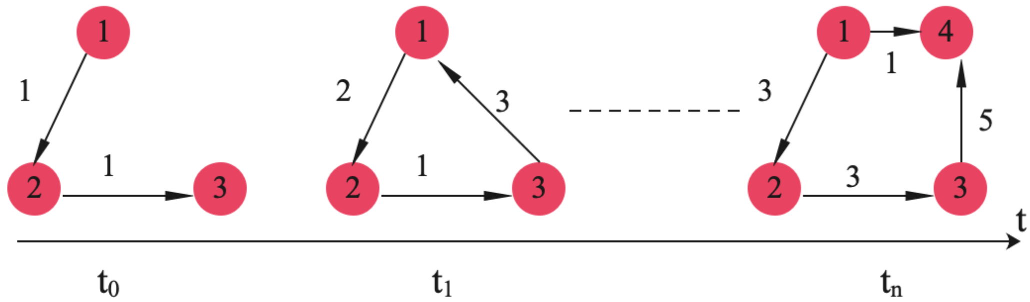


Figure 2. Dynamic interaction graphs.

Experimental Results

Dataset Description

Project meeting in company is one of the important group learning scenarios. Therefore, a project meeting dataset which is named AMI corpus (Carletta et al., 2005) is selected as the evaluation data in this paper.

AMI corpus includes more than 100 hours video, audio, and whiteboard data which was collected from project meetings (Chung et al., 2019). The project meeting includes four different members including project manager, industrial designer, user interface expert, and marketing expert (Manuvinakurike et al., 2021). They can talk to each other, take notes with styluses, and analyzing results using a whiteboard and a projector. Therefore, it could be regarded as a kind of group learning with multimodal interactions.

The AMI corpus underwent preprocessing, resulting in a dataset with various types of annotations, including Transcription, Dialogue Acts, Topic Segmentation, Named Entities, Individual Actions (e.g., head gestures, hand gestures, movements), and Focus of Attention. The annotations are manually marked by multiple workers according to the reference guidelines. The audio signals have

Table I. Partial Annotation Types of the Dataset.

Annotations	Explanations
Abstract	Classify and summarize the meeting according to categories.
Dialogue Acts	Indicates the speaker's intention.
Hand Gesture	The hand movements of each person as a time-series.
Head Gesture	The head movements of each person as a time-series.
Movement	The location of each person during the meeting as a time-series.
Segments	Sentence-level transcription, marked the time of a sentence.
Topic	Topics of discussion in the meeting.
Words	Word-level transcription, marked the time of a word.

been transcribed into texts. Data about segments, head gestures, hand gestures, and movements in rooms has been labeled by experts. Segments were annotated sentence-level, with staff members marking the start and end times of each speaker in a temporal format. Individual Actions (e.g., head gestures, hand gestures, movements) were recorded and included detailed information on each participant's position and movements in the meeting room, as well as time stamps. Table I presents some annotations and explanations obtained from the AMI dataset.

Therefore, multimodal interactions including dialogue, gestures, and movements are analyzed using the dynamic interaction graphs proposed in this paper. Consequently, the role of each member can be identified. Furthermore, this clarification enables both qualitative and quantitative understanding of different interaction types within group learning.

Experimental Analysis

Dataset ES2002a in AMI corpus is selected to analyze. There are total four members in the meeting. The interaction graph is constructed, where node 1, 2, 3 and 4 respectively represent member A, B, C and D. Directed edges are present between nodes if they spoke to each other during the meeting. The feature attributes of nodes include hand gestures and movements.

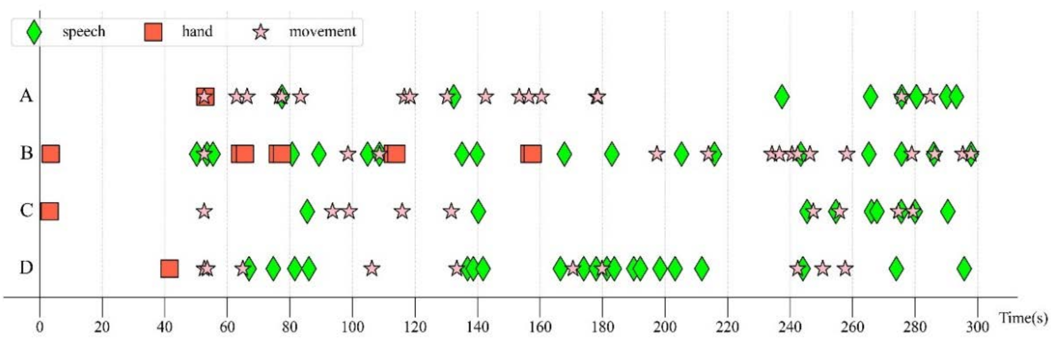


Figure 3. Activities of meeting members in the first 300 seconds.

Figure 3 illustrates the time series and activity of members during the first 300 seconds of the meeting in the ES2002a dataset. The vertical axis represents four distinct meeting attendees, while the horizontal axis represents the time series of the meeting. Various labels depict the behaviors of members, such as speech, hand gestures, and movements, at corresponding points in time. The multimodal data streams chart displays members' interactive status over time, enabling the analysis of their multimodal behavior and the impact of their behaviors on the meeting. As an example, it has been observed that when speaking, the four individuals tend to move, indicating a preference for jotting down notes or moving around in the meeting room while speaking. Moreover, the whole project meeting is also divided into four successive time slices. Furthermore, multimodal interactions including speech, hand gestures, movements are analyzed using dynamic interaction graphs.

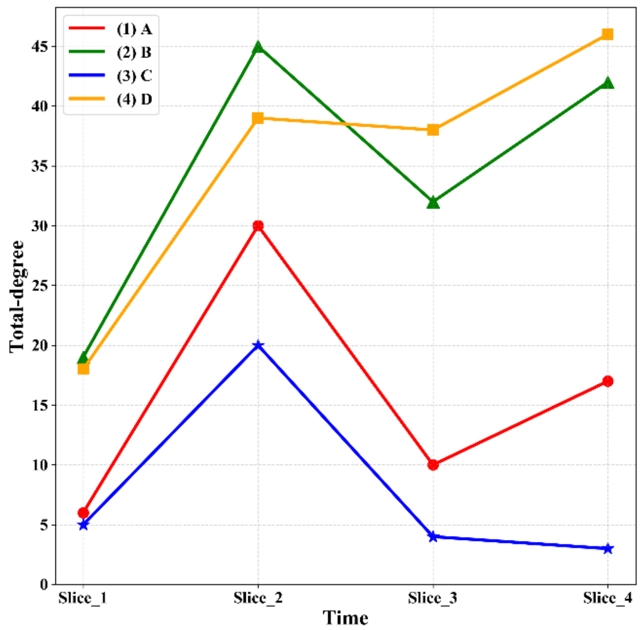


Figure 4. Total node degrees in successive 4 time slices.

(1) Linguistic interaction analysis

Linguistic interactions are represented by the directed edges and their weight values. Therefore, node degrees could be used to evaluate the interaction frequencies between two members. Moreover, in directed graphs, node degree cold be divided into in-degree and out-degree. The in-degree and out-degree of node i could be defined as follows:

$$in - degree(i) = \sum_{j \in V, j \neq i} W(e_{ji}) \tag{7}$$

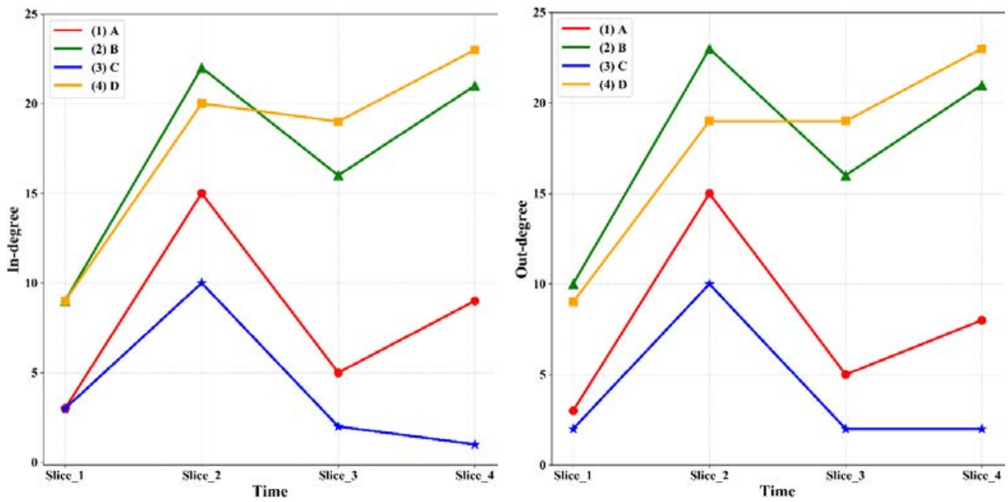
$$out - degree(i) = \sum_{j \in V, j \neq i} W(e_{ij}) \tag{8}$$

where W is the weight value of the edge. The node degree of i could be defined as follows:

$$degree(i) = in - degree(i) + out - degree(i) \quad (9)$$

The results of node degree are shown in Figure 4, where the horizontal axis stands for the four successive time slices, and the vertical axis stands for node degrees in according time slices. The node degrees present the trend of alternatingly rising and falling. This demonstrates that members in the group tend to listen and think before speaking to other members. Moreover, verbal interaction is most frequent during the second time slice, which shows that members are more likely to express their opinions at the earlier stage of the discussions.

Figure 5 (a) and Figure 5 (b) respectively show the results for in-degree and out-degree, with the horizontal axis representing the four time slices and the vertical axis representing in-degree and out-degree. They display the same trends observed in node degrees. Members spoke to others roughly as much as they were spoken to. Moreover, Member B had higher interaction frequencies during the meeting's early stages, while in the final stage of the meeting, Member D had higher interaction frequencies than Member B, suggesting a shift in dominant role. Member C consistently had lower interaction frequencies, indicating that they were less inclined to express their opinions and preferred to follow the group consensus.



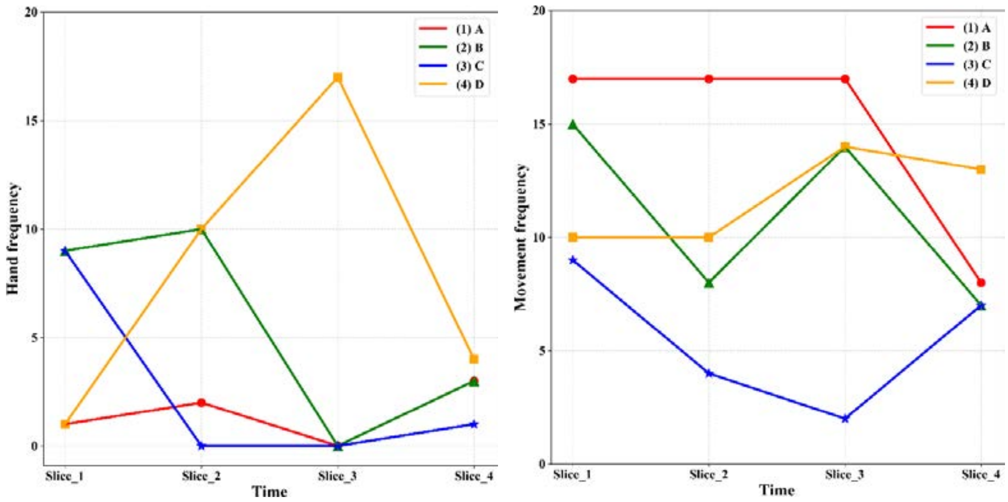
(a) (b)

Figure 5. In-degree (a) and out-degree (b) in successive 4 time slices.

(2) Hand gesture interaction analysis

Hand gestures were also analyzed in this study, including both point and non-point actions. Point actions included pointing to the whiteboard or project manager, while non-point actions included the "OK" hand gesture, passing an object, writing, and drawing. Results are shown in Figure 6 (a), where the horizontal axis displays the four time slices and the vertical axis displays the hand gesture frequencies. Member

D displayed significantly more body language compared to the other three members, and the number of linguistic interactions for Member D remained the highest in time slice 3. This suggests that as a member talks more, they are likely to gesture more. Studies have demonstrated that people tend to use multimodal interactions to better express themselves, leading to improved communication efficiency. In contrast, Member A's hand gesture frequencies were lower, indicating their preference for linguistic interactions to express themselves.



(a) (b)

Figure 6. Hand gesture (a) and Movement (b) interactions in successive 4 time slices.

(3) Movement interaction analysis

The movements of group members can provide insights into their focus during discussions. Movement types recorded in this study include sitting, taking notes, standing before the whiteboard, standing before the screen, and moving around. The result, shown in Figure 6 (b), reveals that the movement frequencies of Member A are higher than those of the other three members, although their linguistic interaction frequencies are not higher. Further analysis suggests that Member A is likely a careful listener who frequently sits and takes notes. On the other hand, Member C has lower movement and linguistic interaction frequencies, suggesting they might be a passive person. Encouragement methods for such members can be introduced to increase their active participation in the discussion.

Furthermore, a comprehensive analysis was conducted on the total frequency of all multimodal interactions. The results indicated that the frequency of movements was generally higher than hand gestures during each time slice, suggesting that movement interactions significantly improve members' cognitive grasp of discussion content. These analysis results could be revealed through the human-machine interface (HMI). As an illustration, the HMI can recommend the analysis results to group members, allowing them to make informed decisions in the future.

Discussions

Social interaction in a group involves two roles: the initiator and the receiver (Redcay and Schilbach, 2019). For instance, when member A communicates with member B, A acts as the initiator, while B is the receiver. And dynamic graph models can effectively model such multi-party multimodal interactions in social groups, which answers RQ1. Experimental studies demonstrate that individuals who engage more as receivers also tend to initiate more interactions within social groups. Each member typically assumes distinct roles, identities, and experiences within a group. To optimize the group's performance, it is imperative to unleash the full potential of each member during discussions. This enables active engagement with other members, facilitated by the host and other roles within the group.

Secondly, in multimodal interactions within social groups, speech serves as the primary mode of communication. The experimental findings indicate that individuals exhibiting a higher frequency of vocal interactions also display increased engagement in gestures and movements, as exemplified by members B and D. These proactive members demonstrate a tendency to express their viewpoints, significantly enhancing the group's interaction efficiency, thus categorizing them as active members. It is crucial to identify and understand the behavioral traits of such active participants. Through the analysis of multimodal interaction data obtained from these individuals, techniques like time series analysis in artificial intelligence can be applied to create a data space representation of active members. This method facilitates the identification of key factors essential for enhancing social group interaction efficacy. On the contrary, individuals who engage less frequently in vocal interactions demonstrate reduced involvement in gestures and movements, exemplified by member C being classified as a passive member. Stimulating interaction initiative among these members is vital to encourage their contributions within the social group. Furthermore, some members exhibit lower frequencies in vocal and gesture interactions but increased mobile interactions, characterizing them as semi-active members. While they respond well to interactions initiated by others, they lack the initiative to initiate interactions themselves, thus requiring guidance to foster proactive engagement. For RQ2, it is obvious that different types of multimodal interactions have different roles, and we can use machine learning methods to mine the different effects of different types of interactions on the efficiency of group cooperation, so as to help members of the group interactions to clarify their positioning, and take different measures to help improve the efficiency of group cooperation with respect to different positioning.

For RQ3, the dataset we used was project meeting interaction data. Whether it is the past social group interactions focusing on teaching and learning, or project meeting interactions we used in this paper, their main purpose is to improve the efficiency of work and learning of the whole social group. Active participation from every member is indispensable for effective social group interactions.

Multimodal interaction presents a robust analytical tool for evaluating and quantifying these interactions. With the advancement of information technology, the acquisition of multimodal data has become feasible. Leveraging artificial intelligence technologies, it is essential to harness multimodal data for extracting, analyzing, and deriving meaningful insights and knowledge that can further enhance social group interactions in practical settings. We can design a digital member utilizing this approach, as depicted in Figure 7. This digital member can accomplish something similar to the experimental process we accomplished above, updating group interaction data in real time during group interactions, providing interaction suggestions, and helping to improve interaction efficiency.

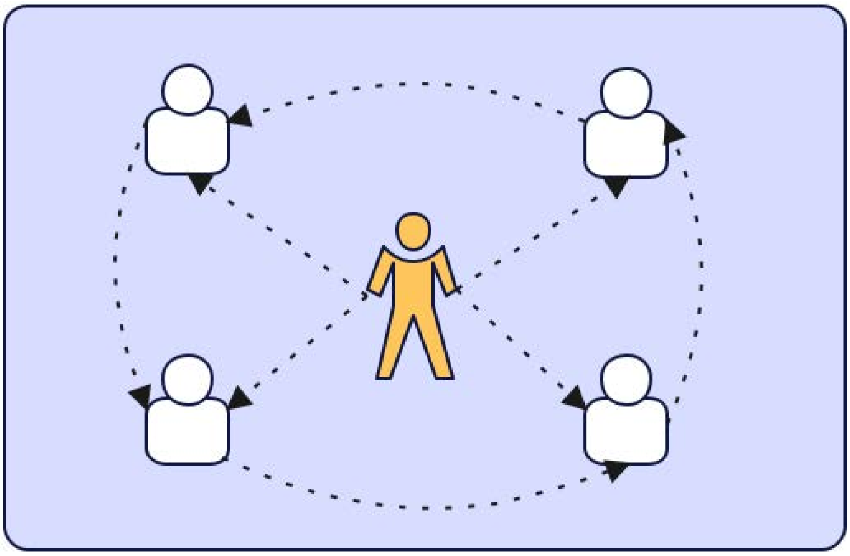


Figure 7. A social group coordinated by a digital member.

A digital member can either be a humanoid robot or a program running on a machine, actively participating in social group interactions and performing two primary assignments: firstly, through its sensor devices, it gathers real-time information in social group settings, enabling the identification of active, semi-active, and passive members using machine learning methods like graph models. By utilizing time series learning models, the valuable insights and experiences of active members can be swiftly assimilated. This process establishes a solid foundation for excelling as a host in social group interactions. Secondly, digital members can facilitate timely coordination among group members in alignment with current interaction objectives. By assessing individual performance, identities, and professional knowledge during interactions, digital members can enhance the efficiency of social group communication. For instance, they can prompt passive members to engage actively in discussions.

The interaction modes of digital members are inherently multimodal. They can issue interactive invitations to other members verbally or boost the activity level of the entire group through expressions and various means. In the case of a humanoid robot serving as a digital member, gestures, movements, and other actions can be utilized to engage in multimodal interactions resembling human behavior. With embodied intelligence gaining prominence within artificial intelligence research, there is growing emphasis on harnessing its potential in social group interactions. The convergence of human intelligence, robot intelligence, and embodied intelligence toward integrated group interaction intelligence represents a trending focus within Computer-Supported Cooperative Work (CSCW). This underscores the necessity of integrating advanced artificial intelligence technologies into the study of social group interactions to enhance interaction efficiency.

Conclusions

Processing and analyzing multimodal interaction data is essential in leveraging valuable human experience to aid in future group behavior, thereby improving overall group performance. In this paper, we propose a human-machine interaction architecture which utilizes social network technology to model the learning group.

This paper proposes dynamic interaction graphs for modelling multimodal interactions in group learning, and its performance is evaluated using the AMI corpus. Linguistic, hand gesture, and movement interactions are analyzed, and different roles and passive members who may require encouragement are identified. The findings provide feedback to teaching strategies, which can improve overall classroom performance. This approach unlocks the potential of novel group learning techniques that can harness the power of multimodal interaction data. In addition, the multimodal data stream format facilitates understanding of heterogeneous data, allowing individuals to acquire more knowledge and develop more practical insights through visualizing data.

Acknowledgments

This work was supported by National Natural Science Foundation of China (No. 61502246, 62006023), and Nanjing University of Posts and Telecommunications Science Foundation (Nos. NY215019, NY220202).

References

Abramczyk, A. and S. Jurkowski (2020): 'Cooperative learning as an evidence-based teaching strategy: What teachers know, believe, and how they use it'. *Journal of Education for Teaching*, vol. 46, no. 3, pp. 296–308.

Alvarez-Rodriguez, U., F. Battiston, G. F. de Arruda, Y. Moreno, M. Perc, and V. Latora (2021): 'Evolutionary dynamics of higher-order interactions in social networks'. *Nature Human Behaviour*, vol. 5, no. 5, pp. 586–595.

Apicella, C. L., F. W. Marlowe, J. H. Fowler, and N. A. Christakis (2012): 'Social networks and cooperation in hunter-gatherers'. *Nature*, vol. 481, no. 7382, pp. 497–501.

Barton, G. and M. Ryan (2014): ‘Multimodal approaches to reflective teaching and assessment in higher education’. *Higher Education Research & Development*, vol. 33, no. 3, pp. 409–424.

Carletta, J., S. Ashby, S. Bourban, M. Flynn, M. Guillemot, T. Hain, J. Kadlec, V. Karaiskos, W. Kraaij, M. Kronenthal, et al. (2005): ‘The AMI meeting corpus: A pre-announcement’. In: *International workshop on machine learning for multimodal interaction*. pp. 28–39.

Chang, X., X. Liu, J. Wen, S. Li, Y. Fang, L. Song, and Y. Qi (2020): ‘Continuous-time dynamic graph learning via neural interaction processes’. In: *Proceedings of the 29th ACM International Conference on Information & Knowledge Management*. pp. 145–154.

Chung, J. S., B.-J. Lee, and I. Han (2019): ‘Who said that?: Audio-visual speaker diarisation of real-world meetings’. *arXiv preprint arXiv:1906.10042*.

Deutsch, E. S., T. Christenson, J. Curry, J. Hossain, K. Zur, and I. Jacobs (2009): ‘Multimodality education for airway endoscopy skill development’. *Annals of Otology, Rhinology & Laryngology*, vol. 118, no. 2, pp. 81–86.

Ding, Z., Z. Yang, H. Lin, and J. Wang (2021): ‘Focus on Interaction: A Novel Dynamic Graph Model for Joint Multiple Intent Detection and Slot Filling.’. In: *IJCAI*. pp. 3801–3807.

Feng, X., X. Feng, B. Qin, and X. Geng (2020): ‘Dialogue discourse-aware graph model and data augmentation for meeting summarization’. *arXiv preprint arXiv:2012.03502*.

Foldnes, N. (2016): ‘The flipped classroom and cooperative learning: Evidence from a randomised experiment’. *Active Learning in Higher Education*, vol. 17, no. 1, pp. 39–49.

Fowler, J. H. and N. A. Christakis (2010): ‘Cooperative behavior cascades in human social networks’. *Proceedings of the National Academy of Sciences*, vol. 107, no. 12, pp. 5334–5338.

Gillies, R. M. (2004): ‘The effects of cooperative learning on junior high school students during small group learning’. *Learning and instruction*, vol. 14, no. 2, pp. 197–213.

Harary, F. and G. Gupta (1997): ‘Dynamic graph models’. *Mathematical and Computer Modelling*, vol. 25, no. 7, pp. 79–87.

Hassett, D. D. and J. S. Curwood (2009): ‘Theories and practices of multimodal education: The instructional dynamics of picture books and primary classrooms’. *The Reading Teacher*, vol. 63, no. 4, pp. 270–282.

Henrich, J. and M. Muthukrishna (2021): ‘The origins and psychology of human cooperation’. *Annual Review of Psychology*, vol. 72, pp. 207–240.

Hughes, E., J. Z. Leibo, M. Phillips, K. Tuyls, E. Dueñez-Guzman, A. García Castañeda, I. Dunning, T. Zhu, K. McKee, R. Koster, et al. (2018): ‘Inequity aversion improves cooperation in intertemporal social dilemmas’. *Advances in neural information processing systems*, vol. 31.

Jewitt, C. (2008): ‘Multimodality and literacy in school classrooms’. *Review of research in education*, vol. 32, no. 1, pp. 241–267.

Leeuwen, T. V. (2015): ‘Multimodality in education: Some directions and some questions’. *Tesol Quarterly*, vol. 49, no. 3, pp. 582–589.

Love, K. (2008): ‘Literacy across the school subjects: A multimodal approach’. *Multimodal semiotics: Functional analysis in contexts of education*, pp. 173–186.

Malone, T. W. (2018): ‘How human-computer ‘superminds’ are redefining the future of work’. *MIT Sloan management review*, vol. 59, no. 4, pp. 34–41.

Manuvinakurike, R., S. Sahay, W. Chen, and L. Nachman (2021): ‘Incremental temporal summarization in multi-party meetings’. In: *Proceedings of the 22nd Annual Meeting of the Special Interest Group on Discourse and Dialogue*. pp. 530–541.

Martinez-Maldonado, R., V. Echeverria, O. C. Santos, A. D. P. D. Santos, and K. Yacef (2018): ‘Physical learning analytics: A multimodal perspective’. In: *Proceedings of the 8th international conference on learning analytics and knowledge*. pp. 375–379.

Mihoub, A., G. Bailly, C. Wolf, and F. Elisei (2016): ‘Graphical models for social behavior modeling in face-to face interaction’. *Pattern Recognition Letters*, vol. 74, pp. 82–89.

Moreno, R. and R. Mayer (2007): ‘Interactive multimodal learning environments: Special issue on interactive learning environments: Contemporary issues and trends’. *Educational psychology review*, vol. 19, pp. 309–326.

Otten, K., U. J. Frey, V. Buskens, W. Przepiorka, and N. Ellemers (2022): ‘Human cooperation in changing groups in a large-scale public goods game’. *Nature Communications*, vol. 13, no. 1, pp. 6399.

Papakostas, G. A., G. K. Sidiropoulos, C. Lytridis, C. Bazinas, V. G. Kaburlasos, E. Kourampa, E. Karageorgiou, P. Kechayas, and M. T. Papadopoulou (2021): ‘Estimating children engagement interacting with robots in special education using machine learning’. *Mathematical Problems in Engineering*, vol. 2021, pp. 1–10.

Redcay, E. and L. Schilbach (2019): ‘Using second-person neuroscience to elucidate the mechanisms of social interaction’. *Nature Reviews Neuroscience*, vol. 20, no. 8, pp. 495–505.

Seebera, I., E. Bittner, R. Briggs, T. De Vreede, G.-J. de Vreeded, A. Elkins, R. Maier, A. Merz, S. Oeste-Reiß, N. Randrup, et al. (2020): ‘Machines as teammates: A research agenda on AI in team collaboration’. *Information Management*, vol. 57, no. 2.

Subburaj, S. K., A. E. Stewart, A. Ramesh Rao, and S. K. D’Mello (2020): ‘Multimodal, multiparty modeling of collaborative problem solving performance’. In: *Proceedings of the 2020 International Conference on Multimodal Interaction*. pp. 423–432.

Swanson, H. L. (2011): ‘Learning disabilities: Assessment, identification, and treatment’. *The Oxford handbook of school psychology*, pp. 334–350.

Tschandl, P., C. Rinner, Z. Apalla, G. Argenziano, N. Codella, A. Halpern, M. Janda, A. Lallas, C. Longo, J. Malvehy, et al. (2020): ‘Human–computer collaboration for skin cancer recognition’. *Nature Medicine*, vol. 26, no. 8, pp. 1229–1234.

Turk, M. (2014): ‘Multimodal interaction: A review’. *Pattern recognition letters*, vol. 36, pp. 189–195.

Turner, J. C. (2010): ‘Towards a cognitive redefinition of the social group.’. In: *Research Colloquium on Social Identity of the European Laboratory of Social Psychology, Dec, 1978, Université de Haute Bretagne, Rennes, France; This chapter is a revised version of a paper first presented at the aforementioned colloquium.*

van Dijk, E. and C. K. De Dreu (2021): ‘Experimental games and social decision making’. *Annual Review of Psychology*, vol. 72, pp. 415–438.

Xu, B., N.-S. Chen, and G. Chen (2020a): ‘Effects of teacher role on student engagement in WeChat-Based online discussion learning’. *Computers & Education*, vol. 157, pp. 103956.

Xu, X., Q. Zhang, and X. Chen (2020b): ‘Consensus-based non-cooperative behaviors management in large-group emergency decision-making considering experts’ trust relations and preference risks’. *Knowledge-Based Systems*, vol. 190, pp. 105108.

Yuan, Z. (2021): ‘RETRACTED: Interactive intelligent teaching and automatic composition scoring system based on linear regression machine learning algorithm’. *Journal of Intelligent & Fuzzy Systems*, vol. 40, no. 2, pp. 2069–2081.

Zaki, A., M. Attia, D. Hegazy, and S. Amin (2016): ‘Comprehensive survey on dynamic graph models’. *International Journal of Advanced Computer Science and Applications*, vol. 7, no. 2.

Zhang, G., J. Wu, M. Tan, and H. Han (2022): ‘Predicting Social Events with Multimodal Fusion of Spatial and Temporal Dynamic Graph Representations’. *Big Data*, vol. 10, no. 5, pp. 440–452.

Bourgeus, August; Vandercruysse, Laurens (2024): Reinvigorating Consent: Exploring New Paradigms for Privacy and Data Sharing. In: Proceedings of the 22nd European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies - Exploratory papers, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591), DOI: 10.48340/ecscw2024_ep08

Reinvigorating Consent: Exploring New Paradigms for Privacy and Data Sharing

August Bourgeus[a] & Laurens Vandercruysse[b]
[a]imec-SMIT, Vrije Universiteit Brussel. Pleinlaan 9 – 1050 Brussels, Belgium
[b]Department of Applied Economics, Vrije Universiteit Brussel. Pleinlaan 5 – 1050 Brussels, Belgium
august.bourgeus@vub.be

Abstract. This paper examines the inadequacies of the notice-and-consent paradigm in personal data processing, which fails to distribute data economy benefits fairly and degrades data privacy. We explore alternative frameworks like group privacy and contextual integrity that propose a communal and contextual approach to data privacy decisions. Critiquing the consent model for overlooking data externalities and the influence of cognitive biases, we argue against the de facto overreliance on individual consent under the General Data Protection Regulation (GDPR). Instead, we advocate for a revised model that integrates group privacy strategies and contextual norms with strategic, selective deployment of active consent. This proposed approach emphasises the balance between individual autonomy, group interests, and communal privacy norms, aiming to empower users with meaningful engagement in consent decisions. We discuss the potential of this model to enhance data privacy in the context of the evolving European Union data spaces and the personal data market.

Introduction

In this paper, we explore the evolving landscape of data privacy through the lens of the notice-and-consent paradigm, a foundational concept in data protection that requires users to be informed about how their data will be used, and to consent to these practices explicitly, e.g. by ticking a box. Despite being widely adopted, this paradigm has faced significant criticism for failing to ensure genuine user understanding and control, which is exacerbated by the complexity of modern data ecosystems. It has long been claimed that the notice-and-consent paradigm for personal data processing has failed to produce a balanced distribution of data economy benefits, leading to further eroding data privacy[1] levels. As a result, alternative normative theories for governing access to personal data have been developed. Group privacy (Floridi, 2017) and contextual integrity (Nissenbaum, 2009) conceptualise data privacy, and the decision as to whether or not personal data processing is desirable, as something group-based/communal. Consent is often sketched as a pragmatic, though misguided, attempt to solve a collective action problem by attributing individual rights to citizens (Sloan & Warner, 2013). Further criticisms include that the consent paradigm makes abstraction of data externalities (J. P. Choi et al., 2019) as well as the fact that cognitive biases and limitations impede rational decision-making in the data context (Kröger et al., 2021).

Article 4(11) of the General Data Protection Regulation defines consent as being actively, freely given, specific, informed, and unambiguous (The European Parliament and the Council of the European Union, 2016). However, the bar for consent to be meaningful is arguably higher and requires consent to be significant. It is possible for consent to be valid under GDPR sensu stricto, though not meaningful per se. Issues such as information asymmetries and the growing complexity of data ecosystems make privacy self-management impractical. While we agree that consent has its limits, we argue here that the overreliance on consent as a legal basis for processing personal data gets in the way of meaningful consent.

In contrast to scholars propagating doing away with notice-and-consent in its entirety, we think employing a combination of group logics - and institutions - for managing privacy in combination with targeted use of notice-and-consent can produce better outcomes for citizens. This model should incorporate individual autonomy, shared privacy norms and collaborative governance to truly empower users, allowing them to focus on important consent decisions for meaningful engagement. Taking into consideration the deployment of the various data spaces

[1] We will focus on data privacy as privacy and personal data protection are two distinct rights (González Fuster, 2014).

at the European Union level and the emergence of personal data markets, an operationalisation of the combination of these ideas imposes itself.

Our contribution lies in demonstrating the limitations of the current paradigm, while proposing a novel governance framework that balances individual consent with collective privacy considerations, and, finally, providing a starting point for the practical implementation of this model.

Background

The Problem with the Consent Paradigm

Over the past decades, privacy self-management (by consent) has been a central tenet of EU data privacy legislation. It is worth noting that while there are alternative legal bases for processing personal data, consent has emerged as the most popular one, with tech companies promoting its use. Although privacy self-management may seem to promote values such as liberalism and individualism, it often fails to succeed in empowering individuals for three main reasons.

First, existing obstacles to informed and rational privacy choices result from human limitations, bounded rationality and modern data processing (Acquisti et al., 2020; Kröger et al., 2021). As data ecosystems grow in complexity, expecting individuals to manage their privacy settings across a myriad of platforms becomes unrealistic. Consent is repeatedly requested and at inappropriate times, leading to a decrease in active user participation and consent rates (H. Choi et al., 2018). Research indicates that data subjects often lack sufficient knowledge to make informed decisions about disclosing personal information (Acquisti et al., 2020; Park, 2013; Weinshel et al., 2019). The explanations provided in privacy policies are insufficient for users to comprehend the outcomes of their consent. Their overwhelming length and complexity (Kröger et al., 2021; Luger & Rodden, 2014; Obar & Oeldorf-Hirsch, 2020), leads to passive acceptance of privacy terms and conditions rather than informed decision-making. This causes many users to inadvertently give permissions without comprehending the full implications of their choices, including aggregation and inference risks. Crabtree et al. (2017) who investigated privacy in a networked world, claim concerns center on maintaining control over personal and others' data privacy, managing unauthorized intrusions from the online world, and navigating the impact of networked interactions on personal relationships. The consequences for individuals can be challenging to trace, as they may occur gradually or over time due to multiple data transactions (Lazaro & Le Métayer, 2015; Solove, 2013).

Second, modern data collection and processing creates significant information asymmetries. These asymmetries inhibit data subjects from making informed privacy choices due to an unfair distribution of opportunities in terms of understanding, knowledge, prediction, and risk assessment (Mantalero, 2014). Information asymmetries mean that access to relevant information is different for different actors. These asymmetries are exacerbated by advancements in information technology that make data practices less visible, making individuals unsure about how much information they share (Acquisti et al., 2013). Information asymmetries become more complex with the growth of online services, policy updates, and users' tendency to disregard these agreements (Bashir et al., 2015).

Third, the current individual-centric consent model fails to address the communal impacts of data sharing and privacy decisions (Fairfield et al., 2015). Data externalities are particularly interesting here, as highlighted by Choi, Jeon, and Kim (2018), who illustrate the discrepancy between individual consent and communal outcomes. Their research demonstrates that even with individual consent, collective privacy can be compromised beyond what is socially optimal due to information externalities and user coordination failures. Moreover, Lovato et al. (2022) emphasise the inadequacy of traditional consent frameworks within digital environments, where a single user's consent can inadvertently expose connected individuals' data (Fairfield et al., 2015; Lovato et al., 2022). When a group of people shares a feature or a combination of features, it is possible to make inferences about them, which is referred to as inferential privacy (Loi & Christen, 2020). Additionally, individual consent decisions may not lead to optimal social outcomes, with privacy risks being both minor and scattered yet significant over time.

While consents under these three reasons could still be formally recorded as valid under GDPR, it is evident that these consents are hardly meaningful.

Alternative Paradigms

Various theories have advocated for an improved personal data ecosystem beyond the privacy self-management model. In what follows, we will introduce theories that could facilitate meaningful consent and go beyond the individual, like contextual integrity (Nissenbaum, 2009) and group privacy (Floridi, 2017; Taylor et al., 2017).

Nissenbaum's privacy as Contextual Integrity (CI) emphasises the importance of the appropriateness of information flows rather than solely relying on individual preferences. In CI, privacy is evaluated based on the contextual alignment of information sharing, where specific spheres, encompassing contexts and intended purposes, establish the guidelines for when and how different actors can access data. CI serves as a critical departure from traditional privacy approaches, offering a robust foundation for evaluating information practices based on the collective understanding and norms of a given context. CI has already been applied in various contexts and formats. Recently, Kumar et al. (2024) defined a roadmap for applying the CI framework in qualitative privacy research in the CSCW field.

Nissenbaum and Solove advocate that privacy and consent decisions must be contextually grounded, recognising that shared perceptions within different environments significantly influence privacy expectations (Nissenbaum, 2019; Solove, 2023). During a conference, a visitor may agree to have their photo taken and shared within the community but may not want the same photo to be used for commercial purposes. This approach underscores that privacy norms and consent mechanisms should be derived from the collective situational awareness and agreed-upon standards within distinct contexts, rather than the isolated preferences of individuals. Multiple studies support this view, illustrating that privacy expectations inherently vary in line with the situational parameters defined by CI (Apthorpe et al., 2018; Martin & Nissenbaum, 2015; Zhang et al., 2022).

Networked privacy (Lampinen, 2015) and group privacy (Floridi, 2017; Taylor et al., 2017) pave the way for alternative models. (Floridi, 2017) argued that groups may have privacy rights that are not reducible to those of their individual members. For example, activist or political groups must protect their strategies, communications, and identities. Exposing such information can threaten their goals and safety, highlighting a collective privacy right tied to their operational integrity and advocacy efforts (Jia & Baumer, 2022; Suh et al., 2018). The focus on group privacy advances the discussion by advocating for the internalisation of information externalities discussed in the previous section and promoting collective decision-making, thereby challenging the traditional individualistic approach. This shift towards group privacy involves developing mechanisms that empower groups to determine their data sharing and privacy standards rather than solely relying on individuals.

The principles of CI and group privacy might be practically facilitated by establishing data intermediaries (von Ditfurth & Lienemann, 2022). Data collective intermediaries like data cooperatives allow their members to have more control over their individual data and to use this data in the interest of their community or the commons (Bietti et al., 2021). Such a system should align with the specific values that a user embodies, and relevant stakeholders should be included in the ownership model. Another example is a data collaborative (Susha et al., 2017), which is a partnership between a private sector entity and a public sector, civil society, or academia entity to use private data for the public good and benefit of society.

CI and group privacy propose interesting perspectives, though they fall short of operationalisation. Seeing the developments at the EU level, there is an imminent need for a revised governance framework for personal data processing, taking into account the learnings from the limitations of consent and the merits of a contextual group-based view on privacy, while at the same time respecting the individual autonomy of the citizen in deciding what happens with their data and to participate in the data economy.

In what follows, we will present how we think such a model could look like – we will be basing some of the conjectures on the Solid-wave in Flanders, where the government is investing in the development of a personal data ecosystem where citizens exercise control over personal data via a decentralised container, based on the Solid specification.

A Revised Model

We propose a revised model that, while retaining the foundation of individual consent, is significantly enhanced by incorporating contextual cues and group norms into the personal data governance ecosystem. The revised model could be described as a type of semi-automated consent model (Gomer et al., 2014). It aims to address the dynamic nature of privacy expectations by enabling individuals to set consent preferences that are sensitive to different contexts and align with the collective norms of groups they belong to or identify with.

Following CI, it could be acceptable for data controllers to obtain consent only once for various operations as long as they are within the reasonable expectations of the data subject. The GDPR, in Article 6(4), permits the continued processing of personal data for purposes that align with the original collection purpose without requiring new consent. Such expectations can be derived by applying the contextual integrity framework. Adding these expectations to the current paradigm would incorporate both individual sovereignty and automated decisions based on individual preferences and communal values. The revised model aligns with the EU's efforts on data spaces and data strategy (Susha et al., 2017). We maintain a role for active consent, but only in important privacy decisions. The level of importance attached to the consent decision could vary based on the context, the sensitivity of the information, and the potential consequences of information misuse. To illustrate, people or their caregivers may desire greater authority over the sharing of their medical data because such information is personal and carries the risk of being misused. Likewise, when seeking a loan, a person may require more active consent due to the wide variance in what information flow is deemed acceptable and the absence of community norms.

Group privacy theory argues for data privacy rights for groups that are distinct from those at the individual level. In practice, managing group privacy will necessitate setting up institutions for deliberation and decision-making at the group level. Also, at this level, CI could inform deriving group-based norms to limit the necessary engagement of individual citizens while allowing them to 'vote' in more contested group consent matters.

The implementation of a semi-automated consent system could potentially enable meaningful consent. By using CI and group privacy, we can derive acceptable information flows that data subjects could automatically consent to, but this is not fully covered. Difficult or ambiguous information flows still require human oversight. Semi-automated consent mechanisms or intermediaries can work as agents for the data subject to manage their daily consent and privacy decisions.

Following the enactment of the Data Governance Act (DGA), there has been a notable increase in the advocacy for the deployment of data intermediaries. Janssen & Singh (2022) define data intermediaries as entities that "serve as mediators between those wishing to make their data available and those seeking to leverage such data." Examples of such intermediaries include clearinghouses, service catalogues, and data cleaners. As an example, the Flemish government has established a data utility company, a public-private entity, to foster data-sharing ecosystems. They offer services such as infrastructure provision, ecosystem auditing, and standardisation (Digitaal Vlaanderen, n.d.). Such intermediaries could also act as consent intermediaries (Lehtiniemi & Kortesniemi, 2017). Lehtiniemi & Kortesniemi (2017, pp. 10) argue that: “intermediaries could be leveraged to develop tools to mitigate obstacles, helping people understand the decisions they make, better evaluate their consequences, and simplify the decisions themselves.”

A technology of interest that has recently received much traction is Solid (Sambra et al., 2016). Solid allows individuals to store their data in personal online data stores (pods) and manage access through granular consent tools. Integrating this technology with the revised consent model facilitates a more nuanced consent process, where individuals can automate their privacy preferences based on predefined contexts and community standards. Using Solid to obtain consent has been researched by (Florea & Esteves, 2023), who investigated a technical and legal approach to consent. We argue that coding privacy norms or rules into a system as access control policies forms a promising approach, worthy of further exploration and research. This approach not only streamlines consent management for data subjects but also aligns with broader social and ethical norms, reflecting the shift towards more informed and context-aware data practices. Solid as a web standard/ interoperable technology should also facilitate setting up data collaboratives, etc., as lack of interoperability is one of the premier hindrances for these institutions to scale (Susha, 2020). In Flanders, the northern part of Belgium, the government has funded a research project to investigate the challenges and opportunities of Solid-enabled Personal Data Store (PDS) ecosystems to improve information flows while safeguarding privacy for citizens. The government-funded PDS-based data ecosystem is attempting to make this work with an eye on allowing citizens to play an active role. Integrating our proposed adaptations could facilitate the shift towards a more inclusive, transparent, and user-controlled data environment. These developments could facilitate the shift to a semi-automated consent model.

In the revised model, a data subject could manage preferences via a dashboard that can be shared with a group. A primary layer of safeguards can be applied for common, socially acceptable information flows, supplemented with a top layer of personalised preferences.

Conclusion & Future Research

In conclusion, the revised model represents a transformative step in personal data governance, combining individual preferences with the nuances of context and group norms. The integration of Solid and the role of data intermediaries illustrate a practical, user-centred approach that aligns with legislative standards like the GDPR and DGA. As long as individuals' privacy choices are falsely painted and perceived as expressions of their freedom and autonomy, there will be little resistance to the status quo. However, future research should focus on several tracks to refine and validate this semi-automated consent model.

First, communal privacy norms need to be derived, which can be programmed into systems as policies. Such policies can reserve active consent for specific instances, but requiring too much effort will adversely affect empowerment. Hence, research on which consents can be automated is necessary. Besides, research is needed to investigate whether the principles and applications of CI, typically considered at the individual level, need to be adapted when these intermediaries are involved, reflecting the potentially different dynamics and privacy concerns at play.

Second, while data intermediaries are the subject of extensive research (Bietti et al., 2021; Janssen & Singh, 2022; Susha et al., 2017; von Ditfurth & Lienemann, 2022), they remain sparsely implemented in real-world settings. Exploring the practical manifestations of novel ecosystems built around these intermediaries is crucial. The concept of data intermediaries often remains obscure to companies and data subjects alike, underscoring the need for research into their adoption and assessing how effectively they balance individual and collective governance approaches. Their development and implementation could ease some of the group privacy concerns while catering to demands for norm-based unburdening of data subjects. However, research is needed on how these group institutions should be managed.

Third, further development of standards, ontologies, and integration of technologies like Solid is needed. Interoperability is key to making the system work for data subjects and avoiding a winner-take-all network effect that leads to insurmountable power asymmetries in the data ecosystem.

Last, exploring a semi-automated consent system's interface and user journey is of considerable importance. Future research should focus on ensuring the remaining consents in the data governance models are genuinely meaningful. This entails investigating strategies for enhancing user understanding and consent quality - what makes consent meaningful, and how can this be achieved? Addressing dark patterns that mislead or manipulate users into providing consent unwittingly and increasing literacy is another vital area. Additionally, research should explore the mechanisms for enhanced enforcement of consent regulations to ensure user decisions are respected and protected.

Although revised consent models provide enhanced protection against tracking and surveillance, they can also introduce new privacy risks and complexities, such as the involvement of additional third parties and the need for disclosing more information. Additionally, these systems require some level of understanding for proper selection and operation, which is something to consider when designing such systems.

Acknowledgments

This research was supported by SolidLab Vlaanderen (Flemish Government, EWI and RRF project VV023/10)

References

Acquisti, A., Adjerid, I., & Brandimarte, L. (2013). Gone in 15 seconds: The limits of privacy transparency and control. *IEEE Security and Privacy*, *11*(4), 72–74. https://doi.org/10.1109/MSP.2013.86

Acquisti, A., Brandimarte, L., & Loewenstein, G. (2020). Secrets and Likes: The Drive for Privacy and the Difficulty of Achieving It in the Digital Age. *Journal of Consumer Psychology*, *30*(4), 736–758. https://doi.org/10.1002/jcpy.1191

Apthorpe, N., Shvartzshnaider, Y., Mathur, A., Reisman, D., & Feamster, N. (2018). Discovering Smart Home Internet of Things Privacy Norms Using Contextual Integrity. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*, *2*(2), 1–23. https://doi.org/10.1145/3214262

Bashir, M., Hayes, C., Lambert, A. D., & Kesan, J. P. (2015). Online privacy and informed consent: The dilemma of information asymmetry. *Proceedings of the Association for Information Science and Technology*, *52*(1), 1–10. https://doi.org/10.1002/pra2.2015.145052010043

Bietti, E., Etxeberria, A., Mannan, M., & ... (2021). Data Cooperatives in Europe: a legal and empirical investigation. *The New School's Platform Cooperativism Consortium and Harvard University's Berkman Klein Center for Internet & Society Research Sprint*. https://openfuture.eu/wp-content/uploads/2022/03/Data_Cooperatives_Europe-group2.pdf

Choi, H., Park, J., & Jung, Y. (2018). The role of privacy fatigue in online privacy behavior. *Computers in Human Behavior*, *81*, 42–51. https://doi.org/10.1016/j.chb.2017.12.001

Choi, J. P., Jeon, D.-S., & Kim, B.-C. (2019). Governance of Platform Markets in the "Big Data" Era. *Journal of Public Economics*, *173*, 113–124.

Crabtree, A., Tolmie, P., & Knight, W. (2017). Repacking 'Privacy' for a Networked World. *Computer Supported Cooperative Work: CSCW: An International Journal*, *26*(4–6), 453–488. https://doi.org/10.1007/s10606-017-9276-y

Digitaal Vlaanderen. (n.d.). *The Flemish Data Utility Company*. Retrieved February 25, 2024, from https://www.vlaanderen.be/digitaal-vlaanderen/athumi-het-vlaams-datanutsbedrijf/the-flemish-data-utility-company

Fairfield, J. A. T., Engel, C., Regan, P., Hirsch, D., Hoofnagle, C. J., Hartzog, W., Bambauer, J., Froomkin, M., Seaman, C., Hu, M., Kaminski, M., Candeub, A., Jost, J., & Lastowka, G. (2015). Privacy as a public good. *Duke Law Journal*, *65*, 385.

Florea, M., & Esteves, B. (2023). Is Automated Consent in Solid GDPR-Compliant? An Approach for Obtaining Valid Consent with the Solid Protocol. *Information (Switzerland)*, *14*(12), 631. https://doi.org/10.3390/info14120631

Floridi, L. (2017). Group Privacy: A Defence and an Interpretation. In L. Taylor, L. Floridi, & B. van der Sloot (Eds.), *Group Privacy* (pp. 83–100). Springer International Publishing. https://doi.org/10.1007/978-3-319-46608-8_5

Gomer, R., Schraefel, M. C., & Gerding, E. (2014). Consenting agents: Semi-autonomous interactions for ubiquitous consent. *UbiComp 2014 - Adjunct Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, 653–658. https://doi.org/10.1145/2638728.2641682

González Fuster, G. (2014). *The Emergence of Personal Data Protection as a Fundamental Right of the EU* (Vol. 16). Springer International Publishing. https://doi.org/10.1007/978-3-319-05023-2

Janssen, H., & Singh, J. (2022). Data intermediary. *Internet Policy Review*, *11*(1), 1–9. https://doi.org/10.14763/2022.1.1644

Jia, H., & Baumer, E. P. S. (2022). Birds of a feather: Collective privacy of online social activist groups. *Computers & Security*, *115*, 102614. https://doi.org/10.1016/j.cose.2022.102614

Kröger, J. L., Lutz, O. H.-M., & Ullrich, S. (2021). The myth of individual control: Mapping the limitations of privacy self-management. *SSRN Electronic Journal*, ...(...), 106705. https://doi.org/10.2139/ssrn.3881776

Kumar, P., Zimmer, M., & Vitak, J. (2024). A Roadmap for Applying the Contextual Integrity Framework in Qualitative Privacy Research. *Proceedings of the ACM on Human-Computer Interaction*, *8*(April). https://doi.org/10.1145/3653710

Lampinen, A. (2015). Networked privacy beyond the individual: Four perspectives to sharing. *Critical Alternatives - Proceedings of the 5th Decennial Aarhus Conference, CA 2015, October 2015*, 25–28. https://doi.org/10.7146/aahcc.v1i1.21300

Lazaro, C., & Le Métayer, D. (2015). Control over personal data: True remedy or fairytale? *SCRIPTed*, *12*(1). https://doi.org/10.2966/scrip.120115.3

Lehtiniemi, T., & Kortesniemi, Y. (2017). Can the obstacles to privacy self-management be overcome? Exploring the consent intermediary approach. *Big Data and Society*, *4*(2), 1–11. https://doi.org/10.1177/2053951717721935

Loi, M., & Christen, M. (2020). Two Concepts of Group Privacy. *Philosophy and Technology*, *33*(2), 207–224. https://doi.org/10.1007/s13347-019-00351-0

Lovato, J. L., Allard, A., Harp, R., Onaolapo, J., & Hébert-Dufresne, L. (2022). Limits of Individual Consent and Models of Distributed Consent in Online Social Networks. *ACM International Conference Proceeding Series*, 2251–2262. https://doi.org/10.1145/3531146.3534640

Luger, E., & Rodden, T. (2014). The value of consent: Discussions with designers of ubiquitous computing systems. *2014 IEEE International Conference on Pervasive Computing and Communication Workshops, PERCOM WORKSHOPS 2014*, 388–393. https://doi.org/10.1109/PerComW.2014.6815237

Mantalero, A. (2014). Social control, transparency, and participation in the big data world. *Journal of Internet Law*, *17(10)*, 23–29.

Martin, K. E., & Nissenbaum, H. (2015). Measuring Privacy: Using Context to Expose Confounding Variables. *SSRN Electronic Journal*, *January*. https://doi.org/10.2139/ssrn.2709584

Nissenbaum, H. (2009). *Privacy in Context: Technology, Policy, and the Integrity of Social Life*. Stanford Law Books.

Nissenbaum, H. (2019). Contextual integrity up and down the data food chain. *Theoretical Inquiries in Law*, *20*(1), 221–256. https://doi.org/10.1515/til-2019-0008

Obar, J. A., & Oeldorf-Hirsch, A. (2020). The biggest lie on the Internet: ignoring the privacy policies and terms of service policies of social networking services. *Information Communication and Society*, *23*(1), 128–147. https://doi.org/10.1080/1369118X.2018.1486870

Park, Y. J. (2013). Digital Literacy and Privacy Behavior Online. *Communication Research*, *40*(2), 215–236. https://doi.org/10.1177/0093650211418338

Sambra, A. V., Mansour, E., Hawke, S., Zereba, M., Greco, N., Ghanem, A., Zagidulin, D., Aboulnaga, A., & Berners-Lee, T. (2016). *Solid: A Platform for Decentralized Social Applications Based on Linked Data*.

Sloan, R. H., & Warner, R. (2013). Beyond Notice and Choice: Privacy, Norms, and Consent. *SSRN Electronic Journal*, *January*. https://doi.org/10.2139/ssrn.2239099

Solove, D. J. (2013). *INTRODUCTION : PRIVACY SELF-MANAGEMENT AND THE CONSENT DILEMMA Author (s): Daniel J . Solove Source : Harvard Law Review , MAY 2013 , Vol . 126 , No . 7 (MAY 2013), pp . 1880-1903 Published by : The Harvard Law Review Association Stable URL : https://. 126*(7), 1880–1903. https://doi.org/https://ssrn.com/abstract=2171018

Solove, D. J. (2023). Data Is What Data Does: Regulating Use, Harm, and Risk Instead of Sensitive Data. *SSRN Electronic Journal*, *118*(4), 1081–1138. https://doi.org/10.2139/ssrn.4322198

Suh, J. J., Metzger, M. J., Reid, S. A., & El Abbadi, A. (2018). Distinguishing group privacy from personal privacy: The effect of group inference technologies on privacy perceptions and behaviors. *Proceedings of the ACM on Human-Computer Interaction*, *2*(CSCW). https://doi.org/10.1145/3274437

Susha, I. (2020). Establishing and implementing data collaborations for public good: A critical factor analysis to scale up the practice. *Information Polity*, *25*(1), 3–24. https://doi.org/10.3233/IP-180117

Susha, I., Janssen, M., & Verhulst, S. (2017). Data collaboratives as a new frontier of cross-sector partnerships in the age of open data: Taxonomy development. *Proceedings of the Annual Hawaii International Conference on System Sciences*, *2017-Janua*, 2691–2700. https://doi.org/10.24251/hicss.2017.325

Taylor, L., Floridi, L., & van der Sloot, B. (2017). *Group Privacy: New Challenges of Data Technologies*. https://doi.org/10.2966/scrip.140117.131

The European Parliament and the Council of the European Union. (2016). *GDPR - 32016R0679 - EN - EUR-Lex*. EUR-Lex. http://data.europa.eu/eli/reg/2016/679

von Ditfurth, L., & Lienemann, G. (2022). The Data Governance Act: – Promoting or Restricting Data Intermediaries? *Competition and Regulation in Network Industries*, *23*(4), 270–295. https://doi.org/10.1177/17835917221141324

Weinshel, B., Wei, M., Mondal, M., Choi, E., Shan, S., Dolin, C., Mazurek, M. L., & Ur, B. (2019). Oh, the places you've been! User reactions to longitudinal transparency about third-party web tracking and inferencing. *Proceedings of the ACM Conference on Computer and Communications Security*, 149–166. https://doi.org/10.1145/3319535.3363200

Zhang, S., Shvartzshnaider, Y., Feng, Y., Nissenbaum, H., & Sadeh, N. (2022). Stop the Spread: A Contextual Integrity Perspective on the Appropriateness of COVID-19 Vaccination Certificates. In *ACM International Conference Proceeding Series* (Vol. 1, Issue 1). Association for Computing Machinery. https://doi.org/10.1145/3531146.3533222

Ortega, Deysi and Bartolini, Rosario and Pareja, Rossina and Creed-Kanashiro, Hillary M. and Stawarz, Katarzyna and Holdsworth, Michelle and Rousham, Emily and Verdezoto, Nervo (2024): Barriers and Facilitators to Participation when Involving Caregivers and Healthcare Workers in Co-design Workshops in Peruvian Low-resource Settings . In: Proceedings of the 22nd European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies - Exploratory papers, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591), DOI: 10.48340/ecscw2024_ep09

Barriers and Facilitators to Participation when Involving Caregivers and Healthcare Workers in Co-design Workshops in Peruvian Low-resource Settings

Ortega, Deysi[1] and Bartolini, Rosario[2] and Pareja, Rossina[2] and Creed-Kanashiro, Hillary M.[2] and Stawarz, Katarzyna[1] and Holdsworth, Michelle[3] and Rousham, Emily[4] and Verdezoto, Nervo[1]
School of Computer Science and Informatics, Cardiff University, Wales, UK[1]
Instituto de Investigación Nutricional, Lima, Peru[2]
Institut de Recherche pour le Développement, Montpellier, France[3]
School of Sport, Exercise and Health Sciences, Loughborough University, UK[4]
Contact Author: ortegaromandh@cardiff.ac.uk, verdezotodiasn@cardiff.ac.uk

Abstract. Participatory Design (PD) approaches aim to engage various stakeholders to democratise the design process and influence the development of technologies. However, the use of PD approaches is challenging in low-resource settings. This paper presents the lessons learned from conducting future workshops with caregivers and healthcare workersas part of a project aiming to co-design health interventions to promote healthy nutrition in low-resource settings in Peru. Reflecting on these workshops, we present a number of barriers and facilitators highlighting the physical, social and temporal factors that affect participation in low-resource settings. Tailoring and adapting design methods do help reducing the level of complexity and fostering engagement and participation in PD activities in low-resource settings.

1 Introduction

Participatory Design (PD) approaches aim to engage various stakeholders through cooperative activities as a way to democratise the design process and influence the development of technologies that will affect their everyday lives (Bødker et al., 2022; Kyng, 1991; Sanders and Stappers, 2008). However, challenges for participation exist, such as power differentials within participants, facilitators and other stakeholders that may hinder participants' engagement in co-design processes (Farr, 2018). These could be exacerbated by the participant's conditions, their level of technology readiness and their everyday environments when designing healthcare interventions (Aarhus et al., 2010). In low-resource settings, the situated power dynamics might not be explicitly recognised or known by researchers, developers, and facilitators before the workshops that could impact the level of participation (Del Gaudio et al., 2014; Winschiers-Theophilus et al., 2012). Furthermore, sociocultural factors such as gender norms, geography, community hierarchical structures, and social and political issues can affect participants' engagement during the design process and the design outcomes, especially in the Global South (Jiang et al., 2022; Hussain et al., 2012; Winschiers-Theophilus et al., 2010; Till et al., 2022).

This exploratory paper describes some of our experiences working with different community stakeholders, including different types of healthcare workers and caregivers of infant and young children (IYC) under 2 years old in a recent project that aimed to co-design community-based healthcare interventions to promote healthy IYC nutrition (Rousham et al., 2023). Our co-design process involved a series of co-design workshops including idea generation workshops, future workshops, storyboarding workshops and prototyping workshops (Ortega et al., 2024) in two low-resource settings in Peru (Rousham et al., 2023). In this paper, we reflect on the practicalities and lessons learned of the future workshops including the role of the physical (the venue, and visual materials), social (verbal encouragement, attitudes, safe spaces, roles of healthcare workers), and temporal (everyday time demands, constraints, and issues with punctuality) factors that affected workshop's participation. Although we considered these factors during the initial plan of the activities, they manifested in different ways highlighting the need for designers and researchers to consider them when co-designing health interventions with caregivers and healthcare workers in low-resource settings.

2 Related Work

Workshops are one of the traditional collaborative methods in PD to support participation where different actors converge to engage in cooperative design activities offering the space for mutual learning by sharing ideas, expertise and knowledge about current and future practices (Bødker et al., 2022; Hansen et al., 2019). Workshops have been used to support the understanding of complex work and knowledge processes (Ørngreen and Levinsen, 2017), to explore the co-design of games with intergenerational participants (Rice et al., 2012), or to facilitate play and engagement while supporting hospitalised children (Huerga et al., 2016), just to mention a few. Rosner et al. (2016) points out that design workshops may serve as a site of inquiry, a research instrument and a research account simultaneously.

Design workshops aim to foster users' participation and better understand users' goals, experiences, and emotions (Ciolfi et al., 2016). Jungk and Müllert (1987) proposed the future workshop to support ordinary people facing a common challenge to explore desirable futures and solve small and large-scale social problems (Suoranta and Teräs, 2023). Future workshops involve a preparatory phase (e.g., practical arrangements and deciding on topics) and three workshop phases: critique (of chosen topics), fantasy (coming up with desires and alternative futures) and implementation (identifying challenges to achieve the best selected scenario and drafting a plan for action) (Jungk and Müllert, 1987; Vidal et al., 2006). The future workshop has been adapted and used widely in different contexts such as healthcare (Clemensen et al., 2007) or to engage with children and young people in vulnerable situations (Alminde and Warming, 2020), switching from "what is to what is not yet, but what could be" (Suoranta and Teräs, 2023). However, it could be challenging as participants might have difficulties voicing their ideas (Jungk and Müllert, 1987) or expressing their preferred futures Dator (1993), and could also be time-consuming, impacting people's willingness to participate due to other work or life activities (Suoranta and Teräs, 2023).

Moreover, previous research highlights how workshops still remain a privileged activity that could fail to produce equitable design solutions, especially for underserved communities (Harrington et al., 2019). Socio-cultural aspects such as community hierarchical structures, religious beliefs, social problems, etc., can affect participants' engagement in design workshops especially in low-resource settings (Hussain et al., 2012; Till et al., 2022). Other challenges include how the location and conditions of the venue influence people's participation (Farr, 2018; Raman and French, 2022) and the time imposed by the workshops' structure that are not always aligned with participants' needs or routines (Rosner et al., 2016). Thus, engaging in participatory design research in low-resource settings requires an ongoing negotiation among diverse stakeholders with different needs, values, expectations and motivations taking into account the sociocultural context and realities of people's everyday lives (Byrne and Sahay, 2007).

To develop the capacity of the users (Byrne and Sahay, 2007), different visual materials such as cards, storyboards and sketches have been utilised to enhance participatory processes and support people in articulating their ideas, especially with marginalised or vulnerable communities (Raman and French, 2022; Till et al., 2022). However, when materials are not contextualised they can also create friction and prevent more engaged participation (Harrington et al., 2019).

3 Research Context and Methods

This study is part of a larger multidisciplinary research project (seven co-investigators from Peru, one from France, and eight from the UK) that started in 2019 aiming to create new strategies to tackle the double burden of malnutrition in children aged 6-23 months in two peri-urban low-income communities in Peru: Manchay in the city of Lima in the Coastal region, and the city of Huánuco, in the Andean highlands. Initially, we conducted qualitative (observations and interviews) and quantitative (surveys) studies to get an understanding of the context and the major challenges around breastfeeding, complementary feeding and maternal dietary diversity (Pradeilles et al., 2022). The fieldwork took place at four health centres (two in Manchay and two in Huánuco) and in the caregivers' households surrounding these healthcare centres. The four major challenges that informed the next co-design phase are: 1) High consumption of unhealthy foods, sugar-sweetened beverages and savoury snacks (fried, salty, and sweet products) in mothers and IYC, 2) Low prevalence of (or difficulties with) iron supplementation in IYC, 3) Issues with nutritional counselling and maternal well-being, and 4) No way of tracking the double burden of malnutrition at the healthcare centres.

In summer 2022, we engaged with healthcare workers (healthcare professionals (HCPs) and health promoters (HPs)) and caregivers of IYC through a series of co-design workshops (idea generation workshops, future workshops, storyboarding workshops and prototyping workshops) to explore the design space for potential solutions to address the aforementioned four major challenges in two low-resource settings in Peru (Rousham et al., 2023). The project received ethical approval from the Nutritional Research Institute in Lima, Peru, and from Loughborough University and confirmed by Cardiff University in the UK.

3.1 Future Workshops: Practicalities and Structure

3.1.1 Pre-workshop activities and Participant Recruitment

Based on the results from idea-generation workshops in Huánuco and Manchay, we got nine clusters of ideas that were transformed into visual representations by the first author (e.g. promoting healthy eating with informative and demonstrative sessions as illustrated in Figure 1a).

To support the critique phase, the research team prepared a big paper template with a circle at the centre to place a selected idea and three main divisions to collect participants' input regarding the selected idea's advantages, disadvantages and the ideal state (see Figure 1a). For the fantasy phase in Huánuco, an A3 template with

Table I. Number of participants during the Future Workshops.

Place	Phases	HC-Staff	Caregivers	Facilitators
Huánuco	Critique	3 HCPs	12	3
	Fantasy	3 HCPs 3 HPs	9	2
Manchay	Fantasy and Critique	3 HCPs	6	2

a sketch of the waiting area of the healthcare centre was created to support the discussion and help them imagine and sketch alternative futures (see Figure 1b).

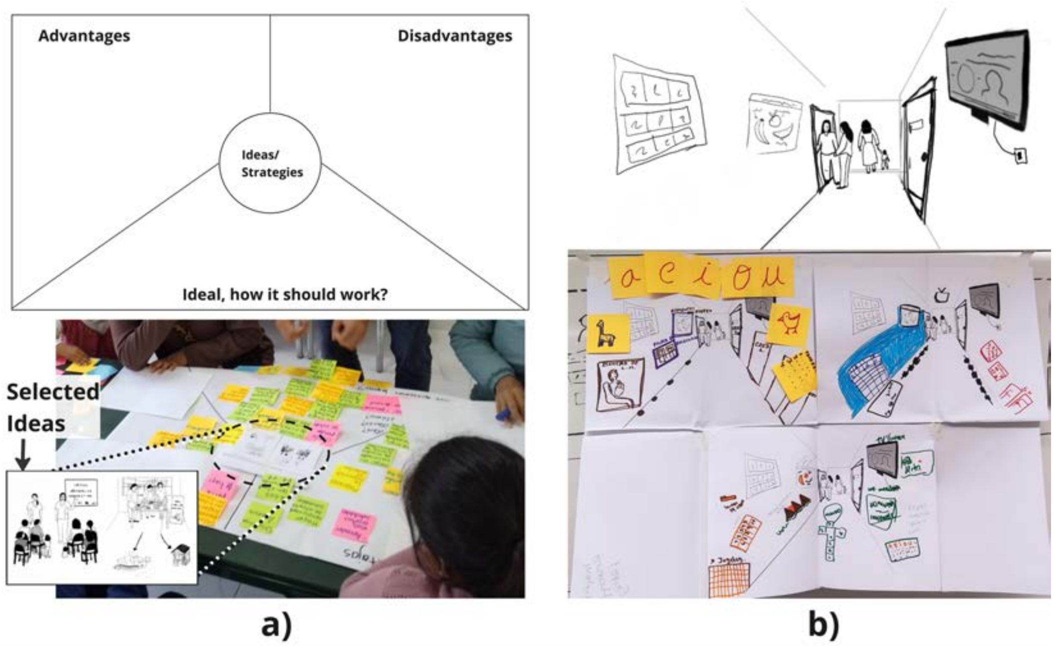


Figure 1. Visual materials for future workshops: a) Above, the big paper template for the critique phase, and below, participants in Manchay using the template for the selected idea; b) Above, an A3 template with a sketch of the waiting area of the healthcare centre, and below three examples of co-produced sketches envisioning a future waiting area in Huánuco.

In partnership with the health centres in Huánuco and Manchay, we recruited nine HCPs that participated during their regular working hours, and three HPs that bring health care services closer to caregivers' homes (e.g., regular visits to monitor the progress and growth of infants during their first year of life). Twenty-one caregivers were recruited in Huánuco and six in Manchay (See Table I). We engage with healthcare workers and caregivers as proxy-users (Sjölinder et al., 2017; Dai and Moffatt, 2021) due to their important role in the development of children's eating habits and considering that IYC under two years are unable to participate in the co-design activities as they depend on their parents.

When planning the workshops, we paid particular attention to the potential factors (e.g., time and location, power dynamics, diverse needs, digital literacy, childcare, etc.) that could influence caregiver's involvement based on previous experiences in other low-resource settings and insights from previous co-design workshops. For example, we arranged sessions in the afternoon considering the children's consultation appointments. We also set up a playing area where three researchers and two HPs helped to supervise babies and toddlers during the workshops to facilitate caregiver's participation. In Huánuco, the workshop took place in an auditorium space at the healthcare centre in two sessions (critique phase in August 2022, fantasy phase in September 2022) to avoid long sessions that could be tiresome for caregivers as participants arrived late to the first session. In Manchay, the future workshop occurred in one session (August 2022) in a rented venue, considering the space restrictions observed in previous workshops, and 10 minutes walking distance from an associated healthcare centre.

3.1.2 Introduction and giving an overview of previous workshops

In Huánuco, we had three facilitators for the critique and two for the fantasy phases. In Manchay, we had two facilitators for the entire workshop. The facilitators were mediators or participating observers (Trapani (2019)), scaffolding the co-design activities, letting the participants work but also asking questions or intervening when necessary. A facilitator welcomed participants and introduced the research team with an icebreaker activity in every co-design workshop. Next, another facilitator briefly explained the nine visual clusters of ideas placed on the walls around the venue and invited participants to stand up and walk around (like a visit to the museum) to check the clusters of ideas, and voice their understanding or ask further questions. Considering the number of participants in each setting, participants voted for the top three visual clusters in Huánuco and the top two in Manchay according to their perceived importance in relation to their own realities.

3.1.3 Critique Phase

Participants were divided into small groups to brainstorm at separate tables where they got pens, markers, post-its, and flip charts to sketch or write all the criticism down. We balance the number of participants in each small group so that the number of caregivers would never be less than the number of healthcare workers. In Manchay, the first group had 5 participants (2 HCPs and 3 caregivers) and the second group had 4 participants (1 HCP and 3 caregivers). In Huánuco, there were three small groups: the first group with 5 participants (1 HCP and 4 caregivers), the second group with 5 participants (1 HCP and 4 caregivers), and the third group with 4 participants (1 HCP and 3 caregivers).

Each small group randomly received one of the top clusters of ideas and asked to confirm if they were happy to continue with the assigned cluster. Participants were asked to rank the individual visual ideas within the selected cluster and decide which one they would want to criticize or combine. The selected idea was then placed at the centre of the big paper template (as illustrated in Figure 1a). First, facilitators invited participants to discuss the advantages, disadvantages, and problems around the selected ideas. Second, participants were asked to reflect on how they could address the emerging challenges, and whether technology could be helpful or not.

3.1.4 Fantasy Phase

In Manchay, facilitators asked participants to address the critiques and be creative by sketching how they envisioned alternative futures based on their own experiences. Considering their level of digital literacy uncovered in previous workshops, we suggested imagining without restrictions and assuming that everything could be possible. In Huánuco, the fantasy phase took place a month after the critique phase. The first small group had 6 participants (2 HCP, 1 HP, 3 caregivers) and the second group had 7 participants (1 HCP, 1 HP, 5 caregivers). Participants worked together in pairs. One HCP or HP was paired with a caregiver in the first group. The second group had three pairs (a pair of two caregivers and two pairs of one HCP/HP with a caregiver). As suggested by previous research (Markham (2021); Suoranta and Teräs (2023)), and considering the low level of digital literacy we observed in previous workshops, we invited each small group to go on a short tour to the waiting area of the healthcare centre to facilitate envisioning. We asked them to observe the physical and material elements of the waiting area, recall their experiences while waiting for their child's appointment, and think about what is missing and what they could imagine to add to transform the space and draw it on the A3 templates.

At the end, participants shared their drawings within their groups and commented on how to improve each other's ideas. Then, they had 5 minutes of break to eat, relax, and talk between them about their collective ideas.

3.1.5 Closing the workshop

Each group shared their sketches with everyone to get feedback and comments. Next, the workshop finished by reflecting on what participants like, what they did not like, what could be improved, and participants provided feedback.

3.2 Data Analysis

The first author captured the sketches and notes from participants' outcomes, transcribed the audio recordings of the workshops (5h 55m in Huánuco and 2h 30min in Manchay) and used Reflexive Thematic Analysis (Braun and Clarke (2021)) for analysis. After being familiarised with the data, initial codes were generated. The codes with their quotes were placed in virtual post-its notes on Miro (an online collaborative board tool). Miro allowed the first author to verify and reflect on the codes and use Miro's 'comments' functionality to make questions and annotations to better understand the data. For generating the themes, the first author discussed the partial results with two members of the research team: one with expertise in global public health (ER) and the last author with expertise in human-computer interaction for development (NV). Last, the first and last authors reviewed and refined the potential themes. All the data collected was analysed in Spanish and translated to English for reporting.

4 Findings: Barriers and Facilitators for Participation

4.1 Physical factors: The role of the venue and visual materials

The research context and the venue of the workshops played an important role to make participants feel comfortable. While we rented a big venue with good illumination not far from the healthcare centre in Manchay that was well received e.g., the venue was *"very nice"* (Manchay HCP01), we could not find a big venue to rent close to the healthcare centre in Huánuco, and activities took place in the auditorium of the health centre. On the one hand, this facilitated the attendance of healthcare workers and caregivers. On the other hand, it might not have been considered as important as healthcare workers were mostly late as they tried to fit the sessions as part of the working hours.

In addition, setting up the playing area for children (e.g., a mat with toys) in the same room was attractive and playful for children and also supported caregivers' participation enabling them to check on their children at any time while focusing on the activity at hand. If a child started to cry, the researchers immediately took them to their mom to feed them or calm them down. For instance, a caregiver stated: *"Right now, I'm focused on this because someone is caring for my baby"* (Manchay Caregiver05). However, we still faced an unavoidable challenge when a child cried as it could have been distracting for the participants, e.g.,: *"[a child] is crying, [...] where is his mom?"* (Huánuco-S2 Caregiver01). In these few occasions, caregivers had to take care of their IYC and either continue participating while breastfeeding them at the table, or some preferred to go to a separated space to feed them, preventing them to fully focus.

The visual materials also played an important role to facilitate participation while catching the participant's attention and being simple to understand. First, the visual clusters of ideas facilitated a share understanding of the illustrated ideas, and supported caregiver's engagement as participants discussed them or asked questions to confirm their understanding of the ideas. For example, a caregiver commented: *"It [the idea] is to feed the child, micronutrients, [the mom in the drawing] is giving him with puree, right?"* (Huánuco-S1 Caregiver). Similarly, a HCP commented about the visual cluster:

> *"One idea is for the mother to have more recipes or help to make the preparations. The other... has to do with the packaging or where it is going to be served. And the other has to do with the presentation of the supplement"* (Manchay HCP01).

Furthermore, the visual sketch of the waiting area (see Figure 1b) helped participants to visualise the spatial dimensions of the waiting area including the existing constraints of the physical infrastructure. For example, the following dialogue between a HP and a caregiver clearly illustrate this:

> *"HP02: maybe the waiting room could be spacious. Caregiver08: yes, but the waiting room, as it is, cannot be expanded"* (Huánuco-S2)

The visual sketch also helped participants to examine the current state of the waiting area before envisioning future alternatives. For example, a caregiver stated: *"That part, the television, in front, directly... move it to the centre, because if they put it on the side or on the other side [of the room] you can no longer see it"* (Huánuco-S2 Caregiver09). While imagining alternative futures, participants spatially visualised the waiting area and modified the sketches. A HP expressed:

> *"Let's see what I want to put... here I wanted to put weight and height, the scale that weighs the children and all that"* (Huánuco-S2 HP01).

The co-created sketches also offered an opportunity to express participant's ideas and values while keeping them engaged in the activity. For instance, a caregiver commented:

> *"on this side the image, if you have noticed, [...] well, I have done it more or less in this way because I believe the family very important within society"* (Manchay Caregiver05).

During presentations, the co-produced sketches helped participants to remember details and facilitated the engagement with the audience while visualizing multiple perspectives, as a HCPs commented:

> *"Well, to complement those I see in the previous group... Because in reality, they covered needs that perhaps we had not seen from our perspective"* (Huánuco-S2 HCP02).

4.2 Social factors: Verbal encouragement, attitudes, safe spaces and the different roles of HCPs

Considering the needs and digital literacy of our different groups of participants, as observed in previous workshops, we simplified the activities for Huánuco. Despite the favourable outcomes (e.g., co-produced sketches) and successfully completing the co-sketching activities, it is noteworthy that at the beginning of the workshops some participants perceived themselves as lacking creative skills or self-confidence for sketching or doing presentations. For example, a caregiver commented: *"No, I'm very nervous, I'm going to stumble over my words"* (Huánuco-S1 Caregiver03). Here, HCPs offered help with the sketching activities or practicing the presentations with them. A HCP expressed: *"putting it together, we have to practice to present it, right?"* (Huánuco-S2 HCP03).

During workshops, we observed how the use of visually-oriented methods helped to generate a more positive attitude from participants. For example, a HP expressed: *"[laughs] I'm not much of an artist, but I'll do my best* (Huánuco-S2 HP01). Participants put effort into their drawings, wanting to draw and paint them better. For example, the same HP commented to her team member: *"You have to paint the place to make it look nicer"* (Huánuco-S2 HP01). Similarly, a caregiver highlighted how she added details to her drawing: *"here, a little son, right?... It is the path so that he is not on the air"* (Manchay Caregiver01).

Moreover, the verbal encouragement provided by healthcare workers, facilitators and other caregivers was helpful for caregivers who needed help with the activity at hand. For example, our analysis highlighted a case where all participants at the table encourage a caregiver to speak/explain her work to the group. Another caregiver commented: *"As in family [...] there is nothing to be afraid"* (Huánuco Caregiver01). Once the caregiver presented to the team, everybody celebrated her stating, *"Well done!" [clapping]* (Members of the group), and a HP expressed: *"bravo!! You did it very well!"* (Huánuco-S2 HP01), and a facilitator positively reinforced that *"[she] did it very well!"*. In addition, participants and facilitators also praised each other's sketches. For instance, a HCP expressed: *"look now, a very cool drawing"* (Manchay HCP01).

We also observed how participants considered the workshop as a safe space to share their experiences, ask questions, and raise concerns about the services at the healthcare centre. A caregiver expressed:

> *"Also the nurses who provide us with the services... they may treat us with kindness. Sometimes they treat us quickly, quickly, and sometimes there is no [good] treatment [...] There should always be a [good] treatment"* (Huánuco-S2 Caregiver02)

Similarly, a HP commented:

> *many [healthcare] professionals weigh, size [the child] and that's it, but you don't know if it's appropriate [for the child] and they don't explain it to you"* (Huánuco-S2 HP02).

A HCP also recognised the weaknesses of the services and commented:

> *"A mother also told us about the values many times as I already mentioned, the mothers come in and [the HCPs] only do weight, height, or complain, and sometimes they treat [the caregiver] badly."* (Huánuco-S2 HCP02).

In some cases, HCPs adopted a mediator role and scaffold the tasks for caregivers, reinforcing caregiver's engagement and motivation. A HCP expressed:

> *"What will this allow you [a caregiver]? What advantage does it have? One, for example, having this marked in the schedule, [another caregiver] has said, for example, in due time we are going to give iron [supplementation] to the child... This is an advantage. Another [caregivers] has said that this is accessible..."* (Huánuco-S1 HCP02).

In most co-produced sketches, caregivers drew while HCPs contributed with ideas. When caregivers could not draw, some HCPs offered to draw (e.g, *"I draw it, but tell me the idea"* –Manchay HCP01), and facilitators also gave the option to write down the ideas instead of drawing. . We also observed one case where both (a caregiver and a HCP) stated that they *"don't know how to draw"*, and the HCP suggested the caregiver should draw. When healthcare workers (HCPs or HP) and caregivers collaborated without any pressure in a comfortable and equal environment they co-produced enriched ideas. For instance, the following dialogue shows how caregivers and a HCP discussed a problem and alternatives to solve it:

> *"Caregiver03: For me, when it is my baby's turn for the consultation, [the doctor] always tells me about food and I forget.*

Caregiver02: Sometimes, when they explain it to you, you forget, right? They tell you this is [what] you have to give to the child... We didn't know, [and then] we arrive home and my mind is empty [forget].

Caregiver03: We forget.

HCP02: But with the images...

Caregiver02: With images, sometimes you are in a hurry you can take a photo and once you get home you can take care of your little daughter...

HCP02: a portrait of foods with iron" (Huánuco-S2)

Finally, we also observed how caregivers looked for feedback from facilitators: *"Is [the concept] okay? what do you think?"* (Manchay Caregiver03). Overall, caregiver's involvement and confidence was influenced by the health workers and facilitators that provided verbal engagement, had a positive attitude, and provided a safe and comfortable environment. However, we also observed some discussions dominated by HCPs when a facilitator asked and the HCP answered on behalf of the group. Here, facilitators asked again directly to the caregivers.

4.3 Temporal factors: everyday constraints, and punctuality

Participants mentioned that usually, the time for medical appointments and demonstrative sessions was not planned according to the caregiver's needs. As workshops are extraordinary events in caregivers' day-to-day activities, some caregivers' faced difficulties to plan their attendance to the workshops. Participants mentioned that most of their activities are planned around children's needs (e.g., children's time to eat). When they have older children, they also have to consider the older children's schedules (*"sometimes it's already time to go to school [for older children]"* –Manchay Caregiver02). Indeed, engaging caregivers throughout the project has been difficult due to the complexity of caregiver's every day lives and the socioeconomic demands in low-resource settings. In contrast to the healthcare workers who have continuously participated in the workshops, caregivers found it difficult to fully commit their time and workshops were attended by previous caregivers and new caregiver participants.

In addition, we realised that punctuality is an important factor to consider. In Huánuco, the first workshop had a 40 minutes delay because some caregivers arrived late and few HPs were attending a last minute training session that overlapped with the time of the workshop, which affected the planned activities. In this case, we finished the workshop after the critique phase because *"it [was] already getting dark"* (Huánuco Caregiver04), as it was inconvenient for caregivers and HCPs to avoid a long session. In Manchay, the HP who recruited the caregivers scheduled them an hour before the scheduled time for the workshop to prevent delays taking into account the sociocultural context. In this case, some caregivers arrived at the time indicated by the HP and then complained that the workshop started too late.

5 Discussion

Reflecting on how participation took place in our workshops, we presented a number of barriers and facilitators that highlight how the physical, social and temporal aspects of co-design workshops can influence the involvement of caregivers and healthcare workers in low-resource settings.

Future workshops are not an easy method to use as it can be time-consuming, people could find it difficult to imagine desired futures and to participate due to the constraints of everyday life (Dator, 1993; Suoranta and Teräs, 2023). To facilitate future workshops and envisioning activities with low-resource communities, we used a variety of visual materials (Sturdee and Lindley, 2019) to convey information and ideas during the workshop, and to support participant's engagement with the activities. Our findings confirmed that all visual materials clearly facilitated a shared understanding of ideas between participants and showed how the collaborative sketching activities helped to reduce the effect of traditional unequal power relations between healthcare workers and caregivers (e.g., HCPs leading discussions). The workshops and the visually-oriented materials helped building a positive relationship between caregivers and healthcare workers, where HCPs with a positive attitude often acted as mediators of caregiver's participation, and where caregivers felt comfortable and safe to share and voice their concerns, empathising with each other's perspectives (Lewis and Coles-Kemp, 2014). Nevertheless, negotiating power dynamics (Jiang et al., 2022; Guo and Hoe-Lian, 2014) between multiple stakeholders with different values and demands is one of the major challenges when co-designing interventions for maternal and child health in low-resource settings (Till et al., 2022, 2023; Coleman et al., 2023).

When deciding on the venue, we considered setting up a space for children in the same room to supervise them while caregivers could see them, aligned with prior work (Balaam et al., 2015; Wardle et al., 2018). However, despite the benefits, it is also worth noting that some challenges still remained, as in some cases, it was difficult to grab caregivers' full attention when their babies were in their arms. Aligned with Balaam et al. (2015) and Wardle et al. (2018), our caregivers' attention was divided between the workshop activities and their children. Future work should investigate additional ways for keeping children engaged in the play area to minimize interruptions in caregiver's participation.

In addition, we need to be mindful and consider caregivers schedules when organising co-design workshops as most of their activities revolve around children's routines (babies and older children). Indeed, previous research has shown that low-income families often have less control of their time (Roy et al., 2004). Aligned with Rosner et al. (2016), we initially consider that workshops have to be planned taking into account participants' availability and routines while attaching them to the consultation appointment. However, our participants found it difficult to attend the workshops due to the less control of their time in their busy routines, and existing cultural traits such as lack of punctuality (Basu and Weibull, 2003) that we did not envisage. Even when the venue of the workshop was located in the area where caregivers live in Huánuco, they still had to travel. We provided transportation costs to help participants reach the venue. Regarding HCPs, some of them were late even though the workshop took place as part of their working hours, due to their busy schedules or unexpected training.

Regarding caregiver's confidence in drawing, our approach was consistent with Sturdee and Lindley (2019)'s recommendation of making a team effort to draw more detailed images. Aligned with Till et al. (2022) and Wardle et al. (2018), our findings confirmed the important role of visual materials and words of encouragement from other caregivers and healthcare workers to support peer-to-peer interactions, build caregiver's confidence, and support positive reinforcement (Wardle et al., 2018).

5.1 Limitations

One limitation is the fact that as facilitators, we may have impacted the HCPs and caregivers' participation, intentional or unintentional (Dearden and Kleine, 2018), since we were external actors in their day-to-day context (Mainsah and Morrison, 2014). In the workshops, facilitators played an active or passive role when it was necessary.To mitigate our influence, we encouraged open participation for both caregivers and HCPs and recruited participants through our local team. We also attempted to balance their interaction in group work to avoid caregivers feeling intimidated by another group of participants. Another limitation relates to the positionality of the research team belonging to an upper-middle socio-economic class that shaped how we framed the project and analysed data. Here, our multidisciplinary team have extensive experience conducting participatory research on maternal and child health in low-resource, urban and rural settings in Latin America and the Global South. We followed the best practices to continuously involve community participants before, during, and after the project.

6 Acknowledgments

We thank all the investigators, field and research assistants on the PERUSANO project as well as the community participants, and stakeholders from participating health centres. This study was funded by the Medical Research Council, part of the United Kingdom Research and Innovation (UKRI). Grant reference number: MR/S024921/1.

References

Aarhus, R., E. Grönvall, and M. Kyng (2010): 'Challenges in participation'. In: *2010 4th International Conference on Pervasive Computing Technologies for Healthcare*. pp. 1–4.

Alminde, S. and H. Warming (2020): ‘Future workshops as a means to democratic, inclusive and empowering research with children, young people and others’. *Qualitative Research*, vol. 20, no. 4, pp. 432–448.

Balaam, M., R. Comber, E. Jenkins, S. Sutton, and A. Garbett (2015): ‘FeedFinder: a location-mapping mobile application for breastfeeding women’. In: *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. pp. 1709–1718.

Basu, K. and J. W. Weibull (2003): ‘Punctuality: A cultural trait as equilibrium’. vol. -, no. -.

Bødker, S., C. Dindler, O. S. Iversen, and R. C. Smith (2022): ‘What Are the Activities and Methods of Participatory Design?’. In: *Participatory Design*. Springer, pp. 49–64.

Braun, V. and V. Clarke (2021): ‘One size fits all? What counts as quality practice in (reflexive) thematic analysis?’. *Qualitative research in psychology*, vol. 18, no. 3, pp. 328–352.

Byrne, E. and S. Sahay (2007): ‘Participatory design for social development: A South African case study on community-based health information systems’. *Information technology for development*, vol. 13, no. 1, pp. 71–94.

Ciolfi, L., G. Avram, L. Maye, N. Dulake, M. T. Marshall, D. van Dijk, and F. McDermott (2016): ‘Articulating co-design in museums: Reflections on two participatory processes’. In: *Proceedings of the 19th ACM conference on computer-supported cooperative work & social computing*. pp. 13–25.

Clemensen, J., S. B. Larsen, M. Kyng, and M. Kirkevold (2007): ‘Participatory design in health sciences: using cooperative experimental methods in developing health services and computer technology’. *Qualitative health research*, vol. 17, no. 1, pp. 122–130.

Coleman, T., S. Till, J. Farao, L. Shandu, N. Khuzwayo, L. Muthelo, M. Mbombi, M. Bopape, A. van Heerden, T. Mothiba, et al. (2023): ‘Reconsidering priorities for digital maternal and child health: community-centered perspectives from South Africa’. *Proceedings of the ACM on Human-Computer Interaction*, vol. 7, no. CSCW2, pp. 1–31.

Dai, J. and K. Moffatt (2021): ‘Surfacing the voices of people with dementia: Strategies for effective inclusion of proxy stakeholders in qualitative research’. In: *Proceedings of the 2021 CHI conference on human factors in computing systems*. pp. 1–13.

Dator, J. (1993): ‘From future workshops to envisioning alternative futures’. *Futures Research Quarterly*, vol. 9, no. 3, pp. 108–112.

Dearden, A. and D. Kleine (2018): ‘Minimum ethical standards for ICTD/ICT4D research’.

Del Gaudio, C., A. J. de Oliveira, and C. Franzato (2014): ‘The influence of local powers on participatory design processes in marginalized conflict areas’. In: *Proceedings of the 13th Participatory Design Conference: Research Papers-Volume 1*. pp. 131–139.

Farr, M. (2018): ‘Power dynamics and collaborative mechanisms in co-production and co-design processes’. *Critical Social Policy*, vol. 38, no. 4, pp. 623–644.

Guo, Y. and D. G. Hoe-Lian (2014): ‘" We want to hear your voice": Power relations in participatory design’. In: *2014 11th International Conference on Information Technology: New Generations*. pp. 561–566.

Hansen, N. B., C. Dindler, K. Halskov, O. S. Iversen, C. Bossen, D. A. Basballe, and B. Schouten (2019): ‘How participatory design works: mechanisms and effects’. In: *Proceedings of the 31st Australian Conference on Human-Computer-Interaction*. pp. 30–41.

Harrington, C., S. Erete, and A. M. Piper (2019): 'Deconstructing community-based collaborative design: Towards more equitable participatory design engagements'. *Proceedings of the ACM on Human-Computer Interaction*, vol. 3, no. CSCW, pp. 1–25.

Huerga, R. S., J. Lade, and F. Mueller (2016): 'Designing play to support hospitalized children'. In: *Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play*. pp. 401–412.

Hussain, S., E. B.-N. Sanders, and M. Steinert (2012): 'Participatory design with marginalized people in developing countries: Challenges and opportunities experienced in a field study in Cambodia'. *International Journal of Design*, vol. 6, no. 2.

Jiang, Q., M. Naseem, J. Lai, K. Toyama, and P. Papalambros (2022): 'Understanding Power Differentials and Cultural Differences in Co-design with Marginalized Populations'. In: *ACM SIGCAS/SIGCHI Conference on Computing and Sustainable Societies (COMPASS)*. pp. 165–179.

Jungk, R. and N. Müllert (1987): *Future Workshops: How to create desirable futures*. Inst. for Social Inventions.

Kyng, M. (1991): 'Designing for cooperation: cooperating in design'. *Communications of the ACM*, vol. 34, no. 12, pp. 65–73.

Lewis, M. M. and L. Coles-Kemp (2014): 'Who says personas can't dance? The use of comic strips to design information security personas'. In: *CHI'14 Extended Abstracts on Human Factors in Computing Systems*. pp. 2485–2490.

Mainsah, H. and A. Morrison (2014): 'Participatory design through a cultural lens: insights from postcolonial theory'. In: *Proceedings of the 13th Participatory Design Conference: Short Papers, Industry Cases, Workshop Descriptions, Doctoral Consortium papers, and Keynote abstracts-Volume 2*. pp. 83–86.

Markham, A. (2021): 'The limits of the imaginary: Challenges to intervening in future speculations of memory, data, and algorithms'. *New media & society*, vol. 23, no. 2, pp. 382–405.

Ørngreen, R. and K. T. Levinsen (2017): 'Workshops as a research methodology'. *Electronic Journal of E-learning*, vol. 15, no. 1, pp. 70–81.

Ortega, D., R. Bartolini, R. Pareja, K. Stawarz, H. Creed-Kanashiro, M. Holdsworth, and N. Rousham, Emily Verdezoto Dias (2024): 'Design Opportunities to Facilitate Tangible Play and Promote Healthy Nutrition in Low-resource Healthcare Settings in Peru'. In: *Proceedings of the 7th ACM SIGCAS/SIGCHI Conference on Computing and Sustainable Societies. In press*.

Pradeilles, R., R. Pareja, H. M. Creed-Kanashiro, P. L. Griffiths, M. Holdsworth, N. Verdezoto, S. Eymard-Duvernay, E. Landais, M. Stanley, and E. K. Rousham (2022): 'Diet and food insecurity among mothers, infants, and young children in Peru before and during COVID-19: A panel survey'. *Maternal & Child Nutrition*, vol. 18, no. 3, pp. e13343.

Raman, S. and T. French (2022): 'Participatory design in sensitive contexts: A proposal for a conceptual framework'. *The Design Journal*, vol. 25, no. 5, pp. 752–767.

Rice, M., Y. L. Cheong, J. Ng, P. H. Chua, and Y.-L. Theng (2012): 'Co-creating games through intergenerational design workshops'. In: *Proceedings of the designing interactive systems conference*. pp. 368–377.

Rosner, D. K., S. Kawas, W. Li, N. Tilly, and Y.-C. Sung (2016): ‘Out of time, out of place: Reflections on design workshops as a research method’. In: *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing*. pp. 1131–1141.

Rousham, E., R. G. Pareja, H. M. Creed-Kanashiro, R. Bartolini, R. Pradeilles, D. Ortega-Roman, M. Holdsworth, P. Griffiths, and N. Verdezoto (2023): ‘Protocol: Designing intervention prototypes to improve infant and young child nutrition in Peru: a participatory design study protocol’. *BMJ open*, vol. 13, no. 12.

Roy, K. M., C. Y. Tubbs, and L. M. Burton (2004): ‘Don’t have no time: Daily rhythms and the organization of time for low-income families’. *Family Relations*, vol. 53, no. 2, pp. 168–178.

Sanders, E. B.-N. and P. J. Stappers (2008): ‘Co-creation and the new landscapes of design’. *Co-design*, vol. 4, no. 1, pp. 5–18.

Sjölinder, M., I. Scandurra, A. Avatare Nou, and E. Kolkowska (2017): ‘Using care professionals as proxies in the design process of welfare technology–perspectives from municipality care’. In: *Human Aspects of IT for the Aged Population. Aging, Design and User Experience: Third International Conference, ITAP 2017, Held as Part of HCI International 2017, Vancouver, BC, Canada, July 9-14, 2017, Proceedings, Part I 3*. pp. 184–198.

Sturdee, M. and J. Lindley (2019): ‘Sketching & drawing as future inquiry in HCI’. In: *Proceedings of the Halfway to the Future Symposium 2019*. pp. 1–10.

Suoranta, J. and M. Teräs (2023): ‘Future workshops as postdigital research method’. In: *Constructing Postdigital Research: Method and Emancipation*. Springer, pp. 317–331.

Till, S., J. Farao, T. L. Coleman, L. D. Shandu, N. Khuzwayo, L. Muthelo, M. O. Mbombi, M. Bopane, M. Motlhatlhedi, G. Mabena, et al. (2022): ‘Community-based co-design across geographic locations and cultures: methodological lessons from co-design workshops in South Africa’. In: *Proceedings of the Participatory Design Conference 2022-Volume 1*. pp. 120–132.

Till, S., M. Mkhize, J. Farao, L. D. Shandu, L. Muthelo, T. L. Coleman, M. Mbombi, M. Bopape, S. Klingberg, A. van Heerden, et al. (2023): ‘Digital health technologies for maternal and child health in Africa and Other Low-and Middle-Income Countries: cross-disciplinary scoping review with stakeholder consultation’. *Journal of Medical Internet Research*, vol. 25, pp. e42161.

Trapani, P. (2019): ‘Designing co-design: addressing five critical areas to increase the experience of participants and facilitator in a co-design session’. In: *Cross-Cultural Design. Methods, Tools and User Experience: 11th International Conference, CCD 2019, Held as Part of the 21st HCI International Conference, HCII 2019, Orlando, FL, USA, July 26–31, 2019, Proceedings, Part I 21*. pp. 79–93.

Vidal, R. V. V. et al. (2006): ‘The future workshop: Democratic problem solving’. *Economic analysis working papers*, vol. 5, no. 4, pp. 21.

Wardle, C.-J., M. Green, C. W. Mburu, and M. Densmore (2018): ‘Exploring co-design with breastfeeding mothers’. In: *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. pp. 1–12.

Winschiers-Theophilus, H., N. J. Bidwell, and E. Blake (2012): ‘Altering participation through interactions and reflections in design’. *CoDesign*, vol. 8, no. 2-3, pp. 163–182.

Winschiers-Theophilus, H., S. Chivuno-Kuria, G. K. Kapuire, N. J. Bidwell, and E. Blake (2010): ‘Being participated: a community approach’. In: *Proceedings of the 11th Biennial Participatory Design Conference*. pp. 1–10.

Galeno, Larissa; Barbosa, Carlos Eduardo; Costa, Luis Felipe Coimbra; Lima, Yuri; Nascimento, Luciana Maria Azevedo; Xexéo, Geraldo; de Souza, Jano Moreira (2024): A Rapid Review of Gender Parity and Collaboration in Technology: Insights from the Past Decade. In: Proceedings of the 22nd European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies - Exploratory papers, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591), DOI: 10.48340/ecscw2024_ep10

A Rapid Review of Gender Parity and Collaboration in Technology: Insights from the Past Decade

Larissa Galeno[1], Carlos Eduardo Barbosa[1,2], Luis Felipe Coimbra Costa[1], Yuri Lima[1], Luciana Maria Azevedo Nascimento[1], Geraldo Xexéo[1], Jano Moreira de Souza[1]

[1] Universidade Federal do Rio de Janeiro (UFRJ), Brazil

[2] Centro de Análises de Sistemas Navais (CASNAV), Brazil

Contact Author: galeno@cos.ufrj.br, eduardo@cos.ufrj.br, luisfcosta@cos.ufrj.br, yuriodelima@cos.ufrj.br, lmnascimento@cos.ufrj.br, xexeo@cos.ufrj.br, jano@cos.ufrj.br

Abstract. Gender diversity is a recurrent topic in the STEM field. The lack of women's presence in the field is a concern for important organizations such as the UN and UNESCO. This matter impacts collaboration since the absence of team diversity can affect the result obtained. Due to this context, the present study aims to analyze collaboration regarding gender parity. The rapid review methodology was used to search for primary studies on these themes and understand how collaboration and gender have been investigated in the last ten years. We used the Rapid Review methodology to select twenty papers evaluated by type of collaboration, model of collaboration, type of research, and research strategy.

While it wasn't possible to determine a definitive collaboration model, the analysis revealed that most studies focused on collaborative learning. The research type showed a balanced distribution between explanatory and descriptive approaches, with the majority employing surveys as their primary research strategy.

1 Introduction

The lack of diversity in STEM (Science, Technology, Engineering, and Mathematics) is gaining more relevance as time passes. In STEM-related fields of higher education, female students comprise just 35% of the total student population (Chavatzia, 2017). In 2015, women accounted for 57% of all professional occupations; however, they represented only 25% of all computing roles (Ashcraft et al., 2016). This data illustrates a particular issue across various educational levels and corporate settings. It becomes evident that the matter is a concern of global significance, as even prestigious organizations like the United Nations (UN) are addressing the issue. For instance, gender equality is explicitly highlighted as one of the Sustainable Development Goals (SDG) (United Nations, 2015).

As this topic raises concerns in different levels of education and work environments in technology, it's also possible to check that this affects collaboration. Drawing from the evidence on the impacts of gender balance within teams, gender diversity can potentially elevate group dynamics, a factor of growing significance as collaboration takes center stage in scientific production, leading to innovation (Bear and Woolley, 2011).

In light of this context, the current study seeks to analyze gender diversity in collaboration in technology. We employed the Rapid Review (RR) methodology (Cartaxo et al., 2018) to identify primary studies investigating this topic. Subsequently, the study aggregates the findings and analyzes the research conducted over the past decade concerning the intersection of gender and collaboration.

We expect to advance the understanding of gender parity in STEM through the comprehensive overview of the analysis and categorization of papers based on collaboration type, model, research type, and strategy. We provide diverse collaboration models, suggesting interdisciplinary and industry-academic partnerships, and propose exploring gender intersectionality with other diversity dimensions for a more nuanced understanding. Finally, the study highlights the ongoing need to explore gender implications in collaborative environments and present some avenues of research that can be made into actions as public policies.

The remaining of this work is organized as follows: the next section presents other secondary works that seek to analyze the field of collaboration, especially regarding gender; the third section focuses on describing how the rapid review was applied to select the primary studies; then the next part shows results about the chosen papers and discussion concerning the topic; finally, the last section it's the conclusion of this study.

2 Related Work

The subject of gender diversity is a well-established topic within the field of computer science. Therefore, this section will introduce three secondary studies that are pertinent and connected to the current research. Therefore, that difference and the contributions the present work can offer to the scientific community will be highlighted.

Wallace et al. (2017) focused on synthesizing findings related to Computer-Supported Cooperative Work (CSCW). Their systematic literature review aimed to provide a comprehensive overview of the field's current state, identify research trends and establish a foundation for future work. Wallace et al. (2017) build upon two existing systematic reviews in the ACM digital library, encompassing 1209 articles. The primary objective was to categorize these articles based on:

- Model of collaboration: whether the collaboration happened synchronous, asynchronous, remote, or collocated.
- Types of research: design and evaluation, descriptive, explanatory, bibliographic, and not empirical.
- In case the type of research is Design and Evaluation, then the study would have the category of evaluation: field experiment, field and case study, and laboratory experiments.
- Devices: the kind of device in which the collaboration happens, such as PCs and tablets.

These categories were described and defined by Wallace et al. (2017), and some will be useful for the present study. This study utilizes the collaboration model and various research classifications to provide a clear reference for comparison. However, due to the nature of this study, the bibliographic and not empirical studies won't be useful. Therefore, unlike Wallace et al. (2017), the current research systematically reviews the collaboration field, focusing on gender diversity. Although the focus is different, the present study uses Wallace et al. (2017) as a reference to synthesize results.

Dias Canedo et al. (2019) also does a systematic literature review. However, unlike Wallace et al. (2017), they focus on gender parity in software development projects, especially open-source projects. The goal is to understand which factors could contribute to increasing women's interest in cooperating in open-source communities. A total of 24 papers were analyzed to have their data extracted. Dias Canedo et al. (2019) state that increasing women's participation in software development is necessary due to its benefits. One possible solution is to keep senior developers for underrepresented groups.

While Dias Canedo et al. (2019) present a literature review on gender diversity focused on open-source software development projects related to the present research, this study will review the literature following an RR protocol. Our focus is more general in collaboration, not only in open-source collaboration.

The field of CSCW has a scarcity of secondary studies, as indicated by Wallace et al. (2017). Furthermore, there is a noticeable gap in research focusing on collaboration and gender. Therefore, this present study aims to fill this void by conducting a rapid review of the intersection of gender parity and collaboration in technology.

3 Methodology

This study employs the Rapid Review methodology, as outlined by Cartaxo et al. (2018), to conduct a literature review. The objective is to consolidate findings from primary studies on collaboration and gender diversity within the technology field. The upcoming section will outline the steps involved in identifying relevant papers through the rapid review process.

3.1 Research Questions

To guide the rapid review, the following research questions (RQ) were used:

1. How is collaboration in the technology field regarding gender diversity in the last ten years?
2. What is the type of collaboration?
3. What is the model of collaboration?
4. What type of research was used?
5. What research strategy was used?

The RQ1 seeks a better understanding of collaboration with gender parity in mind. Consequently, the following questions have the purpose of characterizing the collaboration reported in the study. RQ2 aims to answer in which context the cooperation happened: research (such as academia), learning (collaborative learning, for example), or industry (collaboration in work environments). RQ3 and RQ4 are categories explored by Wallace et al. (2017). RQ3 seeks to characterize if the model collaboration (synchronous or asynchronous, remote or collocated) as Wallace et al. (2017) did in the systematic literature. While RQ4 aims to portray the type of research conducted in the primary study, following the categories and criteria proposed by Wallace et al. (2017): design and evaluation, descriptive and explanatory. Finally, RQ5 has the goal to describe what research strategy was used in the primary study, having Wohlin et al. (2012) as reference: experiment, quasi-experiment, case study, survey, and simulation.

3.2 Search Strategy

To find the primary studies, the search engine used Scopus[1] since it searches in many of the most relevant digital libraries for the computer science field. And it was only one due to the time frame agreed to complete the research.

The search string used was revised and improved by specialists in the CSCW field, making it possible to balance the quantity and quality of results. The string in question used was:

TITLE-ABS (((("woman" OR "women" OR "female")) OR (("gender") AND ("diversity" OR "parity" OR "equality"))) AND ("collabora*" OR "coopera*" OR "team*") AND ("computer science" OR "programmer")) AND PUBYEAR > 2013 AND PUBYEAR < 2024 AND (LIMIT-TO(DOCTYPE, "ar") OR LIMIT-TO(DOCTYPE, "cp")) AND (LIMIT-TO(LANGUAGE, "English"))

The search was performed on September 07, 2023, with a time restriction of 2013 until the date of the search, returning 158 documents.

3.3 Selection Procedure

The selection procedure for the papers consisted of excluding short papers, reading the title and abstract, and reading full papers. The inclusion criteria to select the studies were:

- Must have more than five pages
  - Short papers were excluded.
- Must be a primary study;
  - Secondary studies were excluded since the present work focuses on synthesizing results based on primary evidence.
- The study provides an analysis of Gender Diversity in the collaboration field
  - Studies that analyzed gender diversity in other computer science fields were excluded since the focus is the collaboration area;
  - Studies that analyzed collaboration regarding other minority groups were excluded due to the focus on gender diversity;
  - Studies that used collaboration to promote gender parity;
  - Studies that only focused on collaboration, not mentioning gender parity, were also excluded.
- The study must apply a research strategy or be an observational study
  - Studies based on opinions were excluded.

Figure 1 illustrates the selection procedure and presents its results. The search was made in Scopus in September 2023 using the search string, returning 158 documents. We excluded 28 articles that failed the minimum page count criterion in our first analysis. We analyzed the titles and abstracts of the remaining 130

[1] https://www.scopus.com/

Table I. List of the Selected Papers.

Reference	Title
Gilal et al. (2019)	A set of rules for constructing gender-based personality types' composition for software programmer
Oka et al. (2019)	Assessing the networking preferences and resource satisfaction among engineering faculty in the California State University system
Buffum et al. (2016)	Collaboration and gender equity in game-based learning for middle school computer science
De Castro-Cabrera and Guerrero-Contreras (2022)	Creating a wiki about Computer Engineering History through its women
Alqahtani et al. (2020)	Diverse group formation based on multiple demographic features
Hirshfield (2018)	Equal but not equitable: Self-reported data obscures gendered differences in project teams
Groher et al. (2022)	Exploring diversity in introductory programming classes: An experience report
Thinnyun et al. (2021)	Gender and engagement in CS courses on Piazza
Küng et al. (2022)	Gender and pair programming–Effects of the gender composition of pairs on collaboration in a robotics workshop
Yamamoto and Frachtenberg (2022)	Gender differences in collaboration patterns in computer science
Hardin (2021)	Gender Differences in Hackathons as a Non-traditional Educational Experience
Ying et al. (2019)	In their own words: Gender differences in student perceptions of pair programming
Heels and Devlin (2019)	Investigating the Role Choice of Female Students in a Software Engineering Team Project
Van Herck and Fiscarelli (2018)	Mind the Gap Gender and Computer Science Conferences
Jimenez et al. (2021)	Pedagogical innovations with a gender approach to increase computer programming self-efficacy in engineering students
Sarvghad et al. (2022)	Scientometric analysis of interdisciplinary collaboration and gender trends in 30 years of IEEE vis publications
Cavero et al. (2015)	The evolution of female authorship in computing research
Early et al. (2018)	Understanding gender equity in author order assignment
Ying et al. (2021)	Using Dialogue Analysis to Predict Women's Stress During Remote Collaborative Learning in Computer Science
Fields et al. (2017)	Youth computational participation in the wild: Understanding experience and equity in participating and programming in the online scratch community

documents, having the criteria already cited in mind, and 84 papers were excluded. Finally, the last step was to perform the full reading of 46 papers. In the end, 20 articles were selected for this review, as shown in Table I. Details of the section procedure are available in Galeno et al. (2023).

3.4 Synthesis

To synthesize the 20 primary studies selected, a narrative summary will be used to summarize the results regarding gender and collaboration with the research questions stated above. Also, the studies were grouped due to their similarities. The following sections will present this synthesis.

4 Results

This section presents the results of each paper concerning the research questions. The distribution of papers will be shown in the groups formed and then by each category: type of collaboration, model of collaboration, type of research used, and type of research strategy used.

4.1 RQ1: How is collaboration in the technology field regarding gender diversity in the last ten years?

To examine gender diversity in the collaboration field, we organized the selected articles into groups. This approach allowed us to gain insights into broader aspects of cooperation while investigating gender parity. Table II and Figure 2 show the distribution of papers.

Many papers predominantly cover collaborative learning and authorship collaboration. Within collaborative learning, a subset specifically delves into pair programming. Several research studies (Groher et al., 2022; Küng et al., 2022; Ying et al., 2019, 2021) concentrate on exploring the influence of this collaborative learning method on the programming learning process for girls. The second topic consists of survey studies using publications data to find patterns in women's participation.

Team formation represents studies that propose software or algorithms to compose software development teams (Alqahtani et al., 2020; Gilal et al., 2019) or understand patterns when women choose their role in the team (Jimenez et al.,

Figure 1. The selection procedure used in this Rapid Review.

Figure 2. Classification of the articles in Groups.

Table II. Classification of the articles in Groups.

Groups	**Papers**
Team Formation	Gilal et al. (2019); Alqahtani et al. (2020); Jimenez et al. (2021)
Authorship Collaboration	Yamamoto and Frachtenberg (2022); Van Herck and Fiscarelli (2018); Sarvghad et al. (2022) , Cavero et al. (2015); Early et al. (2018)
Collaborative Learning	Buffum et al. (2016); De Castro-Cabrera and Guerrero-Contreras (2022); Groher et al. (2022); Küng et al. (2022); Ying et al. (2019, 2021)
Hackathons	Hardin (2021)
Team Behavior	Hirshfield (2018); Heels and Devlin (2019)
Collaborative Foruns	Oka et al. (2019); Thinnyun et al. (2021); Fields et al. (2017)

2021). The group of team behavior consists of studies that focus on understanding the behavior and feelings of women while working in collaborative software development.

Collaborative forums are studies that focus on understanding female behavior in online communities of technology, such as Thinnyun et al. (2021) or Fields et al. (2017) or even in in-person forums, for example, network environments (Oka et al., 2019). Finally, the hackathon group is one study (Hardin, 2021), which has the goal to characterize the female experience in hackathons by surveys and data analysis and trying to understand aspects: how gender stereotypes can affect the team roles and how hackathons can enhance the learning experience.

In conclusion, recent studies conducted over the past decade have yielded more pronounced findings concerning collaborative learning and research cooperation, particularly emphasizing the role of gender diversity.

4.2 RQ2: What is the type of collaboration?

The category of type of collaboration aims to characterize the environment in which the collaboration took place. We have separated them into three possibilities: Industry, Research, and Learning. Table III and figure 3 show the relation between the categories and the selected papers. Most of the works are regarding collaborative learning.

Table III. Classification of the articles by Types of Collaboration.

Collaboration Type	**Papers**
Industry	Gilal et al. (2019)
Research	Oka et al. (2019); Alqahtani et al. (2020); Yamamoto and Frachtenberg (2022); Van Herck and Fiscarelli (2018); Sarvghad et al. (2022); Cavero et al. (2015); Early et al. (2018)
Learning	Buffum et al. (2016); De Castro-Cabrera and Guerrero-Contreras (2022); Hirshfield (2018); Groher et al. (2022); Thinnyun et al. (2021); Küng et al. (2022); Hardin (2021); Ying et al. (2019); Heels and Devlin (2019); Jimenez et al. (2021); Ying et al. (2021); Fields et al. (2017)

Industry is about collaboration in a corporate environment, for example, software development situations for industry (Gilal et al., 2019). *Research* focuses on papers that describe collaboration in research environments, such as academia and scientific research. Some studies focus on collaboration in article authorship, for example, (Early et al., 2018; Yamamoto and Frachtenberg, 2022; Van Herck and Fiscarelli, 2018; Cavero et al., 2015). *Learning* refers to studies that report the use of collaborative learning and, usually, an analysis of how this methodology helped gender diversity. A few studies focus on pair programming to teach programming, for example, (Ying et al., 2021; Küng et al., 2022; Ying et al., 2019; Groher et al., 2022).

Figure 3. Classification of the articles Types of Collaboration.

In conclusion, results show that most studies regarding collaboration and gender focus on collaborative learning or are happening in the research environment, even though some research can be applied in industry.

4.3 RQ3: What is the model of collaboration?

The collaboration model was based on Wallace et al. (2017). To define the collaboration model, it's necessary to determine the synchronicity and distribution. Synchronicity refers to whether the collaboration happens synchronously, simultaneously, or asynchronously at different times. Distribution describes how the cooperation happened: collocated, at the same place, or remote, people collaborating in different places. Figure 4 presents classifications by synchronicity and distribution, data also shown in Tables IV and V. However, due to the nature of some studies, it was impossible to classify them. For example, Early et al. (2018) surveys past data, and the collaboration model was not specified.

Table IV. Classification of the articles by Model of Collaboration: Synchronicity.

Synchronicity	**Papers**
Synchronous	Buffum et al. (2016); Groher et al. (2022); Küng et al. (2022); Hardin (2021); Ying et al. (2019, 2021)
Asynchronous	Alqahtani et al. (2020); Thinnyun et al. (2021); Fields et al. (2017)
Undefined	Gilal et al. (2019); Oka et al. (2019); De Castro-Cabrera and Guerrero-Contreras (2022); Hirshfield (2018); Yamamoto and Frachtenberg (2022); Heels and Devlin (2019); Van Herck and Fiscarelli (2018); Jimenez et al. (2021); Sarvghad et al. (2022); Cavero et al. (2015); Early et al. (2018)

Table V. Classification of the articles by Model of Collaboration: Distribution.

Distribution	**Papers**
Remote	Buffum et al. (2016); Alqahtani et al. (2020); Groher et al. (2022); Thinnyun et al. (2021); Ying et al. (2021); Fields et al. (2017)
Collocated	Küng et al. (2022); Hardin (2021); Ying et al. (2019)
Undefined	Gilal et al. (2019); Oka et al. (2019); De Castro-Cabrera and Guerrero-Contreras (2022); Hirshfield (2018); Yamamoto and Frachtenberg (2022); Heels and Devlin (2019); Van Herck and Fiscarelli (2018); Jimenez et al. (2021); Sarvghad et al. (2022); Cavero et al. (2015); Early et al. (2018)

Figure 4. Classification of the model collaboration by synchronicity (left) and distribution (right).

In general, most of the studies were not able to classify. Even though it is possible to see more works on collaboration and gender diversity dealing with synchronous situations, such as pair programming (Groher et al., 2022; Küng et al., 2022; Ying et al., 2019, 2021) and remote work. Collocated collaboration was partially affected by the pandemic of COVID-19 as studies report their activities were forced to be remote (Groher et al., 2022).

4.4 RQ4: What type of research was used?

Wallace et al. (2017) also inspired the category of type of research. They classified collaboration regarding categories already cited. For the present work, only three collaboration categorizations were useful: design and evaluation (proposal of collaboration software and its evaluation), explanatory (experiments designed to test hypothesis and explain phenomenons), and descriptive (describes an environment where collaboration is important). Table VI shows the distribution of papers regarding these categories, visually represented by Figure 5.

Table VI. Classification of the articles by Research Type.

Research Type	**Papers**
Design and Evaluation	Gilal et al. (2019); Buffum et al. (2016); Alqahtani et al. (2020)
Explanatory	De Castro-Cabrera and Guerrero-Contreras (2022); Groher et al. (2022); Thinnyun et al. (2021); Küng et al. (2022); Hardin (2021); Ying et al. (2019); Heels and Devlin (2019); Jimenez et al. (2021); Ying et al. (2021); Fields et al. (2017)
Descriptive	Oka et al. (2019); Hirshfield (2018); Yamamoto and Frachtenberg (2022); Van Herck and Fiscarelli (2018); Sarvghad et al. (2022); Cavero et al. (2015); Early et al. (2018)

An extensive number of studies classified as explanatory shows that half of the studies had a hypothesis regarding gender diversity in collaboration activities and applied experiments to check it. Seven were descriptive, describing an environment where collaboration is important, such as academia. Finally, three of them presented software and evaluated it.

4.5 RQ5: What research strategy was used?

Due to all studies conducting some experiments, there was also a classification to which kind of experiment they conducted following the taxonomy of Wohlin et al. (2012). Table VII and Figure 6 show which experiment was used in the papers.

A significant amount of research chose the survey method, which analyzes past activities through data, interviews, or questionnaires. One of the advantages of this strategy is cost, being cheap and easy to conduct. The second most used was quasi-experiment, in which the study happens in a controlled environment but not with a random sample. The simulation was used, in general, to taste software and algorithms proposal performances (Gilal et al., 2019). Finally, only Hirshfield (2018) used the case studies strategy to support an observational descriptive study. An experiment was not used, probably due to their cost and difficulty implementing under the study's time frame.

Table VII. Classification of the articles by Experiment Strategy.

Experiment Strategy	**Papers**
Simulation	Gilal et al. (2019); Alqahtani et al. (2020)
Experiment	-
Quasi-Experiment	Buffum et al. (2016); Küng et al. (2022); Jimenez et al. (2021); Ying et al. (2021)
Survey	Oka et al. (2019); De Castro-Cabrera and Guerrero-Contreras (2022); Groher et al. (2022); Thinnyun et al. (2021); Yamamoto and Frachtenberg (2022); Hardin (2021); Ying et al. (2019); Heels and Devlin (2019); Van Herck and Fiscarelli (2018); Sarvghad et al. (2022); Cavero et al. (2015); Early et al. (2018); Fields et al. (2017)
Case Study	Hirshfield (2018)

Figure 5. Classification of Research Types.

5 Discussion

This section aims to provide a comprehensive overview of gender parity in collaboration by synthesizing the results based on two key factors: the portrayal of collaboration and the research conducted within each group. This approach will help paint a clearer picture of the overall scenario regarding gender equality in cooperation.

All papers from the collaborative learning group were classified as "Learning" in collaboration type. Regarding the model of collaboration (Buffum et al., 2016; Groher et al., 2022; Küng et al., 2022; Ying et al., 2019, 2021) had synchronous cooperation and (Buffum et al., 2016; Groher et al., 2022; Ying et al., 2021) had remote collaboration, while Küng et al. (2022) and Ying et al. (2019) had collocated activities. Although some of them can be done remotely, the experiments were collocated. De Castro-Cabrera and Guerrero-Contreras (2022) could not determine the collaboration model. Five out of six papers were explanatory research (De Castro-Cabrera and Guerrero-Contreras, 2022; Groher

Figure 6. Classification of Evaluation Types.

et al., 2022; Küng et al., 2022; Ying et al., 2019, 2021), having only one classified as design and evaluation (Buffum et al., 2016). Buffum et al. (2016) propose a game for collaborative learning using game-based learning and used in the classroom to evaluate their experience. For the research strategy, half used quasi-experiments (Buffum et al., 2016; Küng et al., 2022; Ying et al., 2021). The other half used surveys (De Castro-Cabrera and Guerrero-Contreras, 2022; Groher et al., 2022; Ying et al., 2019), probably due to convenience and to be an experiment in a classroom where the sample is not random.

We highlight that four out of six papers on collaborative learning were about pair programming (Groher et al., 2022; Küng et al., 2022; Ying et al., 2019, 2021), studies to characterize the experience of girls doing pair programming to learn programming a new language. Groher et al. (2022), Küng et al. (2022), and Ying et al. (2019) present great and interesting results that favor pair ramming as a collaborative learning methodology. However, Ying et al. (2021) results present pieces of evidence that, in their sample, girls were more stressed and nervous.

Concerning authorship collaboration, all papers are in "Research" in collaboration type. Also, it was impossible to define any collaboration model since the papers didn't define the cooperation process, and it's a situation that can be anything. All five studies of this group were defined as descriptive since the focus is to describe the research environment regarding women's participation in authorship. Due to the nature of this type of research, the strategy used was a survey, analyzing past data. As for their results, Yamamoto and Frachtenberg (2022) state that there is no significant difference between man and woman collaboration patterns, and Sarvghad et al. (2022) point out that the rate of women being present as authors in computer science-related fields increased from 5% to 30% in the last thirty years. A related result was obtained by Van Herck and Fiscarelli (2018), which reports that this increase in the rate of authorship is related to the increase in interdisciplinary research. Cavero et al. (2015) focus on understanding collaboration between genders in authoring. For that, the research points out, through the data analysis of 1936-2010, that only 9.36% of the papers were written with cooperation. Finally, Early et al. (2018) concentrate on understanding the order in which author names appear on the published paper. Their survey shows that many women occupy the first author position. However, they are not occupying the last position, which interviewed researchers expressed is the most prestigious one.

On collaborative forums, one paper was classified as "Research" (Oka et al., 2019) and the other two in "Learning" (Thinnyun et al., 2021; Fields et al., 2017) for collaboration type. Also, for (Oka et al., 2019), it was impossible to determine the collaboration model since the study goal was to understand the necessity of a collaborative network in the STEM environment. To assess that, they survey faculty members of a university. Therefore, this paper was classified as descriptive research since it aims to describe the necessity of cooperation in given circumstances. Thinnyun et al. (2021) and Fields et al. (2017) present studies about online forums that characterize women's participation. Both are asynchronous and remote due to the online nature of collaboration and used data analysis to test hypotheses, being a survey. Thinnyun et al. (2021) conclude that women are more engaged with the Piazza platform than men but use more anonymous functionality, contrasting with StackOverflow forum data. Fields et al. (2017) show through Scratch Forum data that girls' participation gradually decreases as the course advances.

Regarding team formation, the papers were classified into each collaboration type. Jimenez et al. (2021) focus on collaboration in a learning environment and aim to understand how women see their role in a group. The model of collaboration was not determined. However, it's an explanatory study and uses quasi-experiments to check the hypothesis of gender in team formation. Through the experiment, they conclude that, in general, women tend to keep their stereotype when choosing an assignment. While Gilal et al. (2019) andAlqahtani et al. (2020) are both design and evaluation studies, they propose algorithms to form diverse teams. However, Gilal et al. (2019) focus on teams for industry and use simulation to check the proposal's validity. The results showed that men must have extroverted personality traits, meanwhile women have introverted ones. Thus, the papers conclude that the proposal is ready to be launched. Alqahtani et al. (2020) also use simulation to evaluate but use the academic environment to test it as an asynchronous and remote collaboration model. Also, the proposal showed promising results.

As for team behavior, the two papers are from collaborative learning (Hirshfield, 2018; Heels and Devlin, 2019). Hirshfield (2018) describes the environment of a software development team in a classroom, which makes the study descriptive and uses observations to assess subjects' perceptions, being a case study with a follow-up questionnaire. Then, they triangulate qualitative and quantitative data. Was seen that feedback about the work in the group changed depending on the collected data. For example, through observation, one woman vocalized she did not feel comfortable in the team, while in the questionnaire, there wasn't a complaint. Heels and Devlin (2019) study is exploratory and uses surveys to evaluate women's behavior in teams and, as Jimenez et al. (2021), concluded that they have seen girls usually perform less technical tasks focusing on managing.

Finally, the hackathons only have one work associated with collaborative learning (Hardin, 2021). It is an explanatory work that uses surveys to identify participant conduct patterns by gender. The paper used different hackathons, some collocated and one remote due to the COVID-19 pandemic, and they were all synchronous collaborations. Through the data collected, it was impossible to perceive any significant difference in collaboration behavior by gender.

6 Conclusion

The under-representation of women at various education levels in STEM and in the corporate sector is a pressing issue that has garnered attention from prestigious organizations like the United Nations, impacting collaboration and innovation within these fields. This research aimed to analyze gender diversity in collaboration in the technology field. To achieve this goal, we reviewed the literature following the Rapid Review protocol (Cartaxo et al., 2018). Twenty primary studies were selected to compose the analysis. With them, it was possible to evaluate collaboration aspects regarding gender and cooperation, such as the type and model and type of collaboration, and strategy of research.

The results of our study have revealed several key insights into the state of the art of gender diversity in the field of collaboration. It's possible to see the need for more diverse studies about this theme. Results showed a concentration of works concerning collaborative learning and only one about collaboration in the corporate environment. Also, the most used research strategies were surveys, interviews, or questionnaires. However, researchers can benefit by using observational techniques and doing quasi-experiments. About the model of collaboration, it's not possible to conclude since most studies didn't define it.

This research contributes significantly to our understanding of gender parity, serving as a valuable resource for future studies focusing on collaboration to enhance women's involvement and foster gender cooperation. The results underscore the importance of ongoing exploration and comprehension of gender implications within collaborative environments.

As limitations, the study relied on a single search engine, and the search string had to be simplified due to the high number of documents returned, omitting terms like "group". Future researchers can expand on this work by investigating various aspects of collaboration and gender. This may include exploring how collaboration can positively impact women's participation and leadership roles in STEM, conducting secondary studies on the use of collaboration to promote STEM among women, and encouraging research within the industry environment, particularly focusing on software development teams.

References

Alqahtani, M., S. Gauch, O. Salman, M. Ibrahim, and R. Al-Saffar (2020): 'Diverse group formation based on multiple demographic features'.

Ashcraft, C., B. McLain, and E. Eger (2016): *Women in tech: The facts*. National Center for Women & Technology (NCWIT) Colorado, CO, USA.

Bear, J. B. and A. W. Woolley (2011): 'The role of gender in team collaboration and performance'. *Interdisciplinary science reviews*, vol. 36, no. 2, pp. 146–153.

Brasil, O. (2022): 'Os objetivos de desenvolvimento sustentável no Brasil'.

Buffum, P. S., M. Frankosky, K. E. Boyer, E. N. Wiebe, B. W. Mott, and J. C. Lester (2016): 'Collaboration and gender equity in game-based learning for middle school computer science'. *Computing in Science & Engineering*, vol. 18, no. 2, pp. 18–28.

Cartaxo, B., G. Pinto, and S. Soares (2018): 'The role of rapid reviews in supporting decision-making in software engineering practice'. In: *Proceedings of the 22nd International Conference on Evaluation and Assessment in Software Engineering 2018*. pp. 24–34.

Cavero, J. M., B. Vela, P. Cáceres, C. Cuesta, and A. Sierra-Alonso (2015): 'The evolution of female authorship in computing research'. *Scientometrics*, vol. 103, pp. 85–100.

Chavatzia, T. (2017): *Cracking the code: Girls' and women's education in science, technology, engineering and mathematics (STEM)*, Vol. 253479. Unesco Paris, France.

De Castro-Cabrera, M. D. C. and G. Guerrero-Contreras (2022): 'Creating a wiki about Computer Engineering History through its women'. In: *2022 International Symposium on Computers in Education (SIIE)*. pp. 1–6.

Dias Canedo, E., H. Acco Tives, M. Bogo Marioti, F. Fagundes, and J. A. Siqueira de Cerqueira (2019): 'Barriers Faced by Women in Software Development Projects'. *Information*, vol. 10, no. 10, pp. 309.

Early, K., J. Hammer, M. K. Hofmann, J. A. Rode, A. Wong, and J. Mankoff (2018): 'Understanding gender equity in author order assignment'. *Proceedings of the ACM on Human-Computer Interaction*, vol. 2, no. CSCW, pp. 1–21.

Fields, D. A., Y. B. Kafai, and M. T. Giang (2017): 'Youth computational participation in the wild: Understanding experience and equity in participating and programming in the online scratch community'. *ACM Transactions on Computing Education (TOCE)*, vol. 17, no. 3, pp. 1–22.

Galeno, L., C. E. Barbosa, L. F. Coimbra Costa, Y. Lima, L. M. Azevedo Nascimento, G. Xexéo, and J. Moreira de Souza (2023): 'Rapid Review on Gender and Collaboration'. DOI: 10.5281/zenodo.10340697.

Gilal, A. R., J. Jaafar, M. Omar, S. Basri, and I. D. A. Aziz (2019): 'A set of rules for constructing gender-based personality types' composition for software programmer'. In: *Proceedings of the International Conference on Data Engineering 2015 (DaEng-2015)*. pp. 363–374.

Groher, I., M. Vierhauser, B. Sabitzer, L. Kuka, A. Hofer, and D. Muster (2022): 'Exploring diversity in introductory programming classes: An experience report'. In: *Proceedings of the ACM/IEEE 44th International Conference on Software Engineering: Software Engineering Education and Training*. pp. 102–112.

Hardin, C. D. (2021): 'Gender differences in hackathons as a non-traditional educational experience'. *ACM Transactions on Computing Education (TOCE)*, vol. 21, no. 2, pp. 1–30.

Heels, L. and M. Devlin (2019): 'Investigating the Role Choice of Female Students in a Software Engineering Team Project'. In: *Proceedings of the 3rd Conference on Computing Education Practice*. pp. 1–4.

Hirshfield, L. J. (2018): 'Equal but not equitable: Self-reported data obscures gendered differences in project teams'. *IEEE Transactions on Education*, vol. 61, no. 4, pp. 305–311.

Jimenez, P. P., J. Pascual, J. Espinoza, S. San Martin, and F. Guidi (2021): 'Pedagogical innovations with a gender approach to increase computer programming self-efficacy in engineering students'. In: *2021 IEEE Global Engineering Education Conference (EDUCON)*. pp. 322–328.

Küng, J., A. M. Schmid, and D. Brovelli (2022): 'Gender and pair programming–Effects of the gender composition of pairs on collaboration in a robotics workshop'. In: *Frontiers in Education*, Vol. 7. p. 973674.

Oka, L. G., K. Stillmaker, C. Jones, A. Sadrinezhad, and M. Nazari (2019): 'Assessing the networking preferences and resource satisfaction among engineering faculty in the California State University system'. In: *2019 ASEE Annual Conference & Exposition*.

Sarvghad, A., R. Franqui-Nadal, R. Reznik-Zellen, R. Chawla, and N. Mahyar (2022): 'Scientometric analysis of interdisciplinary collaboration and gender trends in 30 years of ieee vis publications'.

Thinnyun, A., R. Lenfant, R. Pettit, and J. R. Hott (2021): 'Gender and engagement in CS courses on piazza'. In: *Proceedings of the 52nd ACM Technical Symposium on Computer Science Education*. pp. 438–444.

United Nations (2015): 'The 17 goals | sustainable development'.

Van Herck, S. and A. M. Fiscarelli (2018): 'Mind the Gap Gender and Computer Science Conferences'. In: *IFIP International Conference on Human Choice and Computers*. pp. 232–249.

Wallace, J. R., S. Oji, and C. Anslow (2017): 'Technologies, methods, and values: changes in empirical research at CSCW 1990-2015'. *Proceedings of the ACM on Human-Computer Interaction*, vol. 1, no. CSCW, pp. 1–18.

Wohlin, C., P. Runeson, M. Höst, M. C. Ohlsson, B. Regnell, and A. Wesslén (2012): *Experimentation in software engineering*. Springer Science & Business Media.

Yamamoto, J. and E. Frachtenberg (2022): 'Gender differences in collaboration patterns in computer science'. *Publications*, vol. 10, no. 1, pp. 10.

Ying, K. M., G. A. Katuka, and K. E. Boyer (2021): 'Using Dialogue Analysis to Predict Women's Stress During Remote Collaborative Learning in Computer Science'. In: *Proceedings of the 26th ACM Conference on Innovation and Technology in Computer Science Education V. 1*. pp. 60–66.

Ying, K. M., L. G. Pezzullo, M. Ahmed, K. Crompton, J. Blanchard, and K. E. Boyer (2019): 'In their own words: Gender differences in student perceptions of pair programming'. In: *Proceedings of the 50th ACM Technical Symposium on Computer Science Education*. pp. 1053–1059.

Wagner, Ina; and Kjeld Schmidt (2024): The work to make coordination technologies work. In: *Proceedings of the 22nd European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies: Exploratory papers (ISSN 2510-2591), DOI: 10.48340/ecscw2024_ep11*

The work to make coordination technologies work

Ina Wagner* and Kjeld Schmidt*§
*University of Siegen, Germany
§Copenhagen Business School, Denmark
ina.wagner@tuwien.ac.at; schmidt@cscw.dk

Abstract. Motivated by the long-standing concern in CSCW with the state of digital *coordination technologies* and the ensuing accumulated empirical evidence of how the shortcomings of coordination technologies are handled in practice, this paper presents four examples of coordination technologies and coordinative artifacts that show how workers cope with their shortcomings through workarounds and hacks: CAD systems in architectural practice; the medical record in a cardiology clinic and the problem of ICD data; the IMDS database in the car industry; and the problems of making MRP systems work for the purpose of local planning. Concluding with the question what is required to support workers in their cooperative effort to 'make coordination systems work', the notion of computer support for '*peer-to-peer plan management*' is introduced.

'"The work to make the network work" is considerable.'
John Bowers (1994, p. 296)

This study is motivated by the long-standing concern in CSCW with the state of digital *coordination technologies* and the ensuing accumulated empirical evidence of how the shortcomings of coordination technologies are handled in practice. The occasion to revisit this issue arose when looking back on findings from ethnographic and similar in-depth workplace studies that we and our colleagues have been conducting over a period spanning about three decades, in work domains as different as manufacturing planning and control, software engineering, air-traffic control, automobile design, architectural design, oncological treatment, and cardiological treatment. While our more immediate goal is a comparative analysis of coordinative artifacts in these domains, we were again struck by how coordination technologies often offer insufficient or no support to workers in handling alignment problems that occur in their daily work and how workers nonetheless *make them work*. The aim of this paper is, first, to point to, or remind us of, these problems and the often innovative ways in which workers cope with them through workarounds and hacks, and second, to outline, or resurrect, a research program aiming at developing computer support for the work of *making coordination technologies work*.

The term 'coordination technologies' covers a broad and manifold category of software applications used in contemporary workplaces. Initially developed in the 1950s, this category of applications has developed significantly since then and now encompasses systems as diverse as airline reservation systems, air traffic control systems, computer aided design (CAD) systems, facilities management systems, manufacturing resource planning (MRP II) or enterprise resource management (ERP) systems, software configuration management systems, patient record systems, accounting systems, inventory management systems, project management systems, group calendar systems, and much more. What the instances of this category of technology have in common are, basically, two features. First, they facilitate and regulate the distributed but interdependent work activities of multiple workers engaged in specialized local activities. Or in other words, they serve as coordinative infrastructures to these settings. Second, they are constructed on and around a distinct computational model of the interdependencies of the work arrangement in question, which serves as a calculus in some essential respects. A coordination system can best be understood as a family of coordinative artifacts, typically predicated on received (paper-based) techniques, which have now been integrated computationally, such as, e.g., a group calendar system in which the established techniques and concepts of calendar and timepiece form the foundation of a complex of techniques and concepts such as meeting, deadline, invitee, appointment, meeting room, etc.

However, while indispensable, the digital coordination systems in which these technologies are embodied at the same time pose significant problems to practitioners: their practical integration in the situated flow of work is hampered by the simple fact that these technologies have not been designed to be integrated in actual work practices. Work organizations and coordinative practices have rather been redesigned, or truth be told: *painfully adapted*, to these systems.

Several problems conspire to hamper the development and deployment of digital coordination technologies. Coordination technologies are, first of all, as all artifacts that embody a 'plan' or 'model' of the world in turn is to be, 'local and temporary closures' (Gerson and Star, 1986, p. 263). That is to say, their application is inexorably contingent and requires skill. For a given computational model, however well designed and however 'intelligent', 'situations unanticipated by the original system designers will inevitably arise', 'for both practical and theoretical reasons', and situations will always be possible where the system 'is beyond its bounds' (Roth and Woods, 1989, p. 237). Digital coordination technologies today are not designed so as to support users in dealing with contingencies. They offer no or little in terms of which users can meet contingencies. Workers instead strive to make them work by engaging in all kinds of workarounds and plain hacks.

On the other hand, coordination technologies are based on a single conceptual structure or schema, or in some cases, such as MRP or ERP systems, a few closely related conceptual structures. Coordination technologies of course share this limitation with the coordinative artifacts that have come down to us. They all typically embody a single conceptual structure. However, the conventional (paper-based) coordinative practices and artifacts we are talking about here typically comprise a multitude of artifacts used in conjunction. In the development of (computational) coordination technologies only a select few of these artifacts were emulated and integrated in the system, and they rarely, if ever, incorporate the entire received repertoire of coordinative artifacts of the given practice. In the development of coordination technologies, coordinative practices were subjected to the Procrustes Bed of managerialist software engineering.

That is, coordination technologies are carefully devised to address limited and specific issues of coordination, initially often also issues of concern only to specific work domains. As a consequence, they are reciprocally closed. Architects or engineers using a CAD application, for example, are bound to find that it does not interface with the calendar system, the project management system, and the document or workflow management system they are likely to also use. Nor can the functionalities of coordination technologies be integrated with other work tools (word processors, desktop publishing applications, process control systems). These limitations are fundamental and cannot be overcome simply by devising a few *ad hoc* 'application program interfaces' (APIs). The number of possible combinations grows exponentially with the number of different systems to be 'interfaced' and defeats such a strategy.

‘A world of pain’

The examples we briefly present in the following[1] concern different types of coordinative technologies; hence, they pose different problems for complex distributed work. The CAD system with its layer organization, designed to align different plan drawings requires an enormous amount of manual work to manage task interdependencies. It also offers no support with respect to designing elements of different scales. The second case is a medical record system in a cardiology clinic that shows signs of falling apart, due to the fact that different medical teams act as custodians of an individual patient’s illness trajectory. The IMDS database in the car industry brings unresolved problems of mapping different part numbering systems in use in the big network of care manufacturers and suppliers to the fore. Finally, MRP systems are not adapted to local use, with the consequence that workers need to create their own coordinative artifacts (and copies of them).

CAD systems in architectural practice

CAD plans date back to late 1950s and early 1960s. The first stand-alone commercial CADD platform IDIIOM was developed during the mid-1960s at Information Displays, Inc. (IDI). It was a general-purpose design workstation, and the first software drafting package (Bissell, 1998). Important precursors to CAD technology were the Automatic Programming Tool (APT) developed by Ross at MIT in the 1950s to control machines numerically (Ross, 1984) The movement in the late 1970s from direct numerical control (DNC) to computer numerical control (CNC) was a breakthrough for CAD/CAM (O’Connell, 1987). Another key to CAD/CAM's development was computer graphics, which accommodated both design and manufacturing activities (Machover, 2002). Kale and Arditi (2005) distinguish three generations of CAD technology: computer aided drafting, geometric modelling, and product modelling. Most architectural offices use AutoCAD, a desktop software application for 2D and 3D design and drafting which was first launched in 1982.

First of all, AutoCAD does not support architects and other building specialists in drawing concurrently on different layers of one and the same plan. It also does not support the development and maintenance of conventions. When 20 or more people work in a project, this results in considerable coordination problems. The management of task interdependencies in a CAD system is supported indirectly by its layer organization, a key feature. It is based on overlay drafting that was used by architects well before the adoption of CAD systems. Layering is a method of aligning related plan drawings. This is done by dividing a CAD drawing into

[1] The examples are selected from the authors’ corpus of fieldwork (e.g., Carstensen, Schmidt and Wiil, 1999; Odgaard et al., 1999; Carstensen et al., 2001; Carstensen and Schmidt, 2002; Schmidt and Wagner, 2004; Jacucci, Tellioğlu and Wagner, 2007; Bansler et al., 2011; Bansler et al., 2016).

multiple levels or categories, each with its own name and attributes. First, a base drawing is prepared, generally the floor plan. The related drawings are prepared directly over the base and aligned. This ensures that all structural features are aligned as well as all overlapping electrical, piping and other facilities (Hepler, Wallach and Hepler, 2012).

Layering affords the division of labor as it helps maintain the fit between the contributions of the different external specialists to the detailed planning of a building. All information pertaining to a particular task and purpose, such as fire protection, escape routes, ventilation system or structural elements, can be extracted from the file by copying the relevant set of layers. A first limitation, however, is that this process involves substantial manual work: the construction engineer or the heating and ventilation specialists will for instance receive a copy of the relevant layers from the central CAD plan, work on them, and return them to the architects for re-integration into the system. Much of this work is done by copying and pasting.

A second issue results from the limitation of scale. A large building contains hundreds of details, which can either be left open, to be decided upon later by the construction company or craftspeople, or they can be carefully designed up front. However, detail drawings are of a scale of 1:20, 1:10, 1:5 or even 1:1 and therefore cannot be fitted into the central CAD construction drawing. A common solution to this problem is to reference detail drawings in the CAD plan by a simple symbol such as 'circle' and the detail number, a numerical code (Figure 1). This limitation does not only apply to detail drawings but also to components (referenced by 'rectangle' and component ID) and product specifications, all elements that cannot be represented directly in the CAD plan (Schmidt and Wagner, 2004).

Figure 1. References to detail drawings (in circles) in a CAD plan.

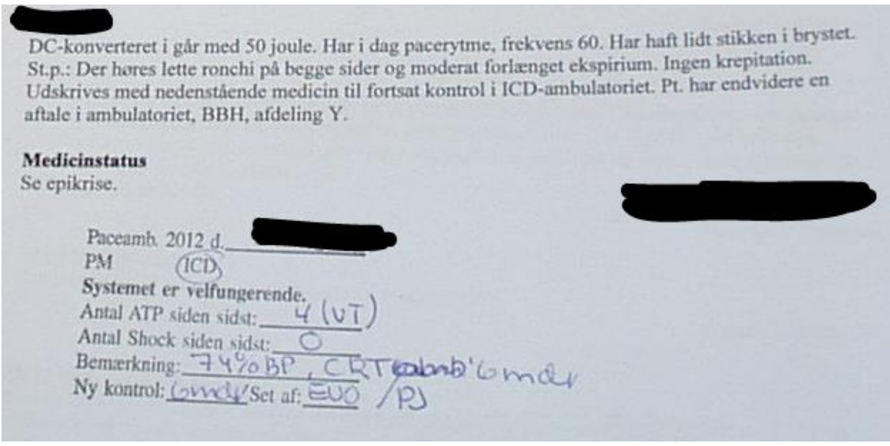
CAD technology supports the coordination of distributed work - the multiple interdependencies that need to be mastered, with each design change potentially propagating through a building – but only in indirect ways. Aligning the contributions of different specialists requires considerable manual work; so does aligning representations of elements of a building on different scale. Moreover, there is no concept of workflow: what needs to be done next, by whom, where, how – the questions that Strauss (1985) sees as fundamental to the alignment of distributed activities.

The medical record and the problem of ICD data

The second example is based on a study of a cardiology clinic and, more specifically, how patients with ICD implants are monitored on a regular basis, both in terms of ordinary cardiology and in terms of the functioning of the device (Bansler et al., 2016). This is done by different clinical workers at different locations: on one hand by the cardiologist at the patient's regional hospital and by the patient's own doctor (GP), and on the other by the ICD cardiologists, or 'electrical doctors' as they are called at the cardiology clinic and by the bio-technicians at the hospital's out-patient clinic who download and print data from the implanted device for specialist scrutiny. Newer ICD devices can be scanned remotely, while the patient is at home (via wireless download to a reader and subsequent transmission to the hospital over the Internet). The data then have to be recorded, filtered, interpreted, classified, put on record, handed over, etc.

Coordination of activities related to ICD devices currently occurs through various artifacts and communication methods used in conjunction. The key artifact is the heart center's patient folder. It holds up to about 500 sheets of paper, some loose sheets, some stapled together. The patient folder is hefty simply because it delineates the trajectory of chronically ill patients as represented in notes, lab reports, test results, clinical imagery, and so on that have accumulated over time, typically several years, and it thus gains size and weight over time.

The medical record concerning a particular patient is not confined to the content of the patient folder. In fact, the clinical record is distributed over an assortment of paper-based and electronic archives and databases. In this context, the most important 'satellite record' is what is called the 'green folders'. It is a large set of suspension folders, housed in about 40 cabinet drawers in the hallway. Each folder contains information about a particular patient's ICD unit, its configuration, and printouts from the data accumulated by the unit. It consists of documents related to the individual unit's status (battery level) as well as its interventions (date, time) since the last reading, along with graphs. The 'green folders' are kept by the bio-technicians at the outpatient clinic and are only occasionally accessed by doctors.



[redacted]

DC-konverteret i går med 50 joule. Har i dag pacerytme, frekvens 60. Har haft lidt stikken i brystet. St.p.: Der høres lette ronchi på begge sider og moderat forlænget ekspirium. Ingen krepitation. Udskrives med nedenstående medicin til fortsat kontrol i ICD-ambulatoriet. Pt. har endvidere en aftale i ambulatoriet, BBH, afdeling Y.

Medicinstatus
Se epikrise.

[redacted]

Paceamb. 2012 d. [redacted]
PM (ICD)
Systemet er velfungerende.
Antal ATP siden sidst: 4 (VT)
Antal Shock siden sidst: 0
Bemærkning: 74%BP, CRT [illegible] 6mdr
Ny kontrol: 6mdr Set af: EVO /PJ

Figure 2. A summary of the ‘read-out’ of an ICD (number of events, etc.) is manually transferred to the clinical notes in the patient folder, using a stamp with empty fields.

Hence, there are two medical record systems that are maintained by different specialists. To counteract the fragmentation of the medical record and ensure a minimum of coordination across the two record systems, a summary of the ‘read-out’ (number of events, etc.) is manually entered into the clinical notes in the patient folder (Figure 2).

The IMDS database in the car industry

Part numbers are key identifiers in product development and manufacturing. Part numbering systems allow easy recognition of a part through its significant aspects. An ‘intelligent’ part number embeds important information about, e.g., usage, function, material properties, color, finish, mounting or assembly interface of a specific part. Although different manufacturing domains have developed standards and classification systems to resort to, as well as some general rules about how to compose a part number, its structure very much depends on the specifics of a part and its production process. Part numbering is extremely important for a supply chain to be successful. This is why it should be usable in the whole industry. However, large companies tend to use their own part numbers, and mapping between systems is not sufficiently supported.

A study at *Carparts*, a 1st (in some cases) and 2nd (in other cases) tier supplier of the Automotive Supply Chain, brought some of the difficulties of mapping different part numbering systems to the fore (Jacucci, Tellioğlu and Wagner, 2007; Schmidt, Tellioğlu and Wagner, 2009). The particular occasion was the introduction of the *International Material Data System (IMDS)* in the automotive industry in compliance with the ‘End-of-Life Vehicle directive’ issued by the EU in 2000 upon an initiative of German car manufacturers. This system is supposed to track chemical ingredients of parts and assemblies across the entire automotive Original Equipment Manufacturer (OEM) supply chain. It is:

'[…] designed to act as an easily accessible database to help manufacturers record and track material usage. The system supports recyclability and recoverability of materials in a vehicle and addresses the disposal of substances of concern' (HP International Material Data System - Fact Sheet - 4AA4-0326ENW).

The IMDS was a joint development of Audi, BMW, Daimler, EDS, Ford, Opel, Porsche, VW, and Volvo. Further manufacturers have since joined, and IMDS has become a global standard used by almost all global OEMs. The IMDS database supports searching for materials and suppliers, as well as creating materials and components. The latter requires inputting all substances, their percentage and weight, and, in the case of some substances (e.g., with a polymer classification) to specify how they are used/the parts are made, as well as answer 'recyclate questions'.

Databases are special kinds of coordinative artifacts. In the case of the IMDS, which is used by all actors in the supply chain, it allows the tracing of hazardous substances back to the individual part and work with suppliers to reduce, control, or eliminate the hazard. This presupposes a standardized terminology and requires specialized chemical knowledge. However, there are many unresolved issues around the IMDS database.

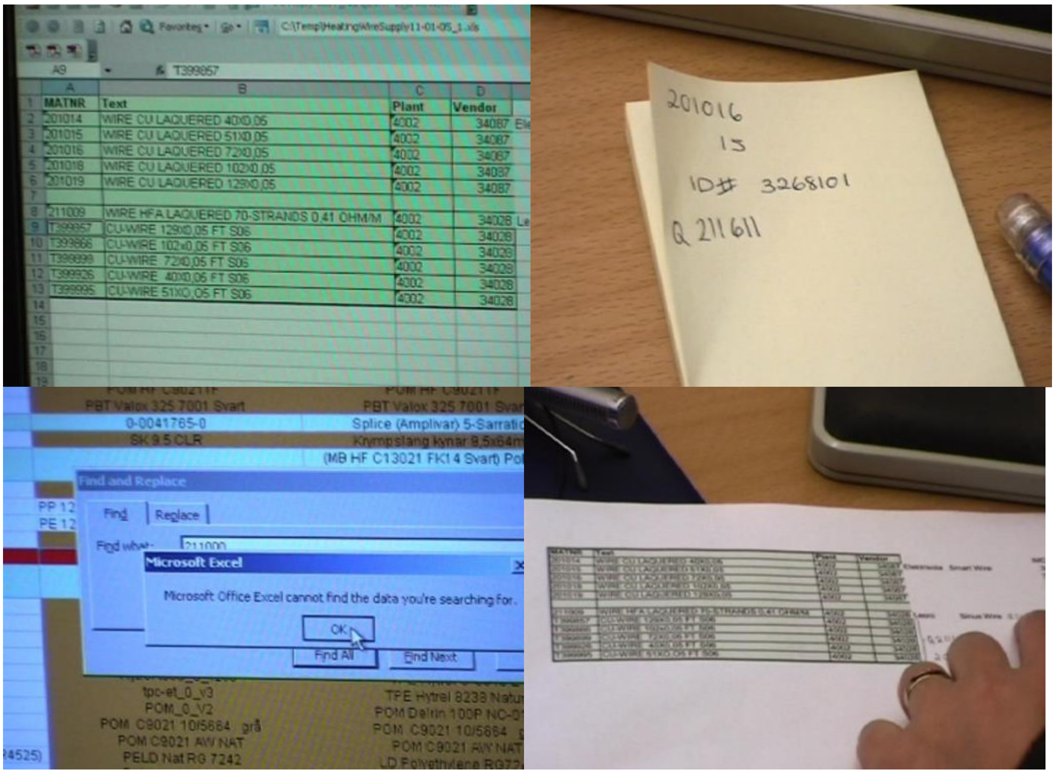


Figure 3. Trying to enter information about part SMART TCU-UN from a supplier and to add it to the IMDS database using a customer part ID.

Placed at *Carparts* within a network of in-house specialists, suppliers and customers, workers have to face the complexities of making IMDS work in practice.

For example, when one part is delivered directly to the car producer and another one to let's say the seat producer, each of those companies uses a different part number. Suppliers, in particular small ones, have problems in providing detailed information about their parts that are required by the IMDS system. The responsible person at *Carparts* has problems to retrieve this information in order to be able to add it to the IMDS database. She struggles with numerous documents while sending out an email, making phone calls, printing out lists, carrying them to another office to discuss the problem, and so forth. She consults an MS Excel sheet with part numbers of different heating wires, finding out that it has not been updated, goes through an annotated printout of a list with part numbers, and jots down alternative part numbers (Figure 3).

The fact that the mapping problems between different part numbering systems have not been resolved, affects many workplaces at *Carparts*, among them testing, purchase, and sales.

Making MRP systems work for the purpose of local planning

The fourth example is based on a series of six studies in Danish manufacturing plants all engaged in devolution of operational control to locally autonomous working groups: a factory producing facilities for the distribution of electrical power from power plants to consumers, a medium-size enterprise producing steel wardrobes and steel wire products, one of the largest shipyards in Europe, a leading European power cable manufacturer, a leading manufacturer of propulsion plants for smaller and medium-sized ships, and a leading manufacturer of sound and vibration measurement equipment. (For summaries of findings, see Odgaard, 1994, 1995; Carstensen, Schmidt and Wiil, 1999; Odgaard et al., 1999; Carstensen et al., 2001; Carstensen and Schmidt, 2002).

Cooperative work in manufacturing is basically and generally characterized by the challenge of coping with a very high level of coordinative complexity. For each product a very large number of parts and subassemblies are to be produced in different predetermined sequences at specialized workstations, and in contemporary plants multiple products are being produced in parallel, competing for the same resources. To deal with this, engineers have over the last century or so developed a sophisticated set of coordinative techniques and associated artifacts. Central to these is the 'bill of materials', a hierarchical representation of the total set of parts (components and subassemblies) comprising the final product. Taking that representation as a framework and combining it with the empirically determined times to produce each part (preparation, time to obtain materials, set-up time at the workstation, processing, cleaning, etc.) and intermediary transportation between workstations, the planners calculate a 'master schedule' indicating the time for each of the constituent processes to begin to enable the overall production series to meet a given deadline.

Until the emergence of host computers in the 1950, the calculations were entirely manfully performed to calculate a master schedule, a massive task using type- or handwritten lists of parts, blueprints, etc. Unsurprisingly, with computing power available, this massive task was one of the first to be computerized.

Now, the concept underpinning MRP-based production planning and control addresses planning at the population level, so to speak, that is, at the level of the entire operation (by product or by the portfolio of products to be produced in parallel), not the level of the individual workstation (or group of workstations). And it is at that level that contingencies rule the day: defective tools and machinery, absent workers, defective parts and materials, delays in delivery, etc.

It may, to take an example from a marine diesel-engine manufacturer, turn out that the test run of an engine has to be postponed because the engine block turns out to have fractures. A replacement will have to be ordered and produced, of course, but it also has to be transported across Europe on a truck (even an 'oversize load' transportation) which will take weeks. In the meantime, the upstream production of parts and assemblies for this particular engine proceeds as planned by the SAP MRP system, while other production orders competing for some of the same resources (workstations) dutifully wait for this already released production order has cleared the intersection. Or rather, somebody on the shopfloor realized the traffic jam and a new master schedule was generated and the waiting orders were released while the frame made its slow way from Romania to Denmark.

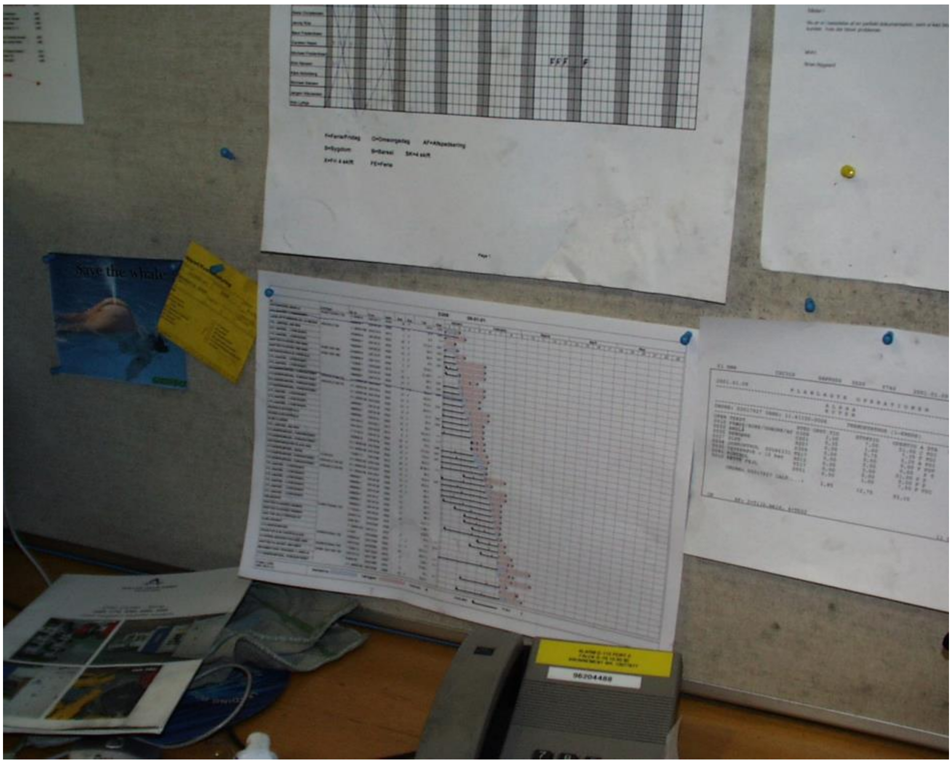


Figure 4. From the ’office’ of the team planner, parts production, MAN B&W Diesel. The Gantt chart at the bottom of the posting board is a print-out of the local production plan.

In fact, the ship engine manufacturer had been experimenting with systematic devolution of operational control to locally autonomous teams on the shopfloor and, realizing that the MRP system was too unwieldy for local planning purposes, the production engineers and planners had developed a hack to extract data from SAP into the Microsoft Project application so that the planners of the local teams could rearrange jobs (order of priority, timing) within their remit as they saw fit. However, this hack did not help in the case of the defective block because it was based on a data master schedule which had not been updated to reflect the upstream consequences of a postponed test and the hack did not support the propagation of such information upstream in the chain. Only gossip and shoptalk among workers made it transpire.

Implications for design: ‘Peer-to-peer plan management’

The complications with making plans work that we have just sketched have quite different causes: In the case of architectural practice, the need to make plans at different scales of representation makes it necessary to operate with different sets of plans: detail plans, components, and the central CAD plan with its scores of layers. To keep order in the vast distributed repository, architects, among many other measures, insert a snippet of text (a comment) next to the relevant object in the layer informing a reader of the existence and ID of a detail drawing. The two representations are thereby cross-indexed, but the textual indicator is as dead as a tombstone, its meaning precariously predicated on proximity in a chart, and amendments to the CAD layer might easily erase the indicator or render it pointless. This is hardly a rigorous solution.

The indicator pointing from the central patient folder to the corresponding file in the cardiology clinic's satellite archive is caused by the arrival of cardiological technology that automatically generates a large amount of clinical data that, if automatically included in the record, would make the record useless for doctors as a basis for making decisions. The solution in this case is to insert a rudimentary textual summary of the latest readout of the ICD in a form stamped onto the clinical progress notes. But again, it is hardly robust. Nor can it be retained, in the observed form or in the existing division of labor vis-à-vis the clinical record, in the transition to the computer-based clinical record system.

The complications faced by the workers at *Carparts* are quite different from these examples of indexing objects in distributed repositories. It is caused by the fact that standardization has its limits. There may or will at any time be areas outside of the domain under the superimposed schema of the standard. Partly due to the fact that the automotive industry, like any other, is not an island; it has supply chains that overlap with the supply chains of other industries such as construction and agricultural machinery, elevators and escalators, batteries and chips, textiles, and electrical conduits. And partly, received repositories of drawings, etc., may be brought together in a process of business mergers and acquisitions, while reclassification would be uneconomical; likewise novel products, materials, processes, etc. may not as yet have been domesticated under the classification schema. There will inevitably be boundaries at which complications must be handled.

And finally, in the case of the diesel engine manufacturer, the complications described here are caused by the inherent limitations of MRP systems in that they are designed to serve overall planning of the operation as a whole, and cannot rationally be used to deal with local contingencies (defective or delayed parts, etc.) for the simple reason that a master schedule that is changed on a daily or hourly basis is not a master schedule. The limitation here is also one of scale, not spatial but temporal. The team planners' work is therefore to reschedule local tasks as needed and, if necessary, stay in touch and negotiate with their colleagues on other teams in case the effects of contingent deviations from the master schedule spill over from one team to the next.

What is to be done?

What is required to support workers in their cooperative effort to 'make coordination systems work' could be termed computer support for '*peer-to-peer* *plan management*'. By that we mean a family of technology that supports the residual coordinative tasks that fall outside of the remit of a coordination system, taking as input the plan generated by the coordination system (CAD plan, car model, patient records, design issue list, MRP master schedule). It uses the conceptual structure of the coordination system to support the horizontal coordination among distributed workers in managing the plan generated by it: using *the plan as a resource for situated action*, to use Suchman's terminology (1987).

Software developers have of course recognized the challenge of making infrastructural coordination systems work in practice, in real cooperative work settings. But they have generally done so simply by offering additional communication channels: video and audio, e.g., Teams or Zoom (or text-based chat as a substitute), supplementing the coordinative functions of the coordination system. (In fact, the declared design aim typically is not to reduce the complexity of shopfloor coordination but rather to facilitate remote collaboration, thus adopting the approach that has dominated CSCW for decades).

What is crucial, however, for collaborative technologies to make significant progress in this regard is that 'the work to make plans work' is done *in domain specific terms*. What is required is digital coordination support in terms of the categories of the domain as expressed in computational terms: objects and object classes (CAD plan objects, cardiological states, MRP object classes such as parts, processes, and resources as well as timeline points).

For example, consider a peer-to-peer plan management system (P3MS) for architects working with a CAD plan of a building. For each 'move' considered by our architect (moving a wall, say), a number of contingencies may arise. The architect may want to explore the history of the design process with respect to this object or make an annotation raising objections to this particular design decision, embedding the note as a property of the object (as an embedded Request for Comments). More dramatically, the considered move may conflict with other design decisions, and the system may detect that by traversing the web of the CAD model of the construction and provide notifications to relevant parties according to a prespecified protocol (perhaps as 'semi-structured messages', perhaps by opening a chat thread, connected to the object).

Or to take another example. In case of local deviations from the master schedule plan generated by the MRP system, workers will need support for checking if the considered plan amendments might be in conflict with tasks assigned to other actors, at other station, both down- and up-stream. If such conflicts are detected by the P3MS, again by traversing the model of interdependencies, the P3MS may be used to notify affected workers at stations down- and up-stream of the intended plan changes, and, if necessary, establish a communication channel for negotiations. And finally, for purposes of accountability, the P3MS should retain a record of local plan deviations, again as properties of the affected objects (jobs, stations, work-in-progress).

These observations are hardly revolutionary revelations. In advanced manufacturing, for example, efforts to develop technologies (such as 'manufacturing execution systems') to support cooperative plan management, taking MRP models as the infrastructure, have been ongoing for many years but seem to be stalling (see, e.g., McKay and Black, 2007; Saenz de Ugarte, Artiba and Pellerin, 2009; Järvenpää et al., 2015; Mantravadi and Møller, 2019).

What would seem to be required is a more radical approach, the practice-centered CSCW approach. Coordinative practices are domain specific (they are, after all, types of situated action) and the challenge is to develop tools that enable domain actors to express the residual tasks arising contingently at the boundary of coordination systems and manage them cooperatively. To move the development of peer-to-peer plan management beyond *ad hoc* solutions requires bottom-up development of programming environments that provide higher-level categories of object classes for coordinative work (such as, for example, 'Who gets to do what, when, and how, how much' (to invoke Strauss, 1985, p. 9), but also what *has* been done, by whom, where, etc. and schemas for naming, classifying, and placing things, etc.). It involves a process of systematic abstraction, 'from the ground up' (Hughes et al., 1994, p. 129). This is what makes it difficult to grasp and do.

In sum, the visionary research program for CSCW that Irene Greif sketched 36 years ago remains highly relevant:

> 'Designers who draw pictures, software developers who jointly write code, financial analysts who collaborate on a budget—they all need coordination capabilities is an integral part of their work tools. That means coordination support within the CAD engineer's graphics package, within the programmer's source-code editor, within the budget writer's spreadsheet program. It means support for managing multiple versions of objects, be they pictures, programs, or spreadsheets. It means ways to distribute parts of the object for work by contributing group members, ways to track the status of those distributed parts, ways to pull completed objects back together again. ' (Greif, 1988, pp. 8 f.).

References

Bansler, Jørgen P.; Erling C. Havn; Troels Mønsted; and Kjeld Schmidt (2011). A study of the fragmentation of the medical record. In P. Bjørn; F. Kensing; and L. R. Christensen (eds): *Infrastructures for Healthcare 2011: Global Healthcare: Proceedings of the 3rd International Workshop, 23-24 June 2011, Copenhagen*. Copenhagen: IT University of Copenhagen, pp. 94-97.

Bansler, Jørgen P.; Erling C. Havn; Kjeld Schmidt; Troels Mønsted; Helen Høgh Petersen; and Jesper Hastrup Svendsen (2016). Cooperative epistemic work in medical practice: An analysis of physicians' clinical notes. *Computer Supported Cooperative Work (CSCW)*. Vol. 25, no. 6, December 2016, pp. 503-546.

Bissell, Don (1998). Was the IDIIOM the first stand-alone CAD platform? *IEEE Annals of the History of Computing*. Vol. 20, no. 2, April-June 1998, pp. 14-19.

Bowers, John M. (1994). The work to make a network work: Studying CSCW in action. In J. B. Smith; F. D. Smith; and T. W. Malone (eds): *CSCW'94: Proceedings of the Conference on Computer-Supported Cooperative Work, 24-26 October 1994, Chapel Hill, North Carolina*. New York: ACM Press, pp. 287–298.

Carstensen, Peter H.; Kjeld Schmidt; and Uffe Kock Wiil (1999). Supporting shop floor intelligence: A CSCW approach to production planning and control in flexible manufacturing. In S. C. Hayne (ed.): *GROUP 1999: International Conference on Supporting Group Work, 14-17 November 1999, Phoenix, Arizona*. New York: ACM Press, pp. 111-120.

Carstensen, Peter H.; Hans Jørgen Lynggaard; Kjeld Schmidt; Alex Skandorff Vestergaard; and Uffe Kock Wiil (2001). *IT-støtte til produktionsgrupper: Debatoplæg fra IDAK-projektet*. København: CO-Industri etc., June 2001.

Carstensen, Peter H.; and Kjeld Schmidt (2002). Self-governing production groups: Towards requirements for IT support. In V. Marík; L. M. Camarinha-Matos; and H. Afsarmanesh (eds): *Knowledge and Technology Integration in Production and Services: Balancing Knowledge and Technology in Product and Service Life Cycle. IFIP TC5/WG5.3. Fifth IFIP International Conference on Information Technology in Manufacturing and Services (BASYS'02), 25-27 September 2002, Cancun, Mexico*. Boston, Mass.: Kluwer Academic Publishers, pp. 49-60.

Gerson, Elihu M.; and Susan Leigh Star (1986). Analyzing due process in the workplace. *ACM Transactions on Office Information Systems*. Vol. 4, no. 3, July 1986, pp. 257-270.

Greif, Irene (1988). Overview. In I. Greif (ed.): *Computer-Supported Cooperative Work: A Book of Readings*. San Mateo, Calif.: Morgan Kaufmann Publishers, pp. 5-12.

Hepler, D.J.; P.R. Wallach; and D. Hepler (2012). *Drafting and Design for Architecture & Construction*Cengage Learning. <https://books.google.at/books?id=KWoJAAAAQBAJ>

Hughes, John A.; Wes W. Sharrock; Tom A. Rodden; Jon O'Brien; Mark Rouncefield; and Dave Calvey (1994). *Field Studies and CSCW (COMIC Deliverable D2.2)*. Lancaster, UK: Computing Department, Lancaster University. (*COMIC, Esprit Basic Research Project 6225*. <https://dl.eusset.eu/handle/20.500.12015/4110>

Jacucci, Gianni; Hilda Tellioğlu; and Ina Wagner (2007). Practices and cultures of knowledge management. In: *CCE'07: 5th Workshop on Challenges in Collaborative Engineering, Kraków, Poland, 11-13 April 2007*. pp. 99-112.

Järvenpää, Eeva; Minna Lanz; Henri Tokola; Tapio Salonen; and Mikko Koho (2015). Production planning and control in Finnish manufacturing companies–Current state and challenges. In C. F. Oduoza (ed.): *25th International Conference on Flexible Automation and Intelligent Manufacturing (FAIM2015), 23-26 June 2015, Wolverhampton, UK*. Gloucester, UK: The Choir Press. <https://urn.fi/URN:NBN:fi:tty-201705191420>

Kale, Sedar; and David Arditi (2005). Diffusion of computer aided design technology in architectural design practice. *Journal of Construction Engineering and Management*. Vol. 131, no. 10, October 2005, pp. 1135-1141.

Machover, Carl (2002). Oral history interview. Interviewed by P. Frana, 20 June 2002, at White Plains, New York. Interview transcript, Charles Babbage Institute, University of Minnesota, Minneapolis (OH 362).

Mantravadi, Soujanya; and Charles Møller (2019). An overview of next-generation Manufacturing Execution Systems: How important is MES for Industry 4.0? *Procedia Manufacturing*. Vol. 30, January 2019, pp. 588-595. <https://www.sciencedirect.com/science/article/pii/S2351978919301155>

McKay, Kenneth N; and Gary W Black (2007). The evolution of a production planning system: A 10-year case study. *Computers in Industry*. Vol. 58, no. 8-9, December 2007, pp. 756-771.

O'Connell, Colette (1987). CAD/CAM (Computer-Aided Design / Computer-Aided Manufacturing): A history of the technology and guide to the literature: Part I. *Science & Technology Libraries*. Vol. 7, no. 4, 1987, pp. 127-154.

Odgaard, Irene (1994). *"Praksis var værre end forventet": Produktionsgrupper på Ålestrup: Grundfos, Denmark. Casestudie-rapport om nye former for arbejdsorganisation*. København: Specialarbejderforbundet i Danmark (SiD), 26 August 1994. – [IMF Project on new forms of work organization (IMF-EMF-FIET.). Unpublished report. In Danish].

Odgaard, Irene (1995). User Requirements for Tools to Support Human Oriented Management of Change. *Advances in Human Factors/Ergonomics*. Vol. 20, no. C, December 1995, pp. 1017-1019.

Odgaard, Irene; Peter H. Carstensen; Kjeld Schmidt; Uffe Kock Wiil; Bruno Clematide; and Maj Fagerberg (1999). *Produktionsgrupper: organisationsudvikling og IT-støtte*. København: CO-industri etc.

Ross, Douglas T. (1984). Oral history interview. Interviewed by W. Aspray, 21 February 1984, at Waltham, Mass. Interview transcript, Charles Babbage Institute, University of Minnesota, Minneapolis (OH 65).

Roth, Emilie M.; and David D. Woods (1989). Cognitive task analysis: An approach to knowledge acquisition for intelligent system design. In G. Guida and C. Tasso (eds): *Topics in Expert System Design. Methodologies and Tools*. Amsterdam: North-Holland, pp. 233-264.

Saenz de Ugarte, B.; A. Artiba; and R. Pellerin (2009). Manufacturing execution system – a literature review. *Production planning and control*. Vol. 20, no. 6, pp. 525-539.

Schmidt, Kjeld; and Ina Wagner (2004). Ordering systems: Coordinative practices and artifacts in architectural design and planning. *Computer Supported Cooperative Work (CSCW)*. Vol. 13, no. 5-6, December 2004, pp. 349-408.

Schmidt, Kjeld; Hilda Tellioğlu; and Ina Wagner (2009). Asking for the moon: Or model-based coordination in distributed design. In I. Wagner*, et al.* (eds): *ECSCW 2009: Proceedings of the 11th European Conference on Computer-Supported Cooperative Work, 7-11 September 2009, Vienna, Austria*. London: Springer, pp. 383-402.

Strauss, Anselm L. (1985). Work and the division of labor. *The Sociological Quarterly*. Vol. 26, no. 1, 1985, pp. 1-19.

Suchman, Lucy A. (1987). *Plans and Situated Actions: The Problem of Human-Machine Communication*. Cambridge: Cambridge University Press.

Grandison, Tanis (2024): Participatory Explorations in the Techno- Spiritual. In: Proceedings of the 22nd European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies - Exploratory Papers, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591.), DOI: 10.48340/ecscw2024_ep12

Participatory Explorations in the Techno-Spiritual

Grandison, Tanis
School of Computing, Engineering and the Built Environment, Edinburgh Napier University, U.K.
Contact Author: t.grandison@napier.ac.uk

Abstract. This exploratory paper presents a pilot study conducted with 64 undergraduate students at Edinburgh Napier University in November 2023. The aim of this study was to understand how people who do not necessarily identify as religious engaged in what they saw as spiritual and or faith-based practices and how those participants saw technology playing a role now, and in the future of these experiences. The pilot study is part of a series of initial investigations to understand two key areas: What do modern practices around religion, faith and spirituality look like? How could technology support modern engagement and new interactive experiences with contemporary faith and spiritual practices?

Introduction

As of 2021, 85% of the world's population subscribe to an organised religion (Rifat et al., 2022). In England and Wales, for the first time ever, less than half the population identified as Christian, a 13.1% drop since the 2011 census (ons.gov, 2021). By contrast "No Religion" was the second most popular response with an increase of 12% since 2011 (ons.gov, 2021). While these respondents have stated no religion, it could still mean that these individuals may have some spiritual beliefs or other broader attitudes toward faith away from a traditional religious concept. In Scotland, The Church of Scotland has been told it needs 'radical' reform or it will not survive in the country, with over 700 churches predicated to close by the end of the decade (Church of Scotland, 2021). There have been growing calls for more research in HCI around religion, faith and spirituality, particularly participatory approaches to support imagining how these futures may look with technology (Markum, Wolf and Luthe, 2022; Jung, Buruk and Hamari, 2022). Furthermore, digital interactions with the spiritual can support overall mental and physical health and well-being (O'leary et al., 2022), with Rifat et al. (2022) calling for a research network at CHI 2022 to investigate how HCI can better support communities, and the integration of HCI practices with religion, faith, and spirituality. One of the first to call for a need for more exploration around this topic was Bell in 2006 where the phrase "techno-spiritual practices" was coined. Another prominent contributor to the field is the work of Buie (2019). Buie argues that while research is continuing, there are a lack of definitions around what it means when researchers discuss different types of experiences that are being studied. A framework is provided consisting of eight terms:

- Spirituality
- Religion
- (Self) transcendent experience
- Spiritual experience
- Religious experience
- Transcendence
- Transformative experience
- Transcendent user experience

As these studies progress, this framework could provide a useful guide for categorising both the types of experiences and interactions described by participants, and at the later stages the types of responses created. Part of the wider goals of this research is to explore the following questions: What do modern practices around religion, faith and spirituality look like? How could technology support modern engagement and new interactive experiences with contemporary faith and spiritual practices? It is then the outcome of this wider research to design new digitally enhanced interactions with religion, faith and spirituality that take into the account more current and non-traditional notions of spirituality and faith.

An exploratory techno-spiritual workshop

Building on the calls for more participatory approaches, this pilot study took the form of a participatory workshop. Workshops create a space where individuals can come together, create community and collaboration and in the process engage in problem solving and gain new knowledge (Ørngreen and Levinsen, 2017).

Furthermore, this playful participation can critically engage with identity and social relations (Markussen and Knutz, 2017). Ahmed and Asraf (2018) argue workshops can be a rich data gathering tool and argue that the use of them can help to foster trust with participants. This is done through the facilitator's enthusiasm and recognising and valuing participants' contributions. This then leads to participants sharing "rich information". Sixty-four participants aged between 18 to 35 took part in the pilot study. All the participants were third year undergraduate students at Edinburgh Napier University. Students were already allocated into groups for the Trimester, so these groups were maintained for the study (groups of four and five).

It is acknowledged that this type of setting may limit the findings of the pilot study. Beyond age, participants were not asked about their specific religious or faith or spiritual background and there was no other demographic data gathered about the participants. The reason for limited demographic data being gathered was that in another pilot study all ten participants were of diverse religious backgrounds (Anglican, Catholic, Jewish, Muslim and Hindu) but only one artefact which specifically supported a religious practice was created. Of interest in the findings of the other study was the discussion in the group where more holistic notions of faith and spirituality were shared.

There is a difference between religion and spirituality. Religion is more organised, there are doctrines, beliefs and systems. Spirituality is how each individual connects with their idea of God, a greater power or whatever it is that the person believes in. It may be informed by their religion, but even when two people are of the same religion, their practice of spirituality may be quite different.

As this is an exploratory study to identify initial understandings of people's concepts of religion, faith and spirituality and their thoughts on the role of technology within them, as well as patterns and themes for potential future study, demographic data was not collected at this stage but as the research becomes more defined this demographic data would be collected. Another limitation to consider is that facilitating the workshops as a group may limit the individual practices that participants would be willing to share in the group. The group may influence the overall responses.

The workshop was two hours long and consisted of two parts. Before undertaking any research, ethical approval was sought through the university and participants asked to sign a consent form. The first part of the workshop was 45 minutes long. Participants were given a series of questions and asked to respond to them in their groups on large sheets of paper. These questions had been informed by another workshop that had taken place in earlier in the year in partnership with Edinburgh Interfaith Association and focused on participants who identified as actively being part of a religious group. The questions asked to the participants were as follows:

1. What does having faith or being spiritual mean to you?

2. When do you feel most spiritual and why?
3. What does sacred mean to you?
4. What spiritual or faith-based activities do you engage in?
5. Have you used any technology to help you in your faith, spiritual or sacred practices?
6. Are there any places you consider sacred, why?
7. Does being outside affect your sense of spiritual and sacred, how?

Fourteen sets of responses were gathered to the questions. An example of the responses can be seen in Figure 1.

Once the groups had completed the question responses, they were then asked to work together to make a 3D model using craft materials such as modelling clay, balsa wood, material, metal wire, paper and so on of an object that could support future spiritual and faith-based practices incorporating technology. They were told that the models were to be scanned using photogrammetry and a digital model of their creation stored digitally. The participants were also asked to create a storyboard explaining their project Figure 2. Vega (2021) discussed the benefits of

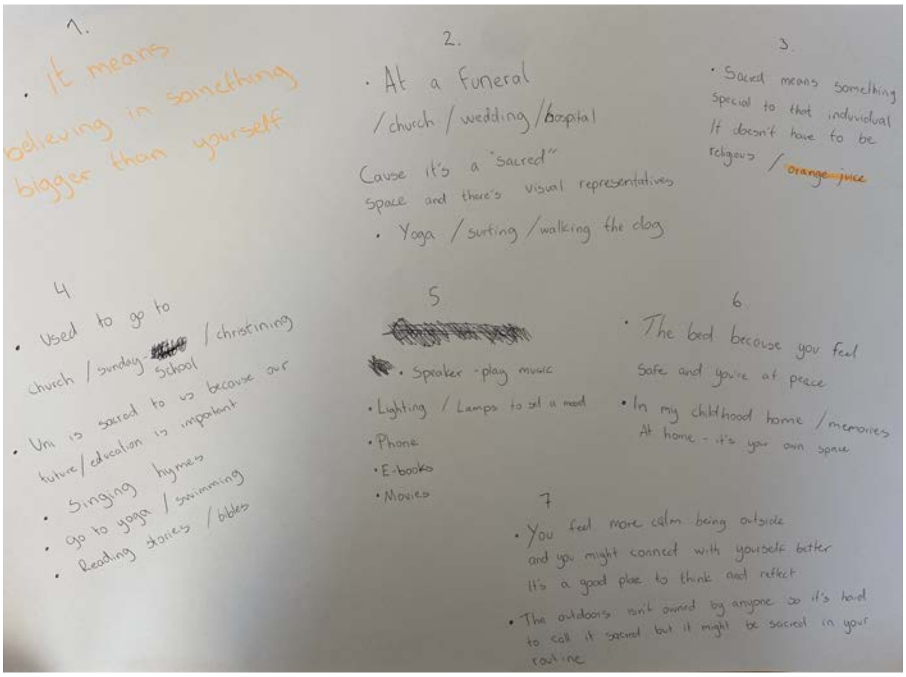


Figure 1. Example of group question responses.

thinking through making and highlights the importance of not just making for the individual but in the social as site of knowledge production. This highlights that thinking through making is a valuable method for not just the individual but for a group's understanding of each other's perspectives and as a learning opportunity.

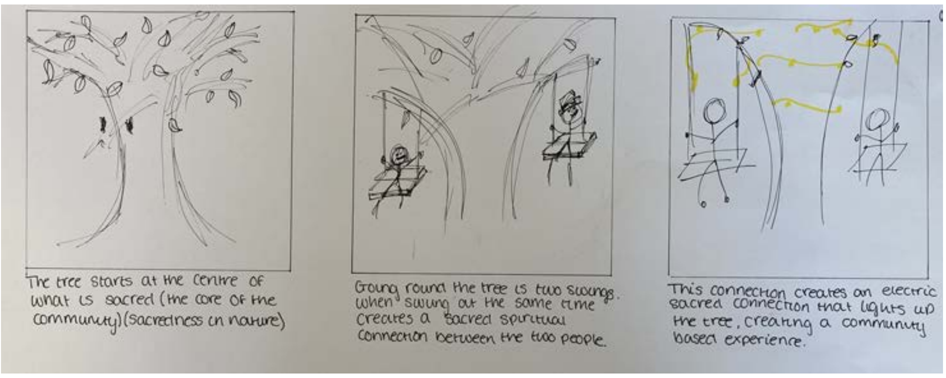


Figure 2. Example of a group storyboard.

The value is highlighted by Wallace et al. (2024) who ran a workshop at TEI using a craft method to explore IoT and connected things. Posch and Fitzpatrick (2021) also highlight how this kind of making is inclusive as it can be done by both experts and novices and this in turn can help to bridge different areas of knowledge. Further, it could be argued that using craft methods can create more inclusive practice when investigating technology, focusing on how something could be done rather than the technical aspects, such as programming. The models were scanned using a mobile phone, Kiri Engine app and a Foldio Studio 3 to ensure lighting quality. An example of the process can be seen in Figure 3. This approach also gave the participants the opportunity to learn about photogrammetry scanning, and if they wanted could have a try of taking their own photos too. Using this approach meant that the models could also be displayed in different ways, i.e. using tablets or online spaces giving the artefacts versatility and future research potential. If models were damaged over time, a digital record of the artefact was still held.

A total of fourteen models was made and scanned and an example of the models can be seen below in Figure 4.

Key Workshop Findings

The approach to analysing the data produced in the participatory workshop is thematic analysis. While data analysis has not yet been completely finished, indicative key findings and other observations of note from the question section and model building are presented. The large questions sheets which are shown in Figure 1. were coded for key phrases. All of the groups' responses to each question were then brought together and sorted into themes.

Question Findings

1. What does having faith or being spiritual mean to you?

Figure 3. 3D scanning with Foldio Studio.

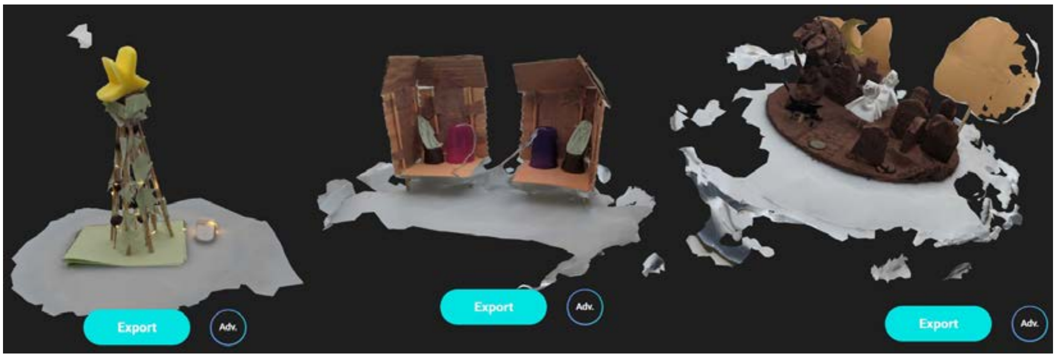


Figure 4. Example of 3D models in Kiri.

In response to question one, a key theme was the concept of considering something bigger in yourself. Common responses in this theme included “trusting in yourself and the future”, “belief in the greater good” and “belief in something bigger than yourself”. Another theme identified was a way of living and seeing the world. Responses in this theme included, “comfort”, “feeling peace”, “a way of life” “belief in something you find important”, “people”, “taking care of yourself” and “faith as a form of encouragement”. What is striking is how few of the responses are aimed toward more traditional religious notions of faith and spirituality. Religion was a theme but only received three responses: “practicing a faith”, “being part of a community that’s religious” and “devoted to an ideology”.

2. When do you feel most spiritual and why?

The first theme that emerged was religious events such as Easter and Christmas which were commonly mentioned. However, it is interesting that the participants feel most spiritual around the times of mainstream British religious holidays, but they did not connect this with question one, around having faith or being spiritual.

Self-care is another predominant theme which appeared to be important such as relaxing, taking a bath, spending time with friends or family.

Another major theme was exercising and being outside in nature such as walking the dog, climbing and wild swimming. Music was also a theme that emerged as participants commented that "they liked the way it made them feel". Self-care and connection are the two dominant themes here showing that participants consider the body and their sense of self as spiritual.

3. What does sacred mean to you?

The main themes that emerged in response to this question where Relationships, Intangible, Nature and Things of High Importance. The responses to this question fell mainly into two categories, connection and memory. Under connection, responses included: "something passed down", "family time", "relationships" and "being together". Under memory, responses were similar, for example, "great value", "holding personal items", "something we attach memories to" and "means important to you".

Connecting both sections are the responses that indicate that to them, sacred is something that is important to them. Some specific things are mentioned, such as nature, family and animals and pets. One response that can link both of these categories is "something intangible" That is striking because it is the meaning that we give to objects that makes them sacred/valuable. It is a representation of memory. We like spending time with people but we also like what it gives us, i.e. a sense of connection.

4. What spiritual, sacred or faith-based activities do you engage in?

The themes that emerged from this section were Exercise, Religious Holidays and Events, Connection, Self Care and Festivals. There were expected responses that fell into the religious theme such as Easter, Christmas, funerals and reading the Bible. One interesting response of note was "wearing meaningful jewellery". Objects that hold memories is a sacred act, possibly even the act of memorialization itself is sacred.

Another interesting theme that emerged was Self Care. Within the theme included hobbies such as drawing, building Lego, reading and music. The theme also included things such as taking time for yourself and going for coffee. Engaging in hobbies or possibly activities that put you in a focused flow state. Again, being in nature or walking, exercising such as swimming and engaging in Yoga and meditation practices featured prominently in the responses, again, showing the connection between physical activity and state of being.

5. Have you used any technology to help you in your faith, spirituality or sacred practices?

The three main themes identified in response to this question were Music, Apps, Entertainment Music was a popular response that included things such as Spotify for music, and speaker to play music. This is possibly the way that music makes us feel, or expresses things we struggle to say, it evokes emotions, and it could be the affect that music has on the self. Apps was the biggest response. The majority of responses included the use of apps such as Headspace, Yoga and meditation apps to support mental health and wellbeing and engaging with social media. Apps also included more traditional religious responses such as engaging with sermons online via zoom and using the internet to look up information about specific religions and apps to annotate their bible.

The theme of Entertainment included responses such as playing PS5 and watching Netflix. This could be as a way to relax and possibly distract the mind. It was interesting that participants consider engaging in things such as social media or gaming as spiritual, faith or sacred practice and this could be explored further.

6. Are there any places you consider sacred, why?

Four main themes were identified in response to this question: Home, Religious Sites, Outdoors and Gym. A small number mentioned places such as churches and graveyards. A major theme was the stating of specific outdoor places such as the beach, walk, woodland and nature. The theme of Gym included responses such as workout routine and yoga. Surprisingly, the largest number of responses related to specific places mostly within the home or specific places within the home such as bedrooms, kitchen making food or in the shower. Some participants elaborated that it was a "safe" and "personal space". There are two dominant components of what created sacred place. A feeling of safety and security, and a feeling of being connected and in a natural space. The aim of these two activities is to evoke a feeling of calm and groundedness, which if achieved, by its nature creates a feeling of safety.

7. Does being outside affect your sense of spiritual and sacred? How?

There were three main themes that emerged from this question. The first theme is Calm. Participants reported a sense of "clarity", "calming", "zen" and a feeling of being "more free" and that being outside can help "you feel you might connect better to yourself". The second theme is Places. This included responses such as "the woods back home" and "the sea". This indicated that specific places can be more spiritual that others. The third theme to emerge was mindset. This included responses such as "communing with nature" and "forced to think about spirituality when not on phone." This indicates that depending on where you are can shift your mindset into a more spiritual place. Two participants responded with concerns for their safety stating. "No protection or safety outside" and "No privacy or peace" One interesting response of note was "Forced to think more about spirituality when not on the phone".

Model Findings

Considering the work of Andersen and Wakkary (2019) and their approach to workshop contributions. It was not possible to get participants to physically design technology rather representations. While participants were asked to imagine future technologies, participants were given freedom in how this was expressed and were not guided back to the brief if they drifted. Personal interpretation can also present interesting contributions which can be interpreted and considered and as Andersen and Wakkary (2019) suggest helping to reframe the enquiry. They also argue that while the artefacts created may not answer the researcher's aim of the study, they could offer insightful critiques to problems posed. While the analysis is still ongoing and exploration still underway, key themes that emerged from the questions were around nature, app usage, connection and relationship, and religious interactions. This can be used as a guide to frame the analysis of the models. It is understood that participants may critique the topic in the theme instead of designing a specific technology.

A theme that seemed to run through many of the responses created was the use of nature to represent interactions that connected people together. As can be seen in Figure 5, this response used a tree to represent what is sacred. The tree would light up when two people swung on the tree in the hope of creating a spiritual connection between the two people. Considering this response in relation to a techno-spiritual practice, the themes of nature and connection are present, suggesting that there is scope to employ digital approaches to how participants can connect to each other through natural spaces. Another interesting response under the theme of connection was the creation of a set of empathic smart hats (Figure 6).

Figure 5. Sacred Tree Model.

These hats allowed people to input your thoughts into the hat and share them with other people. This would allow you to gain an empathic perspective of others. It would also serve as an educational tool. This is interesting as when considering this from a techno-spiritual perspective, the ability to engage in empathic practices seems important to the individuals in this group and they see that technology could support that in some way.

Figure 6. Empathic hats.

In relation to apps, one group made a model of a maze with different social media icons dotted throughout. They saw the maze as a commentary on phone and social media use stating that people view them as sacred. It can be suggested that for techno-spiritualism the immediate reliance of phone or app usage may not be the right path forward to be more connected to the world around you. Following on from this, two responses focused not so much on creating something to facilitate interactions with spirituality using technology, but more of a comment on society and its use of technology. One group presented technology as something that we are over reliant on and struggle to cope without it (Figure 7a), while another group used a Tetris representation to indicate how technology helps them fit in and feel part of society (Figure 7b).

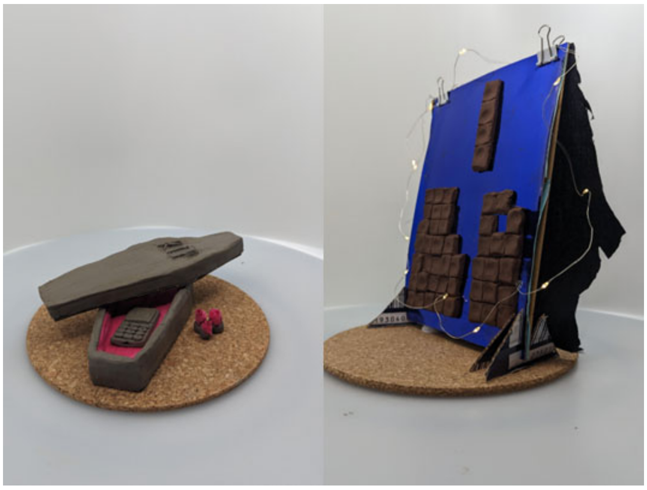


Figure 7. a & b Society responses .

Evaluation

The participants were asked for feedback on the workshop. This was an opportunity to experiment with evaluation tools and Padlet was chosen. The participants were asked

- What three phrases would you use to describe the workshop?
- What did you take away from the workshop?
- Anything that could be improved?
- Is there anything new you have learned?
- Anything that you struggled with?

While some useful feedback was provided, on the whole it was not a useful tool for feedback gathering as students could see other responses which changed the trajectory of the feedback. It became much more about details about the modelling tools and responses for comic effect for their peers to see such as "dirty hands" and "messy tables" when as what did you take away from the workshop. The participants generally found the workshop "fun", "collaborative", "creative" and "engaging". A lot of responses stated that it made them realise all the different understandings we have of faith and spirituality. For improving the workshop, most of the responses wished it could have been longer as one hour was too short to come up with an idea.

Discussion

While analysis is still ongoing, it is clear there are connections between modern interpretations with spirituality and overall health and wellbeing such as self-care, exercise, nature and interaction with other people. A core of new approaches to spirituality and sacred acts can be closely aligned with self-care practices. This idea of something being "bigger than yourself" is an interesting set of responses as it could be suggested that many of the responses in questions and model responses are attempts to engage and connect to that something bigger. This is done through a variety of mediums, walking, apps, talking to others, hobbies, to try and find that connected and grounded sense of self. Doing these things naturally ties in with mental health and well-being. This is interesting if we consider question five and technology use, where people consider using apps for mediation, Yoga, fitbits, ebooks and social media as spiritual or faith-based practices. While there are still more traditional religious practices for a number of participants, such as praying, there is a thread of trying to connect with something more or bigger and achieving a holistic sense of self. The findings suggest that there is scope to explore a middle group where people want technology, the support information and the practices, but not to be totally distracted by the phone. Could this mean there is a space to design new non-obtrusive technologies to support connection with space but not distract from it?

Acknowledgments

The author would like to thank the School of Computing, Engineering and the Built Environment for the starter grant that funded these pilot studies.

References

Ahmend, S. and R. Asraf (2018): 'The workshop as a qualitative research approach. Lessons learnt from a critical thinking through writing workshop'. *The Turkish Online Journal of Design, Art and Communication - TOJDAC*, pp. 1504–1510.

Andersen, K. and R. Wakkary (2019): 'The Magic Machine Workshops: Making Personal Design Knowledge'. In: *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. New York, NY, USA, p. 1–13, Association for Computing Machinery.

Bell, G. (2006): 'No More SMS from Jesus: Ubicomp, Religion and Techno-spiritual Practices'. In: D. Hutchison, T. Kanade, J. Kittler, J. M. Kleinberg, F. Mattern, J. C. Mitchell, M. Naor, O. Nierstrasz, C. Pandu Rangan, B. Steffen, M. Sudan, D. Terzopoulos, D. Tygar, M. Y. Vardi, G. Weikum, P. Dourish, and A. Friday (eds.): *UbiComp 2006: Ubiquitous Computing*, Vol. 4206. Berlin, Heidelberg: Springer Berlin Heidelberg, pp. 141–158. Series Title: Lecture Notes in Computer Science.

Buie, E. (2019): 'Let Us Say What We Mean: Towards Operational Definitions for Techno-Spirituality Research'. In: *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems*. Glasgow Scotland Uk, pp. 1–10, ACM.

CoS, 'Church of Scotland (2021)'. https://www.churchofscotland.org.uk/about-us/general-assembly/previous-general-assemblies/general-assembly-2021. [Accessed 30-04-2024].

Jung, S., O. O. Buruk, and J. Hamari (2022): 'Altered States of Consciousness in Human-Computer Interaction: A Review'. In: *Nordic Human-Computer Interaction Conference*. New York, NY, USA, Association for Computing Machinery.

Krippendorff, K. (2004): 'Reliability in Content Analysis'. *Human Communication Research*, vol. 30, no. 3, pp. 411–433.

Markum, R. B., S. Wolf, and S. Luthe (2022): 'Co-imagining participatory design in religious and spiritual contexts'. *Adjunct Proceedings of the 2022 Nordic Human-Computer Interaction Conference*.

Markussen, T. and E. Knutz (2017): 'Playful Participation'. *Conjunctions*, vol. 4, pp. 1 – 20.

O'Leary, T. K., E. Stowell, D. Sackitey, H. S. Yun, D. Wright, M. Paasche-Orlow, T. Bickmore, and A. G. Parker (2022): 'Church after Sunday: supporting everyday well-being through techno-spiritual health interventions'. *Interactions*, vol. 29, no. 4, pp. 90–93.

ONS, 'Office of National Statistice (2021)'. www.ons.gov.

Ørngreen, R. and K. Levinsen (2017): 'Workshops as a Research Methodology'. *Electronic Journal of E-Learning*, vol. 15, no. 1, pp. 70–81.

Posch, I. and G. Fitzpatrick (2021): 'The Matter of Tools: Designing, Using and Reflecting on New Tools for Emerging eTextile Craft Practices'. *ACM Trans. Comput.-Hum. Interact.*, vol. 28, no. 1.

Rifat, M. R., F. A. Peer, H. Rabaan, N. J. Mim, M. Mustafa, K. Toyama, R. B. Markum, E. Buie, J. Hammer, S. Sultana, S. Sabie, and S. I. Ahmed (2022): 'Integrating Religion, Faith, and Spirituality in HCI'. In: *CHI Conference on Human Factors in Computing Systems Extended Abstracts*. New Orleans LA USA, pp. 1–6, ACM.

Vega, L. (2021): 'Distributed Thinking Through Making: Towards a relational ontology in practice-led design research'. NORDES.

Wallace, J., J. Marshall, J. Verkerk, P. Heslop, L. Clarke, and M. Skelly (2024): 'Entangled Threads: Exploring the value and significance of bringing a craft ethos to debates around the IoT/connected things.'. In: *Proceedings of the Eighteenth International Conference on Tangible, Embedded, and Embodied Interaction*. New York, NY, USA, Association for Computing Machinery.

Permissions

All images used in this paper have been taken by the author.

Taves, Amanda; da Costa, Viviane; Barbosa, Carlos Eduardo; de Souza, Jano (2024): ECSCW 2024 Exploratory Papers Instructions. In: Proceedings of the 22nd European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies - Exploratory papers, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591), DOI: 10.18420/ecscw2024_ep13

Intelligent Services in the IoE Paradigm: A New Age of Collaboration

Amanda A. Taves[1], Viviane C. Farias da Costa[1,2], Carlos Eduardo Barbosa[1,3], Jano Moreira de Souza[1]
[1]Universidade Federal do Rio de Janeiro (UFRJ), Brazil
[2]Fundação Getúlio Vargas (FGV), Brazil
[3]Centro de Análises de Sistemas Navais (CASNAV), Brazil
ataves@cos.ufrj.br, vfarias@cos.ufrj.br, eduardo@cos.ufrj.br, jano@cos.ufrj.br

Abstract. Internet-based paradigms and technologies supported by the Internet of Everything (IoE) gain notoriety by integrating people, sensors, data, and processes in the most diverse applications, especially in collaborative approaches. Intelligent services utilize technologies like Artificial Intelligence (AI) to facilitate teamwork and joint efforts in various environments. Despite its vast potential, a significant knowledge gap exists regarding collaborative approaches for intelligent services within the IoE paradigm. This work conducts a Rapid Review to elucidate contemporary methodologies for intelligent services within IoE and explores forthcoming collaboration trends. We use the 3C Collaboration model to categorize the selected literature based on Communication, Coordination, or Cooperation approaches. Findings highlight a predominant focus on Education, particularly emphasizing paradigms like Intelligence in Learning Things. Smart Cities and Industry 4.0 are also given attention, integrating elements from the Social Internet of Things and Sustainable Collaborative Networks. Future collaboration trends indicate the rise of the Social Internet of Things, which utilizes social network strengths to overcome IoT limitations, fostering collaboration and improving operational efficiency and scalability within distributed networks. This research contributes to a thorough comprehension of current collaborative methodologies within the IoE paradigm, along with insights into future collaboration trends.

1. Introduction

The Internet of Everything (IoE) expands upon the concept of the Internet of Things (IoT) by incorporating the human component into the IoT network (Costa 2022). IoE is the global network through which people, things, and intelligent devices are connected and share information and services (Raj and Prakash 2018). IoE is a much broader concept than IoT, expanding to people, processes, and data in addition to things, making network connections more relevant and valuable, with great potential to be exploited for value extraction (Miraz et al. 2018). IoE aims to enhance the quality of life by facilitating innovative interactions among humans, processes, data, and objects (Nezami and Zamanifar 2019). IoE provides more than machine-to-machine interactions, including connections from person-to-machine and person-to-person (Bodduna 2019). The IoE paradigm can gather and interpret real-time data from diverse and mixed environments, ranging from basic sensors and actuators to intricate robotic systems and from self-operating service agents to human participants (Yu et al. 2018).

Integrating Artificial Intelligence into smart devices facilitates the growing rollout of innovative and practical IoE-centric applications. These applications allow meaningful interactions between people and objects within a social framework and multi-user settings (Miraz et al. 2018).

The growth of smart devices to support IoE applications provides new ways to benefit from human-machine collaboration. In this context, collaboration is the synthesis of communication, coordination, and cooperation – an idea originally encapsulated in the 3C Collaboration model by Ellis et al. (1991). In the 3C Collaboration model, *Communication* involves sharing messages and information between individuals; *Coordination* is related to managing people, their activities, and resources; and *Cooperation* is concerned with productive actions occurring within a shared space (Fuks et al. 2005).

In IoE, a notable knowledge gap exists regarding current collaborative approaches for intelligent services that facilitate communication, coordination, and collaboration. Our research addresses this gap through two primary inquiries: current strategies within IoE and future collaborative trends regarding IoE. This work provides a Rapid Review of IoE and Collaboration and a classification using the 3C Collaboration model.

We expect this work to advance our understanding of current collaborative approaches for intelligent services that support communication, coordination, and collaboration in the IoE paradigm and future trends in collaboration regarding IoE. In addition, it categorizes the references using the 3C Model as a framework.

The remaining text is organized as follows: in section 2, we provide the theoretical background for IoT, IoE, and Intelligent Services. In section 3, we present the methodology used in this work. In section 4, we present and discuss our findings. In section 5, we provide our final remarks.

2. Theoretical Background

This section presents the theoretical background to understand concepts such as the Internet of Everything and Intelligent Services while presenting a few related works.

2.1. From the Internet of Things to the Internet of Everything

The Internet of Things involves connecting various devices through the Internet. This vast network comprises devices equipped with built-in sensors linked to an IoT platform, facilitating the collection and exchange of information through machine-to-machine communication (Bodduna 2019).

The Internet of Everything, shown in Figure 1, revolves around four core pillars: People, Data, Processes, and Things. Information sharing and collection occur through various modes, such as Machine-to-Machine (M2M), Person-to-Person (P2P), or Person-to-Machine (P2M) communication (Wu et al. 2019). In that sense, Bellini et al. (2021) argue that the IoE can be seen as a logical evolution of the IoT paradigm, distinguished by four essential components:

- People: Individuals serve as sensors and sources of knowledge, aiding in data collection, decision-making, behavior modification, and more (Bellini et al. 2021).
- Things: Intelligent devices or machinery equipped with physical sensors and actuators responsible for generating and processing a significant volume of data (Bellini et al. 2021).
- Data: The unprocessed information created, shared, analyzed, and utilized to make informed decisions and implement effective control strategies, enhancing knowledge processes (Bellini et al. 2021).
- Processes: Strategic and value-enhancing interactions designed to deliver pertinent information to the appropriate recipient at the optimal time through the most effective channels (Shilpa et al. 2019).

Kanade (2022) compared the Internet of Things and the Internet of Everything using definition, goal, communication, and hierarchy characteristics. The comparison is presented in Table I. The Internet of Everything extends upon the foundational elements of the Internet of Things, incorporating intelligent network systems (Raj and Prakash 2018). As an advanced version of the Internet of Things, the Internet of Everything is not limited to physical devices but extends to people, things, data, and processes. According to Kanade (2022), the Internet of Everything market reached $1,074.1 billion in 2022 and is forecasted to surge to $3,335.1 billion by 2030.

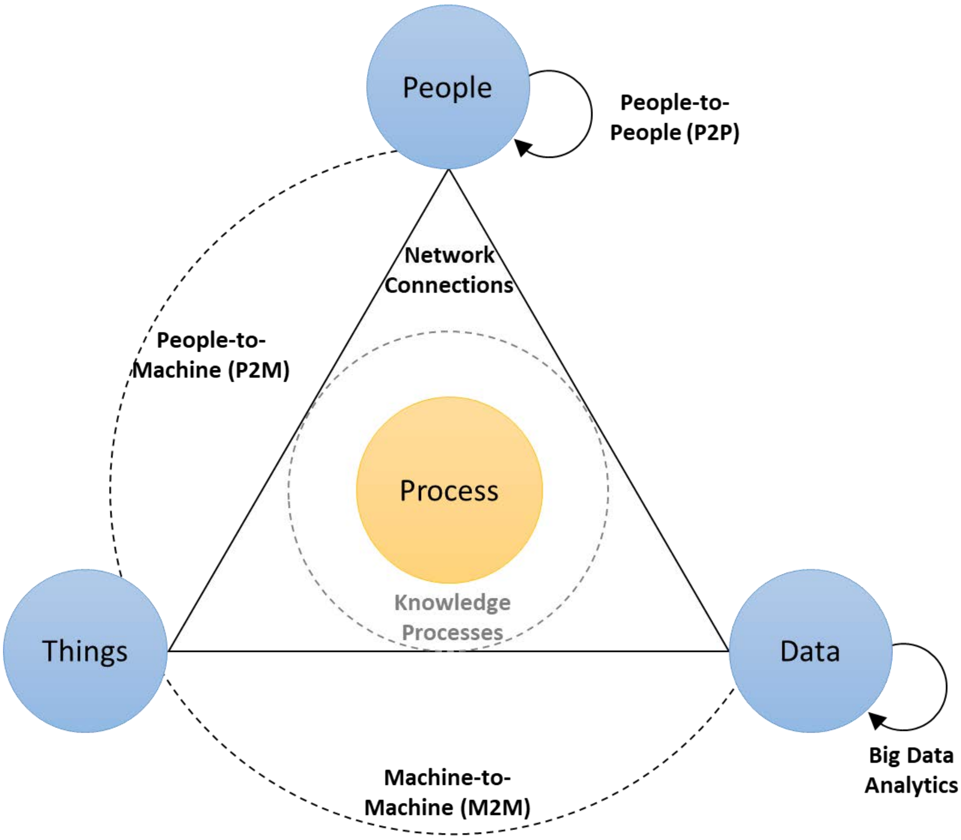


Figure 1. Internet of Everything elements, adapted from Miraz et al. (2015) and Kanade (2022).

Table I. Comparison between IoT and IoE, adapted from Kanade (2022).

Characteristics	Internet of Things (IoT)	Internet of Everything (IoE)
Definition	IoT is about physical devices that communicate without human intervention.	IoE is the intelligent network connection between four elements: people, things, data, and processes.
Goal	IoT aims to develop an ecosystem where physical objects are connected.	IoE has four primary goals: collect data and convert that data into actions, facilitate data-based decisions, enhance the capabilities of participating units, and provide advanced networking opportunities.
Communication	IoT supports machine-to-machine (M2M) communication.	IoE facilitates machine-to-machine (M2M), people-to-machine (P2M), and people-to-people (P2P using tech) communication.
Hierarchy	IoT is a subset or a part of IoE.	IoE is a superset that gives IoT a bigger picture.
Examples	Home surveillance systems, autonomous irrigation systems, connected home appliances, and smart energy grids.	Smart city environments, smart supply chains, and fitness bands that use heartbeats to pay health insurance premiums.

2.2. Smart and Intelligent Services

Advancements in communication technology have driven the proliferation of IoT devices. These interconnected devices collect, process, and communicate data in real-time, enabling modern intelligent services (Zhou et al. 2023). The terminology Smart Services and Intelligent Services is used. However, they present subtle differences in meaning.

Smart Services use technologies such as sensors, IoT devices, and automation to enhance the functionality or efficiency of a service. Smart services typically involve actuation, coordination, communication, and control, supported by virtual or physical resources (Fischer et al. 2020).

Intelligent Services implies a higher degree of sophistication than Smart Services. Koldewey et al. (2020) describe Intelligent Services as data-based services connected to intelligent objects that allow continuous and interactive feedback. Cummaudo et al. (2019) noted that creating intelligent services diverges from conventional services because it incorporates components grounded in Artificial Intelligence. These intelligent services focus their predictions on training datasets, presenting outcomes as likelihoods matching labels (Cummaudo et al. 2019). In addition, Marquardt (2017) defined an intelligent service as part of an intelligent task performed by a computer system, with behavior equivalent to that of a human being when performing a similar task.

2.3. Intelligent Services and the Internet of Everything

Intelligent Services incorporate advanced technologies such as Artificial Intelligence, machine learning, automation, and data analytics to streamline processes (Cummaudo et al. 2019). Meanwhile, the Internet of Everything extends beyond traditional IoT devices by integrating the interconnection of people, data, and processes (Bellini et al. 2021). In IoE, people serve as sensors and sources of knowledge, with data from smart devices and individuals shared and analyzed to facilitate informed decision-making.

Therefore, the relationship between Intelligent Services and the Internet of Everything lies in the interconnection between devices and people and the use of advanced technologies to improve services and processes. While Intelligent Services leverage data and automation to provide valuable information (Yang et al. 2009), the Internet of Everything integrates connections among people, data, and processes alongside traditional IoT devices. This interconnection allows data from smart devices and individuals to be shared and analyzed, contributing to more efficient and personalized services. Intelligent Services within the Internet of Everything ecosystem gather data from connected devices to improve quality of life through informed decision-making (Meridou et al. 2017).

2.4. Related work

This section aims to provide an overview of related articles focusing on Collaborative approaches for Smart and Intelligent Services. According to Stamer et al. (2020), the relationship between Collaboration and Smart Services lies in the potential of smart services to facilitate collaboration. While collaboration is recognized as advantageous for improving production processes in Global Production Networks, smart services offer an innovative approach to overcoming collaboration barriers. Smart services bridge the physical and digital worlds and boost value creation efficiency, fostering collaboration in global networks by aligning business models with customer needs.

Hu et al. (2010) explore collaboration within product development or manufacturing, involving different stakeholders, like designers, engineers, suppliers, and manufacturers, pooling resources and innovating. The nexus between collaboration and smart services is technology's ability to augment and streamline stakeholder collaborative efforts. According to the authors, organizations can facilitate communication, improve decision-making, optimize workflows, and enable personalization by incorporating smart services into collaborative processes.

Devadasan et al. (2013) argue that collaboration and intelligent services are closely related, particularly in knowledge-based service planning. Collaborative Intelligence plays a crucial role in enhancing collaboration among service providers, ensuring the delivery of intelligent services. Some key points illustrating the relationship between collaboration and intelligent service include enhanced decision-making, efficiency and effectiveness, optimal provider selection, and tailored collaboration efforts.

Our review differs from the existing work as it centers on collaborative strategies for Intelligent Services within the Internet of Everything framework. Additionally, it delves into future trends, utilizing the 3C Model to classify the literature found.

3. Methodology

In this work, we used Rapid Review following the methodological guidelines for conducting literature reviews suggested by Hamel et al. (2021). Rapid Review is a systematic literature review approach that uses methods to streamline the review process. Rapid Reviews are lightweight secondary studies focused on delivering evidence to practitioners promptly and should be conducted according to a practical problem inserted into a practical context (Cartaxo et al. 2020). This work aims to evaluate scientific publications related to topics such as communication, coordination, and collaboration in the IoE paradigm and future trends in collaboration regarding IoE.

In this research, we searched the ACM Digital Library, IEEE Digital Library, ISI Web of Science, ScienceDirect, and Scopus. The search string used in Scopus, for example, is shown in Table II. We designed the search string to retrieve as many relevant studies as possible, narrowing current collaborative approaches for intelligent services that support communication, coordination, and collaboration in the IoE paradigm.

Table II. Search String used in Scopus.

TITLE((“CSCW” OR “Collaboration” OR “Collaborative” OR “Coordination”) AND (“Internet of Everything” OR “IoE”)) AND PUBYEAR > 2016 AND PUBYEAR < 2024 AND (LIMIT-TO (DOCTYPE, “ar”) OR LIMIT-TO (DOCTYPE, “cp”)) AND (LIMIT-TO (LANGUAGE, “English”))

The research aimed to answer two research questions:

RQ1: *What are the current collaborative approaches for intelligent services that support communication, coordination, and collaboration in the IoE paradigm?*

RQ2: *What are the future trends in Collaboration regarding IoE?*

The research was limited to publications available since 2017. Initially, we found 157 articles. After eliminating duplicates, inaccessible, and unavailable articles, we selected 72 articles for further reading. After thoroughly reading the articles, this work critically assessed the quality of the contributions considering parameters such as the degree of adherence to IoE applications and the contribution’s relevance to human-machine collaboration in the disruptive context. Finally, after applying the analysis, only 22 relevant articles (see Table III) were able to answer satisfactorily the research questions, presenting collaborative approaches in the IoE paradigm and future trends in collaboration. The 22 selected studies were diverse and promoted different approaches to support Communication, Coordination, and Collaboration within the IoE paradigm.

4. Results

In this section, we present the results of this rapid review. First, we classify the selected articles using the 3C Collaboration Model. Next, we present collaborative approaches relevant areas in our findings: *Education*, *Smart Cities and Industry 4.0*, *Cloud-Edge Collaboration, Cyber Security, and Others*. Finally, we present findings about the future trends in collaboration regarding IoE.

4.1. 3C Model Classification

The 3C Collaboration Model is based on the idea that to collaborate, group members communicate, coordinate, and cooperate. This model originated from Ellis et al. (1991) and categorizes computational support for collaboration.

According to Gerosa et al. (2006), the definitions proposed in the 3C Model, Communication involves exchanging messages and negotiating commitments. Coordination enables managing people, activities, and resources to resolve conflicts and facilitate communication and cooperation (Gerosa et al. 2006). Finally, Cooperation involves group members working together in a shared space to perform tasks, creating and handling collaborative objects (Ellis et al. 1991).

We employ the 3C Collaboration Model to categorize the chosen articles into Communication, Coordination, and Cooperation. In Table III, the selected studies have been categorized based on the context of their application, according to the 3C Collaboration Model and the area in which their technologies belong.

With its various contributions, the field of Education had the most selected articles: 9 of the 22 articles pertained to some area of Education, such as Experiential Learning, Collaborative Learning, Special Educational Needs, Foreign Language, Learning Platforms, Knowledge Collaboration, Group Collaboration, and Note-Making Application.

4.2. Collaborative Approaches in Education

O'Connor et al. (2021) focus on managing virtual teams in large classes, addressing challenges in organizing experimental exercises in virtual environments. They discuss issues like coordinating class and team communication, building trust, and enhancing student engagement. *Coordination* is central to their analysis, especially the difficulties of coordinating large numbers of students across different countries using Virtual Teams, contrasting with traditional face-to-face classrooms. This study gains significance as virtual learning becomes more prevalent, with some classes possibly never returning to physical settings. Understanding how to maintain student engagement in this context offers valuable insights for future learning experiences.

Alkhalil et al. (2021) investigated the Jigsaw cooperative learning method to enhance students' understanding of various topics through online group learning. The case study revealed that participants in Jigsaw groups achieved a slightly higher average than conventional groups. This E-learning approach promotes self-directed learning, teamwork, and collaboration (Alkhalil et al. 2021), with *Collaboration* being particularly notable among the 3Cs, followed by *Coordination*.

Table III. Collaborative approaches based on the 3C Collaboration Model in the IoE paradigm.

Article	Context	3C Model: Collaboration	3C Model: Coordination	3C Model: Communication	Area
(Pliatsios et al. 2023)	Smart Cities	✓			Social Internet of Things paradigm
(Wang et al. 2023)	Cloud-Edge Collaboration	✓			Cyber-Physical Machine Tool
(Agrawal et al. 2023)	Supply Chain	✓		✓	Blockchain
(Dang et al. 2022)	Cloud-Edge Collaboration	✓			Social Internet of Things paradigm
(Kim and Jeong 2022)	Smart Manufacturing	✓			Virtual Reality /Augmented Reality
(Zhao et al. 2022)	Satellite Internet	✓			6G Networks
(Zhang et al. 2022)	Privacy Protection	✓			Collaborative Edge Computing
(Dong et al. 2022)	Device-to-Device Communications	✓	✓	✓	Collaborative Edge Computing, Social Internet of Things
(Gao et al. 2022)	Smart Manufacturing	✓			Dataspace
(García-Pereira et al. 2021)	Asynchronous Collaboration	✓		✓	Augmented Reality -CSCW
(O'Connor et al. 2021)	Education (Experiential Learning)		✓	✓	Virtual Teams
(Costa et al. 2021)	IoE Database	✓			Social Collaborative Internet of Things
(Alkhalil et al. 2021)	Education (Collaborative Learning)	✓	✓	✓	E-learning
(Yahia et al. 2021)	Smart Cities (Smart Governance)	✓	✓		Sustainable Collaborative Networks
(Hafidh et al. 2020)	Education (Special Educational Needs)	✓	✓	✓	Smart School Care Coordination System
(Sanchez et al. 2020)	Industry 4.0, Smart Manufacturing	✓	✓	✓	Artificial Intelligence, Data Mining, Everything Mining
(Queralta et al. 2019)	Autonomous Vehicles	✓	✓	✓	IoE Architecture
(Satu et al. 2018)	Education (Learning Platform)	✓		✓	Intelligence of Learning Things
(Magnussen and Stensgaard 2019)	Education (Knowledge Collaboration)	✓			Citizen Science, IoT, Big Data
(Happa et al. 2019)	Cyber Security	✓		✓	Collaborative Mixed-Reality
(Deng et al. 2018)	Education (Group Collaboration)	✓			Web 2.0, Wikispaces
(Towey et al. 2017)	Education (Note-Making Application)	✓			Open Educational Resources

Hafidh et al. (2020) present the School Care Coordination System, a knowledge-based platform built on a six-layered data management model. It integrates education, health, and social care services, translating special educational needs and disabilities guidelines into a comprehensive knowledge system. The School Care Coordination System aims to streamline coordination and monitoring, providing personalized care plans for children and young people with disabilities by unifying education, health, and social care into one application.

Satu et al. (2018) present the Intelligence of Learning Things educational platform, integrating IoT with traditional education for innovative learning strategies. Intelligence of Learning Things facilitates collaboration among devices and applications, fostering a more innovative educational environment for stakeholders, including teachers and students. In this study, *Collaboration* stands out as the primary aspect of the 3C Model, followed by *Communication,* encompassing both people-to-people and people–to-machine communication, which are characteristics of the Internet of Everything outlined in Figure 1.

Magnussen et al. (2019) reviewed collaboration trends in citizen science, crowdsourcing, and community-driven research from 2013 to 2018. The study highlights man-machine collaboration, with Human-Machine Information Systems as the dominant sub-theme, enabling efficient data processing through human contributions and machine learning.

Deng et al. (2018) explore the use of wikis and other Web 2.0 tools by first-year teacher education students at a university for group work purposes. The findings indicate a deviation from the instructor's original plan to use wikis as the central collaborative space. Instead, students employed various technologies during group work, including Facebook for communication, Diigo for saving, sharing, and annotating, and Google Drive for pooling drafts and notes. This study illustrates practical preferences in organizing *Collaboration* efforts.

Finally, an interdisciplinary team of teachers and computer science students collaborates to create an Open Educational Resource that is freely available for educational use and supports students' note-taking and research (Towey et al. 2017).

The Education topics covered in the field exhibit diversity. While all touch upon Collaboration, four include Communication, and only two address Coordination. Results show that Collaborative approaches within the IoE span from digitizing tasks previously confined to the physical realm. Examples include older paradigns such as Virtual Teams, E-learning, Web 2.0, and Wikispaces, as well as newer paradigms like Smart School Care Coordination Systems, Big Data, Intelligence of Learning Things, Citizen Science, and Open Educational Resources. This extensive range indicates the unexplored terrain in education concerning collaborative approaches for intelligent services that support communication, coordination, and collaboration within the IoE paradigm.

4.3. Collaborative Approaches in Smart Cities and Industry 4.0

Alavi et al. (2018) described a *Smart City* as a contemporary urban environment that operates intelligently and sustainably to guarantee sustainability and efficiency. This description entails the integration of diverse infrastructures and services, all overseen and managed by intelligent devices.

With that in mind, Pliatsios et al. (2023), Kim and Jeong (2022), Gao et al. (2022), Yahia et al. (2021), Sanchez et al. (2020), and Queralta et al. (2019) broadly discuss Smart Cities. Specifically, Kim and Jeong (2022), Gao et al. (2022), and Sanchez et al. (2020) focus on Smart Manufacturing — methods that can use IoT technologies and web-based services to communicate and interact with other products in a factory environment (Kim and Jeong 2022). The first two studies explore the *Collaboration* aspect of the 3C Model, while the latter encompasses all 3Cs.

Sanchez et al. (2020) explore Industry 4.0's integration challenges, emphasizing the importance of innovative solutions to ensure interoperability and self-organization. They argue that 3C processes empower humans and robots to perform intelligent tasks, addressing critical issues like integration and interoperability within production processes. In this context, *Coordination* is the synchronization of activities, resources and actors to achieve common goals efficiently, and plays a crucial role in manufacturing. In the context of Industry 4.0, coordination is essential for seamless communication and collaboration among various smart factory components, facilitated by advanced technologies like AI and data analytics to optimize production processes and enhance overall productivity.

Yahia et al. (2021) focus on Smart Governance, highlighting the importance of cultivating collaboration within the government for effective smart city governance. They emphasize adaptive policy-making to foster internal and external collaborations. Queralta et al. (2019) explore Autonomous Vehicles, introducing an IoE-based architecture integrating cars and drones. Their mixed-team approach enhances situational awareness in autonomous vehicles, showcasing the potential of IoE in the transportation sector.

Within the Smart Cities framework and its subdivisions, various areas, including Social Internet of Things, Virtual Reality, Augmented Reality, Dataspace, Sustainable Collaborative Networks, Artificial Intelligence, Data Mining, and Everything Mining, constitute the collaborative approaches for Intelligent Services supporting Communication, Coordination, and Collaboration in the IoE paradigm.

4.4. Collaborative Approaches in Cloud-Edge Collaboration, Cyber Security and Others

Cloud-edge collaboration is analyzed by Wang et al. (2023) and Dang et al. (2022). Wang et al. (2023) introduce a cloud-edge collaborative architecture for Cyber-Physical Machine Tools addressing resource underutilization and cloud pressure. Dang et al. (2022) propose a road damage classification method based on edge computing, enhancing response time with an edge server between the user and the cloud. Dong et al. (2022) present the recent advanced applications and developments in collaborative edge computing for the Social Internet of Things (SIoT). The *Communication* of the 3C Model is emphasized in machine-to-machine communication, characteristic of the Internet of Everything in Figure 1, emphasizing the importance of communication speed.

On the other hand, Zhang et al. (2022) and Happa et al. (2019) were concerned about Privacy Protection and Cyber Security, respectively. Zhang et al. (2022) introduce data protection for Collaborative Edge Computing in social IoT systems to prevent privacy breaches. Likewise, Happa et al. (2019) investigate cyber-security threats to Collaborative Mixed-Reality systems, focusing on network vulnerabilities. Based on the 3C Model definition of *Collaboration*, their work explores how Collaborative Mixed-Reality integrates Mixed-Reality technologies with collaborative interfaces, enabling real-time interaction in shared virtual environments. These applications facilitate teamwork and productivity by allowing users to collaborate on tasks, projects, or activities in a shared virtual space, emphasizing the importance of secure and private collaboration.

Other topics mentioned in the literature include Supply Chain using Blockchain (Agrawal et al. 2023), Satellite Internet with 6G (Zhao et al. 2022), Asynchronous Collaboration with Augmented Reality-CSCW (García-Pereira et al. 2021), an IoE Database for collaboratively cataloging IoE applications (Costa et al. 2021), and the introduction of the Social Collaborative Internet of Things paradigm (Khan et al. 2017) – in which social objects interact and share information to achieve a common goal.

Regarding collaborative approaches in Cloud-Edge collaboration, the literature explored Cloud-edge collaboration for Cyber-Physical Machine Tools, road damage classification, and advanced applications in collaborative edge computing for the Social Internet of Things. In Cyber Security, the literature mentioned data protection for Collaborative Edge Computing in social IoT systems and cyber-security threats to Collaborative Mixed-Reality systems.

4.5. Future trends in Collaboration regarding IoE

While the Internet of Things offers increased connectivity, its traditional networks often fall short in intelligence, context awareness, and interoperability, limiting their potential to add value for businesses and individuals (Noura et al. 2019). This gap is addressed by the Social Internet of Things paradigm, which merges the strengths of social networks with those of IoT to create a more collaborative and efficient system (Roopa M.S. et al. 2019).

A key advantage of SIoT is its capacity to promote collaboration and cooperation among devices and applications. This capacity leads to a more streamlined and effective operation where multiple components can work together to achieve shared objectives (Amin et al. 2022). Additionally, the exceptional scalability of the Social Internet of Things enables the management of substantial data volumes and devices, facilitating the creation of intricate distributed networks (Shahab et al. 2022). Therefore, SIoT is emerging as a focal point for future collaborative initiatives in service and data science.

Another emerging trend is the Autonomic Cycle of Data Analytics Tasks, defined by Aguilar et al. (2017). It comprises a coordinated group of data analysis tasks to fulfill a specific goal in the process they oversee (Sanchez et al. 2020). These tasks are interdependent, each playing a distinct role within the cycle. Additionally, Sanchez et al. (2020) propose an Autonomic Cycle for Coordination in Industry 4.0. It outlines a series of data analysis tasks to enable self-planning, self-supervision, and self-configuration in manufacturing. It empowers stakeholders to make informed decisions for enhancing factory efficiency, detecting failures, and system repair. As a result, a Smart Product can actively guide its production by coordinating various actors involved.

Another emerging approach leverages the existing computing resources at industrial sites to offload Digital Twin modeling and data processing from the cloud to the edge. Traditionally, devices were primarily used for production tasks and real-time data collection, with data processing centralized in the cloud. However, as the Internet of Everything expands and intelligent algorithms evolve, the massive volume of data and computational demands in industrial settings has skyrocketed (Wang et al. 2023). Relying solely on cloud computing can result in significant delays and data isolation, failing to meet real-time data interaction requirements (Liu et al. 2019). For this reason, the transition to edge computing is increasingly gaining attention.

5. Conclusion

The Internet of Everything integrates people, sensors, data, and processes in the most diverse applications. However, there is a significant gap regarding collaborative approaches for intelligent services in the context of the IoE. In this work, we performed a Rapid Review to improve the comprehension of contemporary methods for such services in the IoE paradigm and explore future collaboration trends. The selected articles are analyzed using the 3C Model to categorize their collaborative approaches into Communication, Coordination, or Cooperation.

Findings reveal a predominance of literature on Education, particularly emphasizing paradigms such as Intelligence of Learning Things. Subsequently, attention is directed toward Smart Cities and Industry 4.0, featuring elements from the Social Internet of Things and Sustainable Collaborative Networks. The Cloud-Edge and Security domains also showcase technologies like Cyber-Physical Machine Tools and Collaborative Mixed-Reality, among other subjects. The results of this work also indicate that future trends in collaboration include the rise of the Social Internet of Things, addressing IoT limitations by merging social network strengths for efficient operations. SIoT fosters collaboration while streamlining processes and exhibits exceptional scalability for intricate distributed networks. Additionally, emerging trends involve Autonomous Cycles for Data Analytics Tasks and the shift to Edge Computing from the cloud in response to the expansion of the Internet of Everything.

The main contributions of this work include a broader understanding of current collaborative approaches for intelligent services in the IoE paradigm while providing future collaboration trends. This work also contributes to the literature when categorizing selected articles using the 3C Collaboration model as a framework.

This work also leaves some avenues for research, including a deeper understanding of collaboration in the Social Internet of Things and Collaborative Mixed Reality. Although Smart Cities and Industry 4.0 are well-researched subjects, we recommend further research in Sustainable Collaborative Networks.

References

Agrawal TK, Angelis J, Ali Khilji W, Kalaiarasan R, Wiktorsson M (2023) Demonstration of a blockchain-based framework using smart contracts for supply chain collaboration. International Journal of Production Research 61:1497–1516

Aguilar J, Cordero J, Buendia O (2017) Specification of the Autonomic Cycles of Learning Analytic Tasks for a Smart Classroom. Journal of Educational Computing Research 56:073563311772769. https://doi.org/10.1177/0735633117727698

Alavi AH, Jiao P, Buttlar WG, Lajnef N (2018) Internet of Things-enabled smart cities: State-of-the-art and future trends. Measurement 129:589–606. https://doi.org/10.1016/j.measurement.2018.07.067

Alkhalil S, Manasrah A, Masoud M (2021) Let’s Learn with a Jigsaw! Implementing a Unique Collaborative Online Learning in an Engineering Course. In: 2021 International Conference on Information Technology (ICIT). pp 396–399

Amin F, Majeed A, Mateen A, Abbasi R, Hwang S (2022) A Systematic Survey on the Recent Advancements in the Social Internet of Things. IEEE Access 1–1. https://doi.org/10.1109/ACCESS.2022.3183261

Bellini E, Bellini P, Cenni D, Nesi P, Pantaleo G, Paoli I, Paolucci M (2021) An IoE and Big Multimedia Data Approach for Urban Transport System

Resilience Management in Smart Cities. Sensors 21:435. https://doi.org/10.3390/s21020435

Bodduna R (2019) A Review on the Different Types of Internet of Things (IoT)

Cartaxo B, Pinto G, Soares S (2020) Rapid Reviews in Software Engineering. In: Felderer M, Travassos GH (eds) Contemporary Empirical Methods in Software Engineering. Springer International Publishing, Cham, pp 357–384

Costa VCF da (2022) A Knowledge-Based Approach to Support Internet of Everything (IoE) Lifestyle. Universidade Federal do Rio de Janeiro

Costa VCF da, Oliveira LF, Souza J de (2021) A collaborative approach to support interoperability and awareness of Internet of Everything (IoE) enablers. In: 2021 IEEE 2nd International Conference on Human-Machine Systems (ICHMS). pp 1–6

Cummaudo A, Vasa R, Grundy J, Abdelrazek M, Cain A (2019) Losing Confidence in Quality: Unspoken Evolution of Computer Vision Services. In: 2019 IEEE International Conference on Software Maintenance and Evolution (ICSME). pp 333–342

Dang X, Shang X, Hao Z, Su L (2022) Collaborative Road Damage Classification and Recognition Based on Edge Computing. Electronics 11:3304. https://doi.org/10.3390/electronics11203304

Deng L, Li SC, Lu J (2018) Supporting collaborative group projects with Web 2.0 tools: A holistic approach. Innovations in Education and Teaching International 55:724–734. https://doi.org/10.1080/14703297.2017.1321494

Devadasan P, Zhong H, Nof SY (2013) Collaborative intelligence in knowledge based service planning. Expert Systems with Applications 40:6778–6787. https://doi.org/10.1016/j.eswa.2013.06.048

Dong P, Ge J, Wang X, Guo S (2022) Collaborative Edge Computing for Social Internet of Things: Applications, Solutions, and Challenges. IEEE Transactions on Computational Social Systems 9:291–301. https://doi.org/10.1109/TCSS.2021.3072693

Ellis CA, Gibbs SJ, Rein G (1991) Groupware: some issues and experiences. Commun ACM 34:39–58. https://doi.org/10.1145/99977.99987

Fischer M, Heim D, Hofmann A, Janiesch C, Klima C, Winkelmann A (2020) A taxonomy and archetypes of smart services for smart living. Electron Markets 30:131–149. https://doi.org/10.1007/s12525-019-00384-5

Fuks H, Raposo AB, Gerosa MA, Lucena CJP (2005) APPLYING THE 3C MODEL TO GROUPWARE DEVELOPMENT. International Journal of Cooperative Information Systems 14:299–328. https://doi.org/10.1142/S0218843005001171

Gao T, Ji Z, Niu D, Xi Y (2022) Research on product sales forecasting based on multi-value chain collaborative data management system in manufacturing industry. In: 2022 IEEE International Conference on e-Business Engineering (ICEBE). pp 86–93

García-Pereira I, Casanova-Salas P, Gimeno J, Morillo P, Reiners D (2021) Cross-Device Augmented Reality Annotations Method for Asynchronous Collaboration in Unprepared Environments. Information 12:519. https://doi.org/10.3390/info12120519

Gerosa MA, Pimentel M, Fuks H, de Lucena CJP (2006) Development of Groupware Based on the 3C Collaboration Model and Component Technology. In: Dimitriadis YA, Zigurs I, Gómez-Sánchez E (eds) Groupware: Design, Implementation, and Use. Springer, Berlin, Heidelberg, pp 302–309

Hafidh R, Sharif MS, Al-Bayatti AH, Alfakeeh AS, Alassafi MO, Alqarni MA (2020) An Effective Knowledge-Based Modeling Approach towards a “Smart-School Care Coordination System” for Children and Young People with Special Educational Needs and Disabilities. Symmetry 12:1495. https://doi.org/10.3390/sym12091495

Hamel C, Michaud A, Thuku M, Skidmore B, Stevens A, Nussbaumer-Streit B, Garritty C (2021) Defining Rapid Reviews: a systematic scoping review and thematic analysis of definitions and defining characteristics of rapid reviews. Journal of Clinical Epidemiology 129:74–85. https://doi.org/10.1016/j.jclinepi.2020.09.041

Happa J, Glencross M, Steed A (2019) Cyber Security Threats and Challenges in Collaborative Mixed-Reality. Frontiers in ICT 6

Hu Y, Zhou X, Li C (2010) Internet-based intelligent service-oriented system architecture for collaborative product development. International Journal of Computer Integrated Manufacturing 23:113–125. https://doi.org/10.1080/09511920903440347

Kanade V (2022) What Is the Internet of Everything? Meaning, Examples, and Uses. In: Spiceworks. https://www.spiceworks.com/tech/iot/articles/what-is-internet-of-everthing/. Accessed 21 Feb 2024

Khan WZ, Aalsalem MY, Khan MK, Arshad Q (2017) When social objects collaborate: Concepts, processing elements, attacks and challenges.

Computers & Electrical Engineering 58:397–411. https://doi.org/10.1016/j.compeleceng.2016.11.014

Kim J, Jeong J (2022) Design and Implementation of OPC UA-Based VR/AR Collaboration Model Using CPS Server for VR Engineering Process. Applied Sciences 12:7534. https://doi.org/10.3390/app12157534

Koldewey C, Gausemeier J, Chohan N, Frank M, Reinhold J, Dumitrescu R (2020) Aligning Strategy and Structure for Smart Service Businesses in Manufacturing. In: 2020 IEEE International Conference on Technology Management, Operations and Decisions (ICTMOD). pp 1–8

Liu B, Zhang Y, Zhang G, Zheng P (2019) Edge-cloud orchestration driven industrial smart product-service systems solution design based on CPS and IIoT. Advanced Engineering Informatics 42:100984. https://doi.org/10.1016/j.aei.2019.100984

Magnussen R, Stensgaard A (2019) Knowledge Collaboration Between Professionals and Non-professionals: A Systematic Mapping Review of Citizen Science, Crowd Sourcing and Community-driven Research

Marquardt K (2017) Smart services – characteristics, challenges, opportunities and business models. Proceedings of the International Conference on Business Excellence 11:789–801. https://doi.org/10.1515/picbe-2017-0084

Meridou DT, Papadopoulou M-ECh, Kapsalis AP, Kasnesis P, Delikaris AI, Patrikakis CZ, Venieris IS, Kaklamani DI (2017) Improving Quality of Life with the Internet of Everything. In: Batalla JM, Mastorakis G, Mavromoustakis CX, Pallis E (eds) Beyond the Internet of Things: Everything Interconnected. Springer International Publishing, Cham, pp 377–408

Miraz D, Ali M, Excell P, Picking R (2018) Internet of Nano-Things, Things and Everything: Future Growth Trends. Future Internet 10. https://doi.org/10.3390/fi10080068

Miraz MH, Ali M, Excell PS, Picking R (2015) A review on Internet of Things (IoT), Internet of Everything (IoE) and Internet of Nano Things (IoNT). In: 2015 Internet Technologies and Applications (ITA). pp 219–224

Nezami Z, Zamanifar K (2019) Internet of Things/Internet of Everything: Structure and Ingredients. IEEE Potentials 38:12–17. https://doi.org/10.1109/MPOT.2018.2855439

Noura M, Atiquzzaman M, Gaedke M (2019) Interoperability in Internet of Things: Taxonomies and Open Challenges. Mobile Netw Appl 24:796–809. https://doi.org/10.1007/s11036-018-1089-9

O'Connor C, Mullane K, Luethge D (2021) The Management and Coordination of Virtual Teams in Large Classes: Facilitating Experiential Learning. Journal of Management Education 45:105256292199555. https://doi.org/10.1177/1052562921995550

Pliatsios A, Lymperis D, Goumopoulos C (2023) S2NetM: A Semantic Social Network of Things Middleware for Developing Smart and Collaborative IoT-Based Solutions. Future Internet 15:207. https://doi.org/10.3390/fi15060207

Queralta JP, Nguyen Gia T, Tenhunen H, Westerlund T (2019) Collaborative Mapping with IoE-based Heterogeneous Vehicles for Enhanced Situational Awareness. In: 2019 IEEE Sensors Applications Symposium (SAS). pp 1–6

Raj A, Prakash S (2018) Internet of Everything: A survey based on Architecture, Issues and Challenges. pp 1–6

Roopa M.S., Pattar S, Buyya R, Venugopal K.R., Iyengar SS, Patnaik LM (2019) Social Internet of Things (SIoT): Foundations, thrust areas, systematic review and future directions. Computer Communications 139:32–57. https://doi.org/10.1016/j.comcom.2019.03.009

Sanchez M, Exposito E, Aguilar J (2020) Autonomic computing in manufacturing process coordination in industry 4.0 context. Journal of Industrial Information Integration 19:100159. https://doi.org/10.1016/j.jii.2020.100159

Satu MdS, Roy S, Akhter F, Whaiduzzaman M (2018) IoLT: An IoT based Collaborative Blended Learning Platform in Higher Education. In: 2018 International Conference on Innovation in Engineering and Technology (ICIET). pp 1–6

Shahab S, Agarwal P, Mufti T, Obaid A (2022) SIoT (Social Internet of Things): A Review. pp 289–297

Shilpa A, Muneeswaran V, Rathinam DDK, Santhiya GA, Sherin J (2019) Exploring the Benefits of Sensors in Internet of Everything (IoE). In: 2019 5th International Conference on Advanced Computing & Communication Systems (ICACCS). IEEE, Coimbatore, India, pp 510–514

Stamer F, Steinke M, Silbernagel R, Häfner B, Lanza G (2020) Using Smart Services as a Key Enabler for Collaboration in Global Production Networks. Procedia CIRP 93:730–735. https://doi.org/10.1016/j.procir.2020.04.065

Towey D, Foster D, Gilardi F, Martin P, White A, Jiang Y, Pan Y, Qu Y (2017) Developing an Open Educational Resource: Reflections on a Student-Staff

Collaboration. In: 2017 IEEE 41st Annual Computer Software and Applications Conference (COMPSAC). pp 707–711

Wang C, Guo R, Yu H, Hu Y, Liu C, Deng C (2023) Task offloading in cloud-edge collaboration-based cyber physical machine tool. Robotics and Computer-Integrated Manufacturing 79:102439. https://doi.org/10.1016/j.rcim.2022.102439

Wu D, Shi H, Wang H, Wang R, Fang H (2019) A Feature-Based Learning System for Internet of Things Applications. IEEE Internet of Things Journal 6:1928–1937. https://doi.org/10.1109/JIOT.2018.2884485

Yahia NB, Eljaoued W, Saoud NBB, Colomo-Palacios R (2021) Towards sustainable collaborative networks for smart cities co-governance. International Journal of Information Management 56:102037. https://doi.org/10.1016/j.ijinfomgt.2019.11.005

Yang X, Moore P, Chong SK (2009) Intelligent products: From lifecycle data acquisition to enabling product-related services. Computers in Industry 60:184–194. https://doi.org/10.1016/j.compind.2008.12.009

Yu J, Kwon S, Kang H, Kim S-J, Bae J-H, Pyo C-S (2018) A Framework on Semantic Thing Retrieval Method in IoT and IoE Environment. pp 1–6

Zhang P, Wang Y, Kumar N, Jiang C, Shi G (2022) A Security- and Privacy-Preserving Approach Based on Data Disturbance for Collaborative Edge Computing in Social IoT Systems. IEEE Transactions on Computational Social Systems 9:97–108. https://doi.org/10.1109/TCSS.2021.3092746

Zhao M, Chen C, Liu L, Lan D, Wan S (2022) Orbital collaborative learning in 6G space-air-ground integrated networks. Neurocomputing 497:94–109. https://doi.org/10.1016/j.neucom.2022.04.098

Zhou X, Liang W, Yan K, Li W, Wang KI-K, Ma J, Jin Q (2023) Edge-Enabled Two-Stage Scheduling Based on Deep Reinforcement Learning for Internet of Everything. IEEE Internet of Things Journal 10:3295–3304. https://doi.org/10.1109/JIOT.2022.3179231

Naoko Abe, Tommaso Colombino (2024): Encounters with indoor delivery robots: a sociological analysis of non-verbal behaviours towards robots. In: Proceedings of the 22nd European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies - Notes, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591), DOI: 10.48340/ecscw2024_n01

Encounters with indoor delivery robots: a sociological analysis of non-verbal behaviours towards robots

Naoko Abe, Tommaso Colombino
Naver Labs Europe
Contact Author: tommaso.colombino@naverlabs.com

Abstract. This paper explores how people behave towards robots when encountering them in public spaces and examines the ways they interact differently with robots compared to humans. Using video data collected in an office building where a fleet of delivery robots is deployed, and drawing on classical sociological theories of people's non-verbal behaviour in public spaces, we provide examples of encounters between robots and bystanders. We focus on the ways in which people routinely acknowledge the presence of and make their own presence visible to other people in shared or public spaces. We then analyse interactions with robots in public spaces and argue that while it may often seem at first glance that people treat robots as social agents, there is in fact very little mutual engagement in incidental encounters due to the robot's limited embodied and social presence. We finally address possible directions for interaction and robot behaviour policy design for service robots in public or open environments.

1 Introduction

There is a general consensus in human-robot interaction research that robots should comply to general social norms and rules of behaviour when moving through public or shared spaces (Gallo et al., 2023a; Knepper and Rus, 2012). This consensus is usually accompanied by the assumption that robots are perceived as social agents and as having human-like qualities. In some ways this mirrors earlier questions about the extent to which people tend to assign human characteristics and agency to technological artefacts. The media equation (Reeves and Nass, 1996) is one of the most famous and frequently cited theories, and CASA (Computers Are Social Actors) paradigm (Nass and Moon, 2000) similarly argues that people intuitively (if not mindlessly) apply social scripts for human-human interaction, and tend to transpose human social categories onto technology, such as gender and ethnicity.

While the actual deployments of robots in shared spaces and open environments are still quite limited, there is in fact increasing evidence that people often behave very differently towards robots than they do towards humans. This appears to be especially true of children (Brščić et al., 2015), but can also be observed in office spaces, in airports and shopping centres (Joosse and Evers, 2017), and also with autonomous vehicles (Brown and Laurier, 2017). In contrast to Human-Computer Interaction and Computer Supported Cooperative Work research, sociological concepts are to date not commonly employed to analyse human-robot interaction in the Human-Robot Interaction research community. But as robots gradually move out of laboratories and experimental setups, and into the real world, there are increasing opportunities for more situated studies that look at how interactions with robots unfold in everyday situations and encounters.

In this paper, we bring a sociological perspective on human behaviours in shared spaces to analyse routine encounters between bystanders and service robots in an office building. Using video data collected in an office building where a fleet of delivery robots is deployed, we compare the ways in which people interact with each other and with the robots in shared spaces. Drawing from sociological approaches (Kendon, 1990; Hall, 1966) and particularly Goffman's (Goffman, 1963) and Garfinkel's (Garfinkel, 1967) analysis of unfocused interactions in public spaces, we aim to understand how people behave in shared spaces through body language and non-verbal cues when encountering robots. We explore the more nuanced ways in which people treat robots as something less than a fully competent social agent.

The robots in question are developed by the research division of an East-Asian multinational technology company and deployed experimentally in the company's own headquarters. They provide a food and parcel delivery service within the building and navigate autonomously between pickup and delivery points. Beyond a simple gaze (stylized eyes which look left and right depending on the direction the robot is turning) on the front screen, the robots do not possess many social features and in fact are not designed to interact with people outside of the end-point delivery, which involves a basic interaction to authenticate the customer.

When navigating through the building, the robots do not distinguish people from any inanimate obstacles they might encounter along their planned path.

The relative simplicity of the platform is a design choice. It does not make sense to invest in financially and computationally expensive features that are not central to the intended use of the robot. If that intended use involves moving through shared spaces quickly and efficiently, it also does not make sense to provide the robot with social features that encourage interaction outside of the intended points of contact within the service. The design problem we present here is that the mere fact of moving autonomously through shared space, treating bystanders as obstacles to be avoided can in itself be subtly disruptive and does not in fact seem to provide the robot with much in the way of social presence or agency. There is in our opinion therefore an interesting research and design challenge in trying to provide a robot with limited embodiment and social behaviors just the right kind and amount of social presence required to allow it to move through shared spaces in a competent and seamless manner.

Our contribution is twofold. Firstly, we present specific examples drawn from our video observations, highlighting various body idioms and expressive behaviors. These examples illustrate situations where robots fail to establish a real mutual presence during interactions with people, leading to undesirable outcomes such as people blocking or interfering with the robot's tasks. Secondly, we provide reflections on possible directions for designing interaction and robot behavior policies to mitigate these issues. We will then discuss the challenges in designing for smoother social interactions.

2 Related Work

2.1 Studies on the robot in public spaces

While research has tackled the technical requirements of a robot deployed in open environments such as museums (Jensen et al., 2005), shopping malls (Glas et al., 2012), stations (Shiomi et al., 2008), and campuses (Sanfeliu et al., 2010), the literature on the reactions or behaviours that people exhibit towards a robot in the wild remains limited. In the early stages of this research, learning people's spontaneous reactions towards the robot is central. Sabanovic et al. (2006) explore the way people approach two different types of robot with the role of receptionist, a moving robot and a stationary robot, and give some design recommendations of the robot behaviours to create an effective interaction with people. Weiss et al. (2008) conduct an experiment in public spaces by employing a "breaching experiment" which is a method to disrupt daily routines of people and analyse their reactions and measure the social acceptance of the robot. In their study, a robot with an interactive interface and voice interaction is moving around outside of the shopping centre, creating an unusual situation for passers-by. Thrun et al. (2000) examine how a guide-robot in a museum can attract people's attention and report that human features such as facial expression and utterance can be an effective communication modality, for instance when the robot is blocked by people who are unconcerned about its presence.

More recent research focuses on passive or unfocused interaction between passers-by and a robot. The concept of InCops (Incidentally Co-present persons) is advocated by Rosenthal-von der Pütten et al. (2020) who emphasise the importance of scoping the interaction with *"people who do not deliberately seek an interaction with a robot but find themselves in coincidental presence with the robots"*. Aligned with the concept of InCops, Moesgaard et al. (2022) are interested in what social role people who encounter accidentally a robot in public spaces attribute to the robot. Their study is based on the concept of "membership categorization analysis" developed by Sacks (1992) and shows that the most common membership attributed to the robot is "unknown robot", "working robot", "pet", "threat", "entertainment", and "dead object" which do not always represent a "social member", but rather a "machine" or an "object". While the robot is perceived as "safe", people also characterised it as "poor at navigation" or "not interactive".

2.2 Studies of attitudes towards the robot as social agent

The media equation and CASA paradigms, developed thirty years ago to study human communication with media such as computers and telephones, today are expanded in the field of HRI and often used to guide research on how people behave towards and treat robots. In general, two research directions exist: one supporting the media equation and the CASA paradigm and the other showing the limitations of these theories.

Some studies report similar phenomena to the media equation and the CASA paradigm when people interact with virtual agents and robots. For example, Hoffmann et al. (2009) conduct an experiment similar to that of Reeves and Nass (1996) and report similar attitudes towards a human-like virtual agent, i.e. participants who had a prior interaction with a virtual agent perceived it as more competent and were more polite than the participants who did not have a prior interaction with the virtual agent. In studies of proxemics between a human and a robot, some rules for human-human interaction were also observed in human-robot interaction such as the familiarity with the robot (e.g. participants having one-year experience with robots were comfortable with being close to the robot) (Takayama and Pantofaru, 2009). In the study of how robots should ask for help from humans, the results of the study by Sanfeliu et al. (2010) also supports the CASA paradigm. Furthermore, from the perspective of communication theories, this phenomenon is supported by the fact that our communication relies heavily on our basic abilities as prerequisites and is built through the human-human relationship, therefore it does not seem to be feasible to develop an alternative, radically different approach to communicating with computer agents or robots (Krämer et al., 2012).

While the findings of these studies are in concordance with the media equation and CASA paradigms, there are also studies that reveal limitations of these theories. By simulating the Milgram experiment on obedience which measures how far participants obey an experimenter who asks them to continue giving an electric shock to a person, Bartneck et al. (2005) demonstrate that people's attitudes towards a robot differ from towards a person. In their study, all 20 administrate the highest and lethal voltage (450 Volt) to the robot, compared to only 40% of participants administrating the highest Volt in Milgram's original study. They report that people are less concerned about abusing robots than other humans. In a human-robot proxemics study, contrary to the findings of Takayama and Pantofaru mentioned above, Joosse et al. (2021) demonstrate that people react more negatively when their intimate space is invaded by a human than by a robot, implying that people would be more lenient with respect to norm violations by robots.

Beyond the discussion for or against the CASA paradigm, Gambino et al. (2020) point out the evolution in the development and expansion of technological devices compared to the time when the CASA paradigm was developed thirty years ago. According to the authors, nowadays technology has gained many more social affordances to enable it to communicate easily with humans and to lead more human social responses. Moreover, the use of media agents is no longer rare. From this fact, they argue that humans apply human-agent scripts that are specific to human-media agent interaction and people do not necessarily follow human-human scripts when interacting with media agents. However, their study does not provide any information on how people would behave or react if they were to apply human-media agent scripts.

Thus, the extent to which people treat robots as social agents seems to be open to question. Our study particularly focuses on people's spontaneous non-verbal attitudes when they encounter a delivery service robot in a shared and open space in an office building, and how they express their attitudes towards the robot as a social agent. To understand people's behaviour in public spaces, we refer to sociological concepts of interaction as our theoretical background.

3 Sociological Approach & Theoretical Background

In this section we describe some of the theoretical concepts we used to analyze our video data of interactions between people and robots. We advocate for a sociological approach because we are interested in how robots can or should behave in shared and public spaces, and consequently we are particularly interested in interactions with bystanders. This means that our analytic focus is more centered on social norms and conventions that define appropriate behaviors in public, and less on the psychology or cognitive mechanism of a dyadic interaction (emotional engagement and theory of mind, for example), which may be more informative when designing interaction mechanisms for focused tasks between a person and a robot.

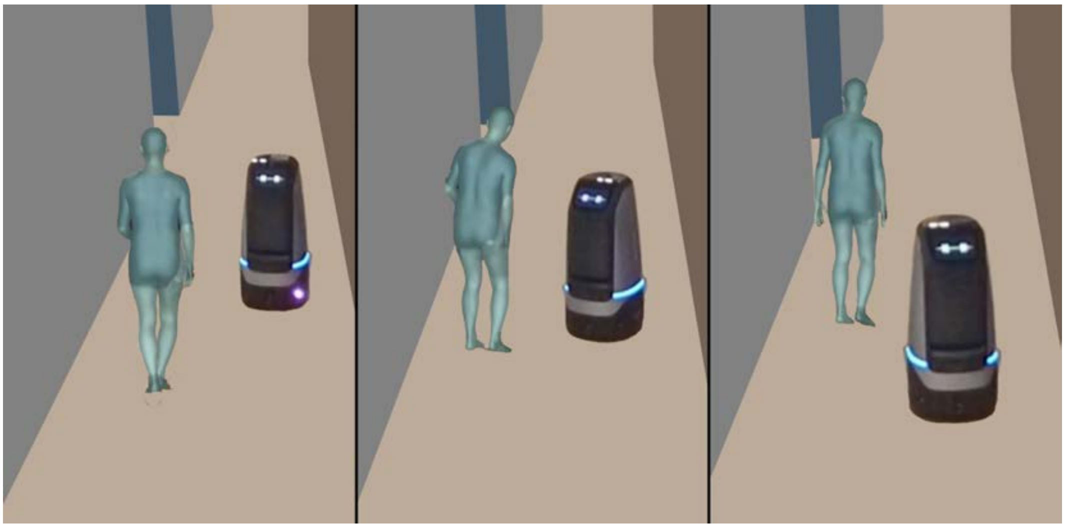


Figure 1. Example of the concept of "civil attention" in HRI. A person glances at the robot by turning the face towards it when passing by. In doing so, he makes his action accountable and signals a message "I am interested in the robot" to others in a non-verbal way. .

Goffman's civil inattention

The American sociologist Erving Goffman introduced the concept of civil inattention to describe a very subtle social phenomenon in public and semi-public places. Civil inattention refers to the social behavior, especially strangers, briefly acknowledge each other's presence. This behavior often occurs through limited visual contact, but then withdrawing from further visual contact so as to not transform an unfocused interaction into a focused one. This may also involve specific body language when people pass each other by, such as rotating one's torso to "make room" for another person while dropping your gaze to the floor. Civil inattention is a form of courtesy, i.e. it is be rude to stare a stranger in public spaces, however this is not the same for agents who do not have the status or social presence to merit it. For example, it is not considered rude to stare at dogs, small children and sometimes people who are engaged in activities that carry a particular status (like servants).

Another feature of unfocused interactions as described by Goffman is the role of body language which Goffman calls "body idiom". Unlike talking, we can't really turn off our body language, even when we try to be quiet or get unnoticed. This is one of the ways in which robots appear to be radically different from people in public spaces, as it is in fact possible for a robot to express absolutely nothing.

Garfinkel's notion of accountable action

The sociologist Harold Garfinkel known for his work in ethnomethodology, a field of sociology that examines how people make sense of their everyday social interactions, introduced the concept of "accountable action." By "accountable action", individuals make their actions "accountable", that is they make their actions understandable to others in that social setting by demonstrating that their behavior aligns with social norms (Garfinkel, 1967). For example, *queue (or queuing)* is studied as an accountable action through people's orientation, position, look, formation and so on (Garfinkel and Livingston, 2003), that is when people are queuing, they are expressing their intention to queue conforming to the expected behavior associated with *waiting in line*.

Through a sociological lens, we consider human conduct in public spaces as social acts, not merely individual behaviors. Even the most ordinary actions are shaped by the social expectations that dictate how we should behave. The concepts of *civil inattention* and *accountable action* enable us to analyze how people behave in public spaces with respect to robots and their interactions, connecting these behaviors to social norms.

Relying on these theoretical concepts, we aim to understand how body language is used and its meanings in the context of incidental encounters between a person and a robot in the office building. What we want to highlight about this context is that even if the encounters are incidental and their interaction occurs in an intentional way, the fact that they take place in a shared public space gives a social character to the encounters and to the people's behaviors.

4 Study

We conducted our observation using video recorded in a corridor where delivery robots routinely circulate. The building has a total of 36 floors and is designed as "robot-friendly" and a robot testbed. For example, its infrastructure is equipped with a robot-only elevator called "Roboport" which allows travel from the basement floor to the top floor. The robots themselves have fairly limited on-board processing and a local 5G network is provided to operate the robot under cloud-based control while minimising latency.

The recording was made at the intersection of a corridor and doorways that give access to the elevator lobby. It is a transit space where people circulate to go to/come from their offices or a parcel delivery room located on this floor or to take an elevator. The Roboport is also located in this corridor. The flow of people is dynamic and there are rarely people who are stuck in one place. The video was recorded over a full working day from morning to evening in November 2022. Its lasts 7 hours and 30 minutes.

4.1 The robot

We observed the robot, depicted in Fig. 2, deployed in the company's headquarters. The size of the robot is 1.07m in height, 50cm in width, and 55cm in depth. The robot's global navigation is controlled by a centralised cloud-based system, which can operate the building's cloud-enabled devices, e.g. the Roboport. The robot detects obstacles with depth cameras, with a deep neural network providing for the

Figure 2. The robot which is in service at the company's headquarters..

local navigation (including collision avoidance). The average speed of the robot is 0.7m/s

The robot provides a delivery service within the building. Employees can use a mobile phone application to order coffee from a coffee shop on the 2nd floor or food from a food court on the 5th floor and have them delivered by the robot to their office or meeting room. The robot also delivers small packages to employees' offices. There are simultaneously 70 to 80 robots in use in the building.

4.2 Ethical Considerations

Permission to record was granted by the company's legal team on the condition that the announcement of the recording in progress must be displayed at the site during the recording and the individuals in the recording must be de-identified immediately after the data acquisition. The images we use in this paper are frames from the original video recordings with people replaced by 3D models that replicate the original poses and the background images flattened.

5 Observation and Analysis

5.1 Civil Inattention Between Humans

Goffman's work (Goffman, 1963) reminds us that even crossing paths with another person in a shared or public space is a social occasion, which entails certain practices and rules of conduct. A corridor is a particular type of "place" (Harrison and Dourish, 1996) in an office building, different from other shared spaces like an

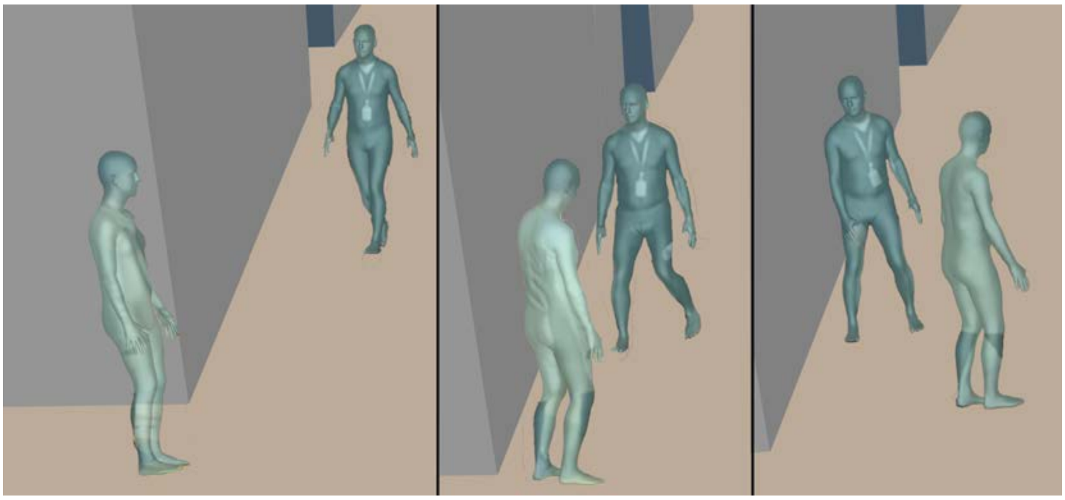


Figure 3. Example of “civil inattention”. Two passers-by acknowledge their presence but turn their heads and look away to avoid any additional interaction. .

office or a cafeteria, where encounters with robots and people are likely to be incidental and transient in nature.

As mentioned in Section 3, there is a particular way of crossing paths in a public space that involves a form of deliberate (civil) inattention. This is especially observable when people happen to pass particularly close to each other. In the encounter depicted in Fig. 3, two passers-by fail to notice other’s presence at the corner of the corridor and nearly collide with each other. We can observe a quick change in path direction and rotation of shoulder to avoid a collision. As is often the case with civil inattention, the person at the top of the figure turns toward the other person instead of turning away, signaling mutual acknowledgment of their presence in the social space. At the same time, they turn their heads and look aside or down to avoid eye-contact. By behaving in this way, the two passers-by can continue on their way without having to engage in any additional interaction (e.g. verbal interaction such as saying “Excuse me.”) It can therefore be characterized as an avoidance of engagement by mutual agreement and coordinated action. This is why we think its absence, as we see in the following example, is socially meaningful.

5.2 Absence of Civil Inattention Towards the Robot

While we observed civil inattention between two people encountering at the corner in the corridor (Fig. 3), we didn’t observe any similar behaviour in the encounters between people and a robot. Why does this not happen in the human-robot encounters? We mentioned in Section 3 that civil inattention is essentially a form of courtesy in public behaviour, but this does not automatically mean that its absence is a form of impoliteness. There are examples of incidental encounters where direct attention (or even staring) is permissible, like looking at babies or dogs. But what distinguishes between these encounters and those involving two adult people is the social standing of another agent in a shared social space. Babies and dogs do not have the social presence and agency of an adult.

In the case of interactions with robots, it is possible to distinguish between inappropriate interactions such as abusing the robot, which have been well documented in (Nomura et al., 2015; Salvini et al., 2010), and the perception that the robot is simply not socially present enough to merit civil inattention. For example, we observed a scene where two men chatting together and walking behind the robot, more focused respectively on each other and a mobile phone than the robot. Their walking pace is faster than the robot speed and the robot becomes an obstacle in their path. The man holding his mobile phone side-steps and slightly changes his path direction to step away from the robot. There is no re-orientation of the upper body towards or away from the robot, no turning of the heads or change in gaze direction, that is there is no attention to the robot by the man. This is one example where absence of civil inattention is obvious because the robot is essentially perceived as a moving obstacle but not a social one.

There are other examples where the lack of civil inattention doesn't necessarily mean there is no engagement. What we argue next is that, even when a person appears engaged with a robot, the focus is not primarily on the robot itself but rather their attitude reflects a form of public behaviour, observable to other people who might be present in the shared social space. These behaviours can contain a range of attitudes that are not meant to be "rude" but rather "attentive", "cautious" or "curious". We try to understand this phenomenon by using the concept of "civil attention and accountable actions".

5.3 Civil Attention

In contrast to civil inattention where people explicitly show their indifference to each other, civil attention refers, in principle, to an attitude of explicitly showing mutual interest. According to Horgan's definition (Horgan, 2020), *"civil attention extends from diffuse mutually aware recognition between co-present persons (e.g. giving an approaching stranger room to pass on a sidewalk) to more explicit breaches of civil inattention, where mutual respect is demonstrated and maintained"*.

Goffman and also Horgan's use of the word "civil" makes specific reference to the normative character of behaviour in public, which is why we previously described it as a form of courtesy or politeness. This differs slightly from, for example, Garfinkel's notion of accountable actions, which highlights the socially visible and available character of all action without any kind of value judgement (Garfinkel, 1967). In Garfinkel's terms, individuals make their actions "accountable", which is to say publicly understandable to whomever may be co-present with them in a shared space or context.

As we have seen in our previous example, mutual attention between a person and the robot is severely limited. Considering this fact and also Garfinkel's notion of accountable actions, we develop the concept of "civil attention" by taking into account the presence of other members who are present in a public space. We employ the term “civil attention” to introduce the ways in which people pay particular attention to others and also make their behaviour visible to people in co-presence in Garfinkel’s sense. Civil attention means both paying attention to someone or something and doing “attentive behaviour” to signal to others what is happening (Ayaß, 2020). Gestures such as glancing at or turning the face towards the robot (see Fig. 1) when passing by show a form of civil attention; a person is emitting in a non-verbal way a message “I am interested in the robot” to others.

This may seem like a trivial distinction to make, but it is important to remember that not all interactions with a robot in a shared space represent an actual engagement with the robot as a social agent. But they can, through the body language of the people involved, reveal a lot about how they perceive the robot’s social presence and agency (or lack thereof).

5.3.1 Signalling Caution

By caution, we mean that a type of civil attention shows particularly one’s cautiousness or prudence towards the robot. As shown in Fig. 4, a women pushing a parcel approaches the robot (which is moving considerably slower than she is) from behind. Upon noticing the robot, she suddenly stops and stares at it, and then keeps her distance from the robot by walking slowly so as to not to overtake it. Once she has confirmed that the robot turns away from her by glancing at it, she goes back to her normal gait.

This behaviour may result from the unfamiliarity with the robot as an “unknown object” (Moesgaard et al., 2022) in Moesgaard et al.’s term. She needs to handle her large (and maybe heavy) parcel and her way that would be disturbed by unpredictable robot behaviour. While we may be speculating, we can reasonably imagine that in a similar situation with a person blocking her way rather than a robot she might have used a verbal phrase (e.g. “Excuse me”) and negotiated her way past. Instead, she visibly hesitates and in doing so, she is also signalling her caution to other members in the space.

5.3.2 Signalling Curiosity

Curiosity is also a form of civil attention showing a positive attitude to or a strong interest in the robot. For example, we observed a scene where a group of people encountering the robot and a person in the group placing her hand in front of the robot. In doing so she showed her intention to interact with the robot and also her curiosity to other members of the group. In the case of Fig. 5, a man noticed the presence of the robot, then he kept watching the whole scene where the robot was taking the Roboport for about 30 seconds.

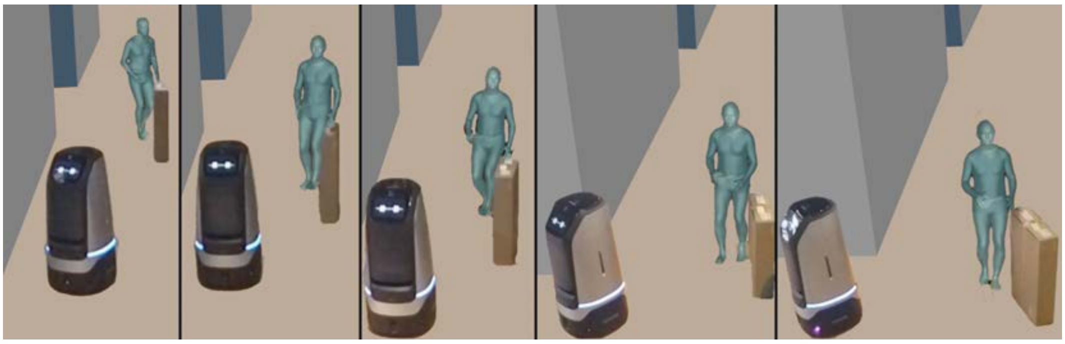


Figure 4. Example of “Civil Attention - Signalling Caution”. A person pushing a parcel notices the robot, then stops and stares at it. She keeps her distance from the robot by walking slowly so as not to overtake it. Once she has confirmed that the robot turns away from her by glancing at it, she goes back to her normal gait..

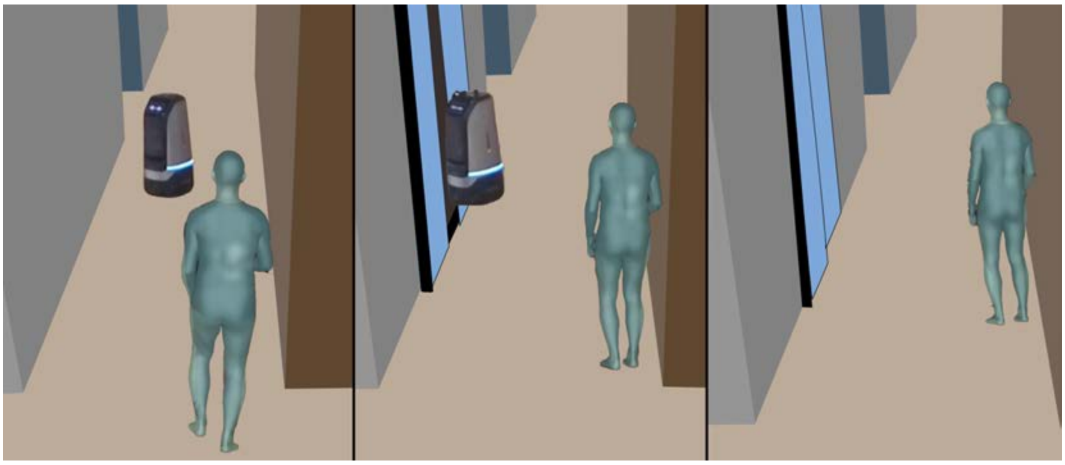


Figure 5. Example of “Civil Attention - Signalling Curiosity”. A person notices the robot, then he keeps watching the robot taking the Roboport for about 30 seconds..

6 Discussion and Implications for Design

The media equation and CASA paradigm have dealt with digital technologies or embodied conversational agents rather than robots. What we do want to point out is that a fully embodied agent, as robots aspire to be, is quite different from, for example, a conversational agent embodied in a smart speaker or other smart device, and that it we should not assume that attitudes towards them will be similar.

Body idiom is particularly difficult to recreate with robots that lack anthropomorphic features, and without expressive behaviour (gestures, posture, facial expression, etc.) it is difficult to establish social presence. Through our study and the examples we presented in this paper we have tried to show how and when there is some form of engagement with the robot (e.g. civil attention). They are often expressive behaviours for the benefit of the social context and other bystanders rather than genuine attempts to establish an interaction with the robot.

Although we have not discussed this at length, the lack of social presence of the robot can, on occasions, lead to undesirable outcomes both for people (increased possibility of accidental collisions or the robot slowing the flow in a crowded space) and for the robot, and the service it is performing (such as the robot "freezing" or even being deliberately blocked). From these findings, we want to provide some high level reflections and more specifically propose two potential approaches to address the robot's lack of social presence.

The first is to actually try to give the robot more social presence. While seemingly obvious, our position is that even simple social interactions like passing each other in a shared or public space involve complex and subtle social exchanges, mainly through body language (upper body posture in particular) and gaze. The current state of the art does not meet the requirements for perception and situational awareness in the unfolding interaction (see for example (Gallo et al., 2023a) for a discussion on the challenges involved in finding a socially appropriate waiting position for a robot using a shared elevator). Even if the required level of contextual understanding and situational awareness are attainable, there is then the challenge of giving the robot the appropriate expressive behaviour to accompany it. This may be easier if a robot already has anthropomorphic features which can be exploited to make it's body language more expressive, such as a torso and a head. A robot with more anthropomorphic features might attract increased attention and engagement. However when designing a service robot for public or open environments, this may not always be desirable, as it could result in more interference with the robot's tasks or even lead to abusive behavior (Nomura et al., 2015; Salvini et al., 2010; Brščić et al., 2015).

The second consists in designing the robot to signal clear information about its function. Civil attention may be more likely to occur if people are unaware of what the robot is doing and why it is present in a share space. For example, clear information about the robot's task as well as "robot's intention", has shown its effectiveness in collaborative tasks (Hoffman and Breazeal, 2004), and may facilitate smoother navigation (because the robot will not be disturbed by people) and improve trust and acceptance in the shared space.

This second design strategy implies a far more pragmatic attitude, viewing robots less as social agents and more as technological artifacts with a well defined function within a workplace. This means it may be better suited to functions that do not need (or event want to avoid) too much social engagement, especially with bystanders.

7 Limitations

One of the limitations in this research is that we can't at this stage account for people's increasing familiarity with the robot. People's curiosity or interest might decrease over time (Kanda et al., 2003) and civil attention would happen less frequently. However, considering the characteristics of public space, there will always be people, even in the case of the office building, who encounter the robot for the first time, making the notion of familiarity difficult to tackle.

The question of the generalizability of findings from purely qualitative approaches is also sometimes raised. The common criticism is that findings from qualitative research tend to be excessively specific, making it difficult to generalize from them. Qualitative research, by nature, focuses on in-depth exploration and understanding of specific contexts and phenomena. To understand the organizational and socio-technical properties of the setting we are looking at, we infer motives, purposes and rules of conduct, and give meaning to the observed activities. These elements are all normative, not causal. They do not exist independently of context and are bound up with the cultures, traditions, and so on. So analytically our goal is to explain how these norms are embraced, observed, acknowledged, understood, enforced, or violated by individuals in the given setting. This does not mean there will not be similarities across different settings, or different instances of the same setting (Randall et al., 2007). If we aimed to generalize our findings, we could anticipate observing similar situations across different office buildings and spaces. However, this was not the primary goal of this paper.

8 Conclusion

Drawing inspiration from Goffman's concept of civil inattention, we repurposed Horgan's concept of "civil attention" to describe the ways people respond to the presence of robots in shared spaces. Our observations in real-world settings contradicted the expectations of the media equation and CASA paradigm, as people do not always treat the robot as a social agent. We observed people's behaviors in a public space and showed that despite appearances of engaging with the robot, their actions were more akin to "accountable action", signaling their interest in or perception of the robot to other people rather than to the robot itself.

When designing for human-robot interactions, it is important to remember that (a) interpersonal communication is not only dyadic, but may be influenced by the social context within which encounters take place, and (b) a robot's ability to perform a task or service can also depend on its ability to move effectively through shared spaces and properly manage incidental encounters with bystanders.

References

Argyle, M. and J. Dean (1965): 'Eye-contact, distance and affiliation'. *Sociometry*, vol. 1, no. 1, pp. 289–304.

Ayaß, R. (2020): 'Doing Waiting: An Ethnomethodological Analysis'. *Journal of Contemporary Ethnography*, vol. 49, no. 4, pp. 419–455.

Bailenson, J. N., J. Blascovich, A. C. Beall, and J. M. Loomis (2003): 'Interpersonal distance in immersive virtual environments'. *Personality and social psychology bulletin*, vol. 29, no. 7, pp. 819–833.

Bartneck, C., C. Rosalia, R. Menges, and I. Deckers (2005): 'Robot abuse : a limitation of the media equation'. In: A. De Angeli, S. Brahnam, and P. Wallis (eds.): *Abuse : the darker side of human-computer interaction : an INTERACT 2005 workshop, Rome September 12, 2005*. pp. 54–57. conference; Abuse : the darker side of human-computer interaction : an INTERACT 2005 workshop ; Conference date: 01-01-2005.

Bowers, J. M. (1991): 'The Janus Faces of Design: Some Critical Questions for CSCW'. In: J. M. Bowers and S. D. Benford (eds.): *Studies in Computer Supported Cooperative Work: Theory, Practice and Design*. Amsterdam, etc., pp. 333–350, North-Holland.

Brown, B. and E. Laurier (2017): 'The Trouble with Autopilots: Assisted and Autonomous Driving on the Social Road'. In: *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. New York, NY, USA, p. 416–429, Association for Computing Machinery.

Bršćić, D., H. Kidokoro, Y. Suehiro, and T. Kanda (2015): 'Escaping from children's abuse of social robots'. In: *Proceedings of the tenth annual acm/ieee international conference on human-robot interaction*. pp. 59–66.

Fisher, J. D. and D. Byrne (1975): 'Too close for comfort: Sex differences in response to invasions of personal space.'. *Journal of Personality and Social Psychology*, vol. 32, no. 1, pp. 15.

Gallo, D., P. L. Bioche, J. K. Willamowski, T. Colombino, S. Gonzalez-Jimenez, H. Poirier, and C. Boulard (2023a): 'Investigating the Integration of Human-Like and Machine-Like Robot Behaviors in a Shared Elevator Scenario'. In: *Proceedings of the 2023 ACM/IEEE International Conference on Human-Robot Interaction*. pp. 192–201.

Gallo, D., P. L. Bioche, J. K. Willamowski, T. Colombino, S. Gonzalez-Jimenez, H. Poirier, and C. Boulard (2023b): 'Investigating the Integration of Human-Like and Machine-Like Robot Behaviors in a Shared Elevator Scenario'. In: *Proceedings of the 2023 ACM/IEEE International Conference on Human-Robot Interaction*. pp. 192–201.

Gambino, A., J. Fox, and R. Ratan (2020): 'Building a stronger CASA: Extending the computers are social actors paradigm. Human-Machine Communication, 1, 71–86'.

Garfinkel, H. (1967): *Studies in Ethnomethodology*. Englewood Cliffs, NJ: Prentice-Hall.

Garfinkel, H. and E. Livingston (2003): 'Phenomenal field properties of order in formatted queues and their neglected standing in the current situation of inquiry'. *Visual Studies*, vol. 18, no. 1, pp. 21–28.

Gerson, E. M. and S. L. Star (1986): 'Analyzing due process in the workplace'. *ACM Transactions on Office Information Systems*, vol. 4, no. 3, pp. 257–270.

Glas, D. F., S. Satake, F. Ferreri, T. Kanda, N. Hagita, and H. Ishiguro (2012): 'The network robot system: enabling social human-robot interaction in public spaces'. *Journal of Human-Robot Interaction*, vol. 1, no. 2, pp. 5–32.

Goffman, E. (1963): *Behavior in Public Places*. The Free Press.

Hall, E. (1966): 'The hidden dimension (anchor books a doubleday anchor book)'.

Hall, T. (1997): 'Ethnography: Principles in Practice. By M. Hammersley & P. Atkinson. Pp. 323.(Routledge, London, 1995.)'. *Journal of Biosocial Science*, vol. 29, no. 1, pp. 119–128.

Harrison, S. and P. Dourish (1996): 'Re-place-ing space: the roles of place and space in collaborative systems'. In: *Proceedings of the 1996 ACM conference on Computer supported cooperative work*. pp. 67–76.

Hoffman, G. and C. Breazeal (2004): 'Collaboration in human-robot teams'. In: *AIAA 1st intelligent systems technical conference*. p. 6434.

Hoffmann, L., N. C. Krämer, A. Lam-Chi, and S. Kopp (2009): 'Media equation revisited: do users show polite reactions towards an embodied agent?'. In: *Intelligent Virtual Agents: 9th International Conference, IVA 2009 Amsterdam, The Netherlands, September 14-16, 2009 Proceedings 9*. pp. 159–165.

Horgan, M. (2020): 'Urban interaction ritual: Strangership, civil inattention and everyday incivilities in public space'. *Pragmatics*, vol. 30, no. 1, pp. 116–141.

Jensen, B., N. Tomatis, L. Mayor, A. Drygajlo, and R. Siegwart (2005): 'Robots meet humans-interaction in public spaces'. *IEEE Transactions on Industrial Electronics*, vol. 52, no. 6, pp. 1530–1546.

Johansen, R. (1988): *Groupware. Computer Support for Business Teams*. New York and London: The Free Press.

Joosse, M. and V. Evers (2017): 'A Guide Robot at the Airport: First Impressions'. In: *Proceedings of the Companion of the 2017 ACM/IEEE International Conference on Human-Robot Interaction*. New York, NY, USA, p. 149–150, Association for Computing Machinery.

Joosse, M., M. Lohse, N. V. Berkel, A. Sardar, and V. Evers (2021): 'Making appearances: How robots should approach people'. *ACM Transactions on Human-Robot Interaction (THRI)*, vol. 10, no. 1, pp. 1–24.

Kanda, T., T. Hirano, D. Eaton, and H. Ishiguro (2003): 'A practical experiment with interactive humanoid robots in a human society'. In: *Third IEEE International Conference on Humanoid Robots*.

Kendon, A. (1990): *Conducting Interaction: Patterns of Behavior in Focused Encounters*, Studies in Interactional Sociolinguistics. Cambridge University Press.

Knepper, R. A. and D. Rus (2012): 'Pedestrian-inspired sampling-based multi-robot collision avoidance'. In: *2012 IEEE RO-MAN: The 21st IEEE International Symposium on Robot and Human Interactive Communication*. pp. 94–100.

Krämer, N. C., A. von der Pütten, and S. Eimler (2012): 'Human-agent and human-robot interaction theory: Similarities to and differences from human-human interaction'. *Human-computer interaction: The agency perspective*, vol. 1, no. 1, pp. 215–240.

Martin, D. and I. Sommerville (2004): 'Patterns of Cooperative Interaction: Linking Ethnomethodology and Design'. *Interactions*, vol. 11, no. 3, pp. 9–10.

Moesgaard, F., L. Hulgaard, and M. Bødker (2022): 'Incidental Encounters with Robots'. In: *2022 31st IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*. pp. 377–384.

Nass, C. and Y. Moon (2000): 'Machines and mindlessness: Social responses to computers'. *Journal of social issues*, vol. 56, no. 1, pp. 81–103.

Nomura, T., T. Uratani, T. Kanda, K. Matsumoto, H. Kidokoro, Y. Suehiro, and S. Yamada (2015): 'Why do children abuse robots?'. In: *Proceedings of the tenth annual ACM/IEEE international conference on human-robot interaction extended abstracts*. pp. 63–64.

Randall, D., R. Harper, and M. Rouncefield (2005): 'Fieldwork and Ethnography: A perspective from CSCW'. In: *Ethnographic Praxis in Industry Conference Proceedings*. pp. 81–99.

Randall, D., R. Harper, and M. Rouncefield (2007): *Fieldwork for Design: Theory and Practice*, Computer Supported Cooperative Work. Springer London.

Reeves, B. and C. Nass (1996): 'The media equation: How people treat computers, television, and new media like real people'. *Cambridge, UK*, vol. 10, pp. 236605.

Rosenthal-von der Pütten, A., D. Sirkin, A. Abrams, and L. Platte (2020): 'The forgotten in HRI: Incidental encounters with robots in public spaces'. In: *Companion of the 2020 ACM/IEEE International Conference on Human-Robot Interaction*. pp. 656–657.

Sabanovic, S., M. P. Michalowski, and R. Simmons (2006): 'Robots in the wild: Observing human-robot social interaction outside the lab'. In: *9th IEEE International Workshop on Advanced Motion Control, 2006.* pp. 596–601.

Sacks, H. (1992): 'Lectures on conversation'. *Malden, Massachusetts: Blackwell*, vol. 1, no. 1.

Salvini, P., G. Ciaravella, W. Yu, G. Ferri, A. Manzi, B. Mazzolai, C. Laschi, S.-R. Oh, and P. Dario (2010): 'How safe are service robots in urban environments? Bullying a robot'. In: *19th international symposium in robot and human interactive communication*. pp. 1–7.

Sanfeliu, A., J. Andrade-Cetto, M. Barbosa, R. Bowden, J. Capitán, A. Corominas, A. Gilbert, J. Illingworth, L. Merino, J. M. Mirats, et al. (2010): 'Decentralized sensor fusion for ubiquitous networking robotics in urban areas'. *Sensors*, vol. 10, no. 3, pp. 2274–2314.

Shiomi, M., D. Sakamoto, T. Kanda, C. T. Ishi, H. Ishiguro, and N. Hagita (2008): 'A semi-autonomous communication robot: a field trial at a train station'. In: *Proceedings of the 3rd ACM/IEEE international conference on Human robot interaction*. pp. 303–310.

Srinivasan, V. and L. Takayama (2016): 'Help me please: Robot politeness strategies for soliciting help from humans'. In: *Proceedings of the 2016 CHI conference on human factors in computing systems*. pp. 4945–4955.

Suchman, L. (2007): *Human-Machine Reconfigurations: Plans and Situated Actions*, Learning in Doing: Social, Cognitive and Computational Perspectives. Cambridge University Press.

Takayama, L. and C. Pantofaru (2009): 'Influences on proxemic behaviors in human-robot interaction'. In: *2009 IEEE/RSJ International Conference on Intelligent Robots and Systems*. pp. 5495–5502.

Thrun, S., J. Schulte, and C. Rosenberg (2000): 'Interaction with mobile robots in public places'. *IEEE Intelligent Systems*, vol. 1, no. 1, pp. 7–11.

Weiss, A., R. Bernhaupt, M. Tscheligi, D. Wollherr, K. Kuhnlenz, and M. Buss (2008): 'A methodological variation for acceptance evaluation of human-robot interaction in public places'. In: *RO-MAN 2008-The 17th IEEE International Symposium on Robot and Human Interactive Communication*. pp. 713–718.

Williams, J. L. (1971): 'Personal space and its relation to extraversion-introversion.'. *Canadian Journal of Behavioural Science/Revue canadienne des sciences du comportement*, vol. 3, no. 2, pp. 156.

Thomas Larsen, Per Larsen, and Pernille Bjørn (2024): Situational Awareness Data Extraction from Cooperative Virtual Reality Maritime Training Simulations. In: Proceedings of the 22nd European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies - Note, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591), DOI: 10.48340/ecscw2024_n02

Situational Awareness Data Extraction from Cooperative Virtual Reality Maritime Training Simulations

Thomas Larsen
University of Copenhagen, Department of Computer Science
tla@di.ku.dk

Per Larsen
Maersk Training
per.Larsen@maersktraining.com

Pernille Bjørn
University of Copenhagen, Department of Computer Science
pernille.bjorn@di.ku.dk

Abstract. Maritime personnel need competence in enacting situational awareness avoiding critical failures risking safety in everyday practices. Cooperative simulator training utilizing virtual reality (VR) technologies provides new opportunities to train situational awareness and offers new ways to collect data about behaviour. We explore different approaches to capturing behavioural data displaying participants' situational awareness practices supporting trainers in teaching and assessing maritime trainees. We argue that to capture situational awareness behaviour we need to design data collection methods documenting 1) artefactual proximity; 2) body movement in the environment; and 3) mutual monitoring while interacting with artefacts. Through experimentation, we demonstrate ways to collect these types of situational awareness data and discuss limitations. Finally, we propose four design recommendations for extracting situational awareness data from behavioural data in cooperative virtual reality simulators.

Introduction

Maritime work is a hazardous practice and the lack of situational awareness when accomplishing the everyday practices poses a severe problem producing high-risk situations (Dominguez-Péry et al. 2021; Sampson et al. n.d.). Loading truck-size containers onto cargo ships for global long-distance freight transportation is dangerous and can lead to fatal and costly outcomes for people, the environment, and equipment. The cooperative task of container loading requires multiple people to coordinate the activity and act while monitoring the crane movement, and positioning of the container preventing cooperative breakdowns. A core asset for high-quality safety training is full-size mock-up training simulators, which allow trainees to engage in cooperative practices in open-ended scenarios (Kozlowski and DeShon 2004). Mock-up simulators produce real-life sociomaterial contexts with access to engage with artefacts (Bjørn and Østerlund 2014) and simulator training has many benefits. Unfortunately, mock-up simulator training is costly, and access is limited (Kim, Sharma, et al. 2021; Kim, Sydnes, and Batalden 2021). Thus, finding ways to provide more access at a lower cost to simulator training is important (Mallam, Nazir, and Renganayagalu 2019). Virtual Reality provides many new opportunities for simulator training in open-ended cooperative engagements (Bjørn et al. 2021; Chellali et al. 2016). To fully take advantage of these opportunities, research is needed to explore and experiment with the potential for enhancing simulator training with virtual reality technologies and identify design requirements.

Working closely with Maersk Training since 2018, we have studied their training practices, their simulators, and the maritime domain for safety training – and identified that an often-neglected aspect when re-thinking simulator training (Mallam et al. 2019) *is the trainers' perspectives*. Virtual Reality brings the possibility of *automatically collecting data about human behaviour* during training simulation. Research has documented that to fully take advantage of simulator training the role of the trainer is crucial (Kozlowski and DeShon 2004), and in this paper we explore how automatic data collection can support this role.

Data collection about work practices is a difficult process and is prone to failure and mistakes in interpretation can potentially lead to unintended consequences (Dombrowski, Alvarado Garcia, and Despard 2017; Holten Møller et al. 2017, 2021; Kristiansen et al. 2018). We explore whether and how behavioural data collection from simulators can assist trainers in their work of teaching and assessing training and performance. One core behaviour which trainers monitor in simulator training is how well trainees execute *situational awareness*. Awareness has been a core interest in CSCW research since the very inception of the field (Ciolfi, Lewkowicz, and Schmidt 2023) and is concerned with how cooperative actors make visible their work for others to monitor and act accordantly (Bjørn, Fitzgerald, and Scopula 2003; Gutwin and Greenberg 2002). Thus, exploring how to extract data demonstrating situational awareness behaviour during cooperative safety training activities in virtual reality simulators can benefit from - while extending – existing CSCW research. Our research question is: *How can we extract and visualize situational awareness data capturing participants' displayed safety behaviour in virtual reality cooperative training simulators?*

We design, implement, and test a cooperative virtual reality prototype with automatic data tracking collecting three types of situational awareness data (Artefactual Proximity; Body Movement in the Environment; and Mutual Monitoring while Interacting with artefacts). We evaluate and confirm the usefulness and applicability of the extracted situational awareness data with three expert maritime trainers. Further, we identify shortcomings and suggest new ways to improve the data collection considering multi-modal interaction patterns (visual and audio input). We document the experimental process and results and finally provide design recommendations.

The rest of the paper is structured as follows. We develop our framework for situational awareness data collection and introduce our research approach. We introduce the prototype design and implementation, as well as the capturing and visualization of situational awareness data. Our result section demonstrates how three expert trainers evaluate the usefulness and applicability of automatic data collection. Finally, we discuss and conclude the paper by proposing four design recommendations for automatic behavioural data collection in cooperative virtual reality simulators.

Situational Awareness Data

Situational awareness data depicts how cooperative actors monitor their environment, the artefacts, and their collaborators during interdependent activities. Awareness is crucial for cooperative activities as a feature of cooperative practice (Heath and Luff 1992; Schmidt 2002). Awareness concerns displaying individual activities so others can monitor and maintain awareness of the collective efforts (Gross 2013). Awareness as a feature of cooperative practice has been documented in multiple ethnographic studies in CSCW and insights have been used for the design of cooperative technologies (Bardram, Hansen, and Soegaard 2006; De Souza and Redmiles 2007; Kusunoki and Sarcevic 2015; Menendez-Blanco and Bjørn 2019, 2022; Mentis, Reddy, and Rosson 2013; Tenório, Pinto, and Bjørn 2018). Moreover, different frameworks for how to approach the design of awareness in cooperative technologies have been developed such as workspace awareness (Gutwin and Greenberg 2002) and awareness cues (Wuertz et al. 2018). When we were to define and develop the theoretical framework for how to collect situational awareness data within the virtual reality simulation, we built our framework on prior work, while considering the kind of situational awareness data which would be relevant for our domain – maritime practices.

Awareness concerns cooperative actor monitoring of others' activities, including but not limited to the movement of their body (both walking and hand gestures), the status of artefacts (including 'piles-of-artefacts', changes in artefact state, and mobility of artefacts etc.); and the location of artefacts (the location provide information about the state of the cooperative environment) which is all part of the sociomaterial environment where the cooperation takes place (Bjørn and Østerlund 2014). Monitoring sociomaterial artefacts concerns noticing current situations to predict the future status of the environment (Bjørn and Rødje 2008) – and is highly related to situational awareness. Each professional practice has its professional language and vocabulary, as well as its indicators for the status of the work. To design a cooperative scenario for maritime safety training which captures behavioural data on situational awareness, we need to identify what kind of situational awareness data would be interesting to capture and understand what trainers look at when assessing trainees.

There are *layers of learning goals in maritime safety training*: The *first learning goal* is the foundational knowledge about how the operation is performed including specific professional terminology; the *second learning goal* is to understand the embedded risks of the operation including talking about rope snapping, snapback zones, risk of arms and legs being squeezed; the *third learning goal* is to understand about weak and early indicators for risk, learning how to notice and recognize any emerging hazards and detecting risk early on to prevent these; and the *forth learning goal* is risk mitigation, understanding how to spot potential risks and engage in active dynamic risk mitigation since preventing risk is not a static activity. As one of the expert trainers expressed situational awareness as:

> "*That holistic view of keeping an eye on your team, understanding the risks, communicating the risks keeping an eye for instance communication.* [Safety 2.0] came out of the realization *that in many of the operations we do there's a high level of complexity*. There are *always variations*, and the *risk picture is changing dynamically on the go,* and *you need to be able to operate that*. (…) there needs to be some acceptance of risk because the whole (…) way we moored the vessel (…) you cannot avoid people having to get into the danger zones" (Expert trainer, March 2023).

Situational awareness is a *dynamic activity*, where participants pay attention to, and notice, any kind of potential risk which might arise from the environment and the interaction with artefacts. Dynamic situational awareness includes the complete group of participants involved in the task or otherwise located in the proximity of the environment. Together with expert trainers, we have identified *three main types* *of activities which could be indications of human behaviour displaying situational awareness* as a dynamic feature in maritime practices.

Artefactual Proximity (bodies and artefacts). Situational awareness displayed as dynamic safety behaviour is observable by the location and proximity between participants' bodies and artefacts. Interacting with artefacts in maritime practices is a crucial part of all activities. Maritime artefacts are multiple and different such as ropes, machines, containers, winches etc. The risk of these artefacts is dynamic since artefacts might not be dangerous per se, e.g., a rope, however, if the state of the artefact changes (a tight rope) the risk increases, and the situation becomes unsafe (the rope snaps). The proximity between artefacts and participants' bodies matters and we need to dynamically capture how the proximity transforms over time. By observing and capturing data about the proximity between artefacts and bodies we can provide insights into the dynamic nature of safety for specific participants in the training environment.

Body Movement in the Environment (snapback zones). Situational awareness displayed as dynamic safety behaviour is observable in participants' movements. Where people are located matters. It is unavoidable to place people's bodies in unsafe zones throughout an activity since participants need to step in and out of 'safe zones' to perform their tasks. The dynamic nature of maritime work fluctuates the locations of safe or risk zones during the task performance. Participants might locate their body in a 'safe zone' at a certain time of the task, however, this zone can become prone to risk later. Painted areas on the ship's deck indicate safe or risk zones (rope snapback zones) risk providing a false sense of safety since the indications display risk as a stable entity instead of as a dynamic entity. Thus, collecting data about situational awareness must include ways to capture the observable pattern of moving dynamically over time.

Mutual Monitoring while Interacting with artefacts (visibility and heavy machinery). Situational awareness displayed as dynamic safety behaviour is observable through access to participants' attention during specific high-risk interactions with artefacts. The state of artefacts transforms during activities and capturing the attention span of participants at specific times (time stamps) during activities to assess the degree of monitoring the environment is crucial. Often such time stamps are related to operations of heavy machinery (high voltage or winches operating ropes). Thus, capturing data points about attention span when operating heavy machinery can provide insights for assessing participants' safety expertise.

To summarize, the theoretical framework for designing and implementing the VR simulator prototype comprises mechanisms to collect data on Artefactual Proximity, Body Movement in the Environment, and Mutual Monitoring while Interacting with artefacts to automatically capture participants' situational awareness behaviour.

Research Approach

Investigating *how to extract and visualize situational awareness data which capture displayed safety behaviour in virtual reality cooperative training simulators* we designed and implemented a cooperative virtual reality prototype following previous CSCW design strategies for CWE prototypes (Bjørn et al. 2021). The development, experimentation, and evaluation were conducted through three iterative cycles.

The first iterative cycle included empirical qualitative data collection at Maersk Training including observations of the mock-up physical simulators, document analysis of trainer observation templates, two individual interviews, and one group interview with three expert trainers about the needs for data about situational awareness. Based on the insights, the first author implemented a cooperative virtual reality prototype. Three teams (two participants each, a total of 6 people) trained in the simulator and the prototype automatically captured data about their behaviour.

We collected three types of situational awareness data: *Body Movement in the Environment, Artefactual Proximity,* and *Mutual Monitoring while Interacting with artefacts*. These were chosen to closely reflect what the experts requested and thus presented a good starting point for exploring the potential for data capture in cooperative Virtual Reality environments. To prompt the three teams to produce different sets of data, we created three types of conditions (safe, speed, and none). All groups were introduced to the same rules and information before entering the simulation. In the safe condition, the group was told that safety was the focus. In the speed condition, the group was told that speed was the most important. The last group did not get any additional information before entering the simulation. We recorded the simulations using video and audio streams from (two) first-person and third-person perspectives. We visualized the collected situational awareness data and interviewed one expert trainer discussing the usefulness and relevance of the automatically collected data. The interview confirmed the overall design approach and provided additional input for the design of the prototype.

The second iterative cycle focused on scaling the test material producing more situational awareness data. The first author made design and implementation adjustments to the prototype based on the feedback from the first cycle and organized and executed a study of 12 experiments (24 people). We collected the same kind of data during the project's second iteration: Four experiments in each condition (safe, speed, and none). Each group only experienced one of the conditions. We compiled all the data making the data ready for conducting within-in and across-cases analysis triangulating *data types* (Body Movement, Artefactual Proximity, and Mutual Monitoring), *conditions* (safe, speed, none), and *performance data* (time to finish the task).

The third iterative cycle focused on discussing the automatically collected dataset from the 12 experiments during expert interviews. For each interview (3), the prototype design and data collection method were described, including the experimental study and capture of situational awareness data. We discussed the results exploring three different perspectives: 1) whether the different situational awareness data types can be triangulated and together provide qualitative insights about safety behaviour; 2) whether comparing within-group behaviour (safety, speed, or none conditions) allows for specific insights about safety behaviour, and finally 3) how cross-case analysis of within-group data can provide specific relevant insights about safety behaviour. The expert interviews were structured as reflective conversations (Bjørn and Boulus 2011) and were all recorded and transcribed for analysis. Below is an overview of our data sources.

Table 1: Research activities and Data sources

Duration/numbers when	Activity and Data Source
1 day (February 2023)	Site visit observing mock-up simulators
Expert no. 1 (February 2023)	Interview with expert (online)
Expert no. 1, 2 and 3 (3 people) (February 2023)	Group Interview three expert trainers (on site)
(March 2023)	Document analysis of trainer material
(April 2023)	Design and implementation of prototype
(September 2023)	Re-design and implementation of prototype
3 Experiments (6 people) (May 2023)	Three experiments with two participants in each (6 people), one for each condition collecting three types of situational awareness data
Expert no. 1 (June 2023)	Expert Interview with data (online)
4 Experiment (8 people) (October-November 2023)	4 experiments with 2 participants (8 people in total): **Safe** condition, collecting three types of situational awareness data
4 Experiment (8 people) (October-November 2023)	4 experiments with 2 participants (8 people in total): **speed** condition, collecting three types of situational awareness data
4 Experiment (8 people) (October-November 2023)	4 experiments with 2 participants (8 people in total): **none** condition, collecting three types of situational awareness data
November 2023	Producing visualization of situational awareness data material
Expert no. 3 (December 2023)	Expert interview on data (online)
Expert no. 4 (January 2024)	Expert interview on data (online)
Expert no. 5 (January 2024)	Expert interview on data (online)
Total	5 individual interviews and 1 group interview with 5 different experts 14 Experiments with 28 different people in the cooperative VR simulation

Cooperative Virtual Reality Prototype

The cooperative virtual reality prototype is based on a scenario where two people load three containers with a crane. The scenario requires participants to perform and produce observable safety behaviour to be captured related to the three types of situational awareness data: *Body Movement* (snapback zones), *Artefactual Proximity* (bodies and artefacts), *Mutual Monitoring* (visibility and heavy machinery).

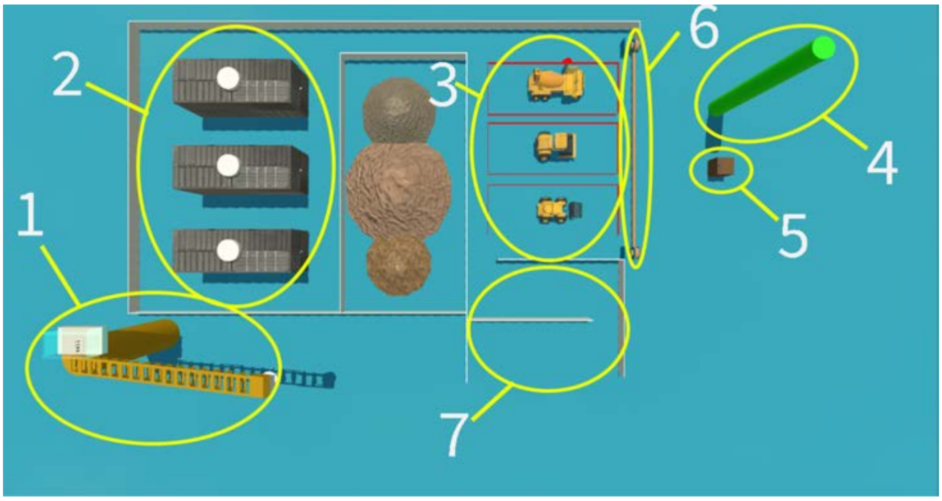


Figure 1: Virtual Reality prototype environment.

The prototype includes an environment (Figure 1) where participants can move freely. One participant controls the crane (1) to lift and load the containers (2), to their correct spot (3). The other participant is moving on the ground and has access to information important for the person in the crane. There is an alarm (4) which randomly turns off the crane, requiring the person on the ground to approach the alarm turning on the crane (5). The route to the alarm can be safe (7) or faster by walking over the rope (6). To ensure that the container is secured in the correct spot, the person on the ground needs to walk over to the container (3) and pull the lever down.

The task is designed to create interdependence between the participants while allowing them open-ended interaction forcing them to move around and enter the high-risk areas and thus train safety as a dynamic entity (Figure 2).

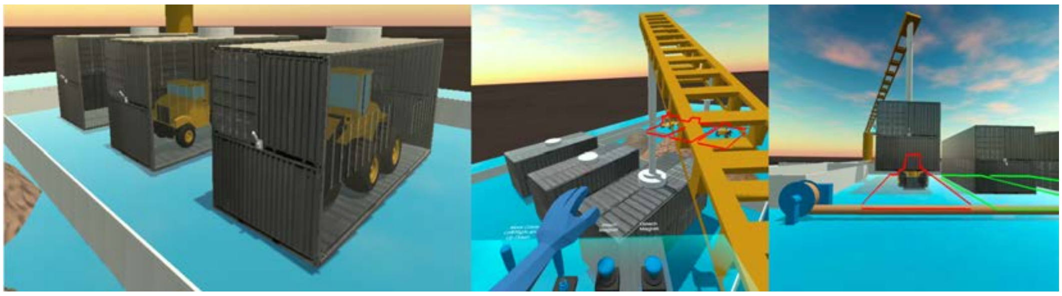


Figure 2: first-person point-of-view from the participant on the ground and the participant in the crane.

We collected data capturing 1) the mobility and route of the person on the ground producing data on *Body Movement*; 2) the proximity between the container and the person on the ground producing data on *Artefactual Proximity*, and finally 3) the attention (visual perspective) of the person in the crane when operating the crane (lifting or relieving the container) producing situational awareness on *Mutual Monitoring*.

Producing Situational Awareness Data

The main purpose of the prototype was to produce situational awareness data depicting the safety behaviour of participants to explore *if and how* this data could assist trainers in assessing safety behaviour. Thus, producing situational awareness data in the prototype was a step towards assessing the relevance of the data, rather than to determine appropriate design for maritime simulator training. We recruited 24 participants to conduct the loading containers scenario at the university in the Fall of 2023. Participants received a gift for participating. We created a rulebook, which presented *three guidelines for the simulation*:

1. Any player should never be directly under or close to a moving container (*Artefactual Proximity)*
2. When either picking up or placing down a container you should always be mindful (know) where the other player is located (*Mutual Monitoring)*
3. It is very dangerous to cross a rope that is on the ground and should therefore be avoided (*Body Movement)*

We had 12 experiments, four emphasized safety (Exp. No. 1, 4, 7, 10), four emphasized speed (Exp. No. 3, 6, 9, 12), and four in a non-condition (Exp. No. 2, 5, 8, 11).

Visualizing Situational Awareness Data

Visualizing Artefactual Proximity data assessing the rule: “Any player should never be directly under or close to a moving container”, we used a Pie chart diagram (Figure 3).

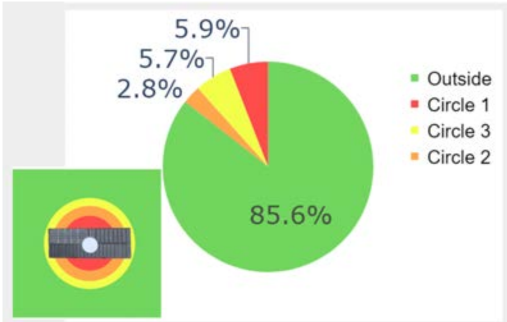


Figure 3: Pie chart capturing situational awareness data on Artefactural Proximity

We chose three different types of visualizations to demonstrate the data captured to the experts. The three types were: Pie chart, timeline, and heatmap. These choices were based upon *prior discussions* about relevant data representation with the experts while designing the virtual reality environment and cooperative task. Figure 3 shows a “proximity calculation around the container”. The calculator shows that if the trainee is close (under) the container they are in the red zone, if they are in the orange zone they are still close, the yellow is further away and in the green zone you are in a safe position to the container. In Experiment No. 4 (Figure 3), the situational awareness data on artefactual proximity show that the person on the ground spent 85.6% in the safe zone (green) away from the container, spent 5.9% of the time under or very close to the container (red), spent 5.7% in the yellow zone a little more away from the container, and finally spent 2.8% of the time in the orange zone. The circle diagram thus shows in terms of numbers how well the participant on the ground followed guideline no. 1.

Visualizing *Mutual Monitoring* data about the rule: “When either picking up or placing down a container you should always be mindful (know) where the other player is located”, we used a timestamp visualization.

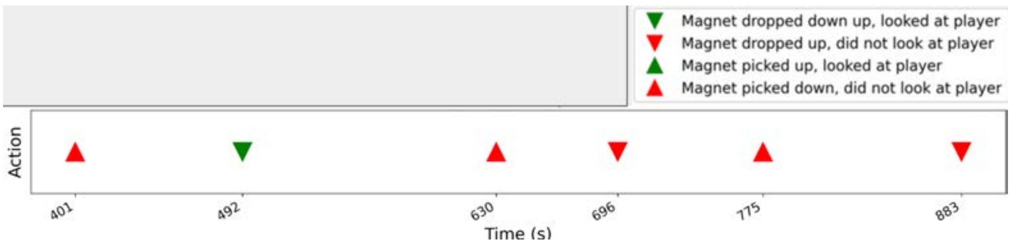


Figure 4: Timestamp capturing situational awareness on mutual monitoring while interacting with artefacts.

Figure 4 shows how the person in the crane lifted the container at 401 seconds into the simulation and then placed the container down at 492 seconds into the simulation. Also, when lifting the container (401 sec) the person in the crane did not look at the person on the ground within a timeframe of 5 sec before and after pushing the bottom on the crane (the little arrow is red). However, when placing the container down (492 sec) the person in the crane did look at the person on the ground (green arrow down). Figure 4 shows how the person in the crane in Experiment No. 4 only looked at the person on the ground once (at 492 sec), otherwise, they did not produce behaviour which demonstrated mutual monitoring while interacting with artefacts.

Finally, visualizing *Body Movement* data about the rule: “It is very dangerous to cross a rope that is on the ground and should therefore be avoided”, we used a heatmap (Figure 5). We collected data about how the person on the ground moved between containers, the alarm, across the rope, or other places. The heatmap displays in different shades of ‘red’ where the person is moving around, with dark red for heavily travelled routes, and lighter orange for less travelled routes. Figure 5 displays the heatmap for Experiment No. 4 and shows how the person on the ground has spent much time around the alarm and did not cross the rope, but walked the safe longer route between the alarm and the containers.

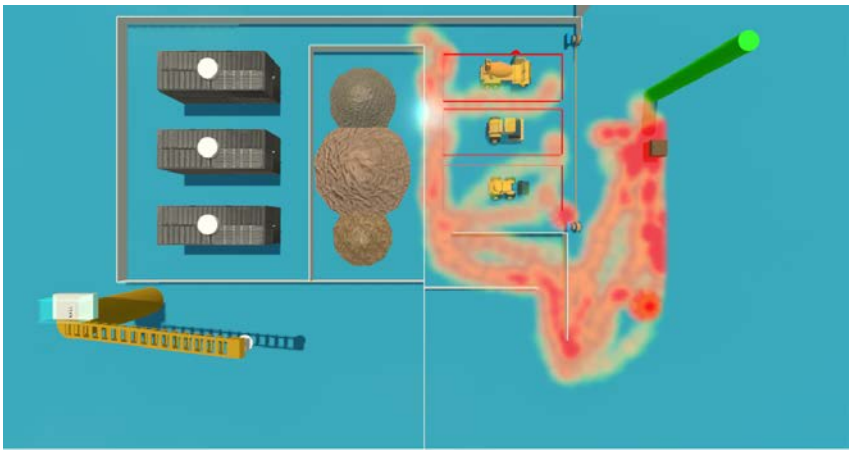


Figure 5: Heatmap collecting data about movements.

Results: Evaluating Situational Awareness Data

Interrogating the data from the 12 experiments, we recruited three expert trainers. We discussed the situational awareness data and recorded how they interpreted the data, and how they evaluated the data as potentially useful in their work. We did not show the experts the recorded videos from the experiments as we wanted to explore the usefulness and value of visualizations for the experts (without access to videos, interviews, and observations) and how they could use these data points to assess and evaluate the trainees.

Discussing different data types from Experiment No. 4: Safe

We showed the visualization of the three situational awareness data types: Pie chart, timeline, and heatmap from Experiment No. 4 (safe condition (Figures 3, 4, and 5 above)). We asked the expert trainer to interpret the data and articulate their thought process (speak-aloud technique) while asking them to guess which conditions (safe, speed, none) the data was produced in. All trainers guessed correctly that Experiment No. 4 was the safe condition, and they explained their rationale by referring to the data. Pedro, Fernando, and Leonardo explain below:

> "I'll say safety (…) because they're not passing the rope at all (…). Also, they are outside the green, away from the box [the container referring to the pie chart] quite clearly" (Pedro referring to Figure 3 and 5).

> "Well, it looks, the way he's walking, I would estimate that one to be where they had been instructed to be safe (…). The labyrinth instead of crossing the rope. He spent most of his time awareness from the area, where they put the containers down and he has not prioritized going over the rope for the ease of speed or getting done faster" (Fernando, referring to Figure 5).

> "For me, it's quite obvious with the heatmap that is actually quite relevant because that's where you see the movement of the person where they've spent a lot of time" (Leonardo, referring to Figure 5).

In all interviews, participants referred to the heatmap as the most pertinent data type arguing that Experiment No. 4 was in a safe condition. During all interviews, the interpretation process began with the heatmap, then the pie chart, and finally the timeline. Comparing the pie chart and the heatmap was a way to determine the condition of the experiment, even if they both were connected to the person on the ground. Fernando reflected that maybe the experiment was not that safe, due to the person being only in the safe zone (artefactual proximity) 86% of the time (Pie chart, Figure 3):

> "So, he has been safe, so to say 86% of the time. No, it's not 100% for sure. I mean, if we're talking about safety, it should be 100%. But not knowing the test subjects' prior knowledge of this type of thing. What really points me in that direction that he has prioritized safety to some degree is not going over the rope and spending most of his time away from the area of the containers" (Fernando, referring to Figure 3).

Interestingly, when the expert trainer begins comparing the different types of situational awareness data, he suggests assumptions about the trainee – and starts discussing the level of knowledge (novices and experts engage in training differently). The experience of the trainees was brought up several times during expert interviews, and data points were referred to as potentially being able to capture the learning process and expertise of individual trainees by showing their development over time.

The timeline dataset provides insights into the situational awareness displayed by the person in the crane. The expert trainers all viewed the data on the timeline (Figure 4) as not very safe:

> "Well, I'm thinking he's not very safety-focused. He doesn't seem to be looking for the other person when he's lifting and putting down the container" (Fernando, referring to Figure 4).
>
> "Yes, if it's a moving container, then I would expect them to look at the area, is there any persons around them in the lifting route (…) because then you need to make sure that you don't lift above persons" (Leonardo, referring to Figure 4).
>
> "I'm a little bit surprised about the other one, but that's probably maybe because they're saying they're safe or something, and they're not observing each other" (Pedro, referring to Figure 4).

All expert trainers were surprised that there was *only one green arrow* in the timeline (Figure 4). Pedro suggested the team might have communicated audibly about safe locations (having a conversation), rather than through visual monitoring (looking at each other). To determine the use of verbal confirmation, we revisited the audio-visual recordings of Experiment No. 4, to see if verbal confirmation could be detected. Throughout the whole recording, the person on the ground is always far away in a safe location, however, 12:45 minutes into the simulation, there is an incident where the person on the ground is potentially in a dangerous zone, because he just secured the second container, while the person in crane lifted the third container and began to move the container to the final spot. The person on the ground says: "*Now wait, so I can move and not be down under the container*", and the person in the crane says: "*I see you, I see you*" while stopping with the container in midair. The person in the crane waits, while the person on the ground walks away and signals verbally that he is safe stating: "You *can go now*". The person in the crane moves the container to the correct spot. Going back to the recordings, it was clear that despite the data on the timeline did not capture visual monitoring, the actual mutual monitoring through verbal communication did take place.

Discussing different data types from Experiment No. 12: Speed

Visualizing the situational awareness data from Experiment No. 12 demonstrated a case of speed (Figure 6). We discussed the data captured with all the expert trainers, and they began their interpretation with the heatmap.

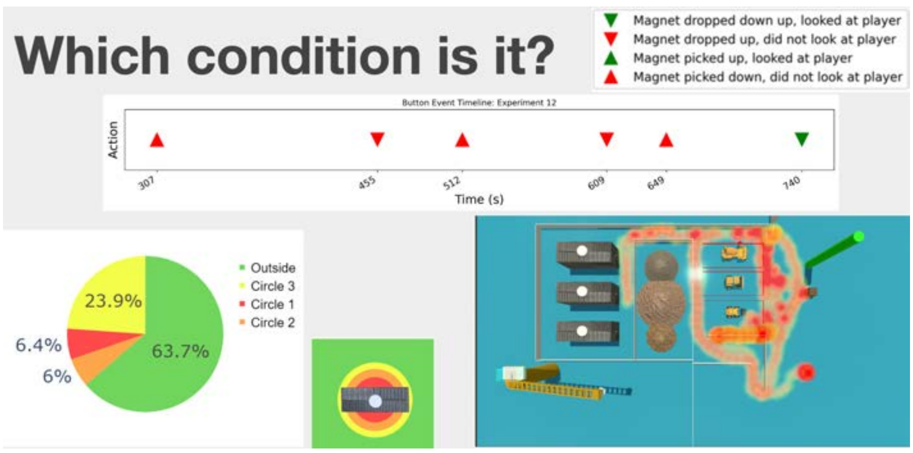


Figure 6: Situational awareness data from Experiment No. 12: Speed condition.

Expert trainer Fernando explains:

> "Again, I'm drawn mostly to the heat map because that tells me that he has not prioritized [safe route to the alarm]. He has prioritized moving directly to and from the alarm button. (…) he has spent a lot of time going over the rope and even spent time right next to the landing area. (…) And then, yeah, he's more unsafe. Of course, if I look at the pie chart, he spent a significant amount of time in the yellow area compared to before (talking about Experiment No. 4 safe condition data). And the other person in the crane, yeah, it's the same story. He only looked at one placing, but none of the lifting. So, I would guess this one probably [is] "be fast". Either disregard safety or not prioritize it" (Fernando, referring to Figure 6).

Fernando noticed and explained how the heatmap visualizes the movements in the unsafe zones of the environment and combined with the Pie chart supports that the participants were not focused on safety ("*he spent a significant amount of time in the yellow area compared to before* [Experiment No. 4 safe condition]"). Further combined with the situational awareness data produced by the person in the crane the expert trainer exclaims: "*And the other person in the crane, yeah, it's the same story. He only looked at one placing, but none of the lifting*". Similar discussions took place with the other expert trainers as Leonardo explains:

> "(…) when we do a crane operation, it depends on which time it is where they actually have to look. Because when they're connecting the magnet to the container, I don't expect them to look at the person. I would expect them to look at the magnet" (Leonardo, referring to Experiment No. 12, figure 6).

Across all three interviews, the timeline turned out to produce some insight, however, it was difficult to interpret, and it emerged that collecting data only by looking before, under, and after lifting the container might not be the best possible data point to capture the monitoring and attention by the person in the crane. As Leonardo points out he *would expect* the participants to pay attention to the magnet attaching it to the container rather than looking at the person on the ground while lifting ("*Because when they're connecting the magnet to the container, I don't expect them to look at the person. I would expect them to look at the magnet*"). This does not mean that it is not crucial to know where the person on the ground is when lifting and putting down containers, however, 'monitoring data' might need to be captured differently and adjusted for the application.

In combination, the three data types gave the expert trainers interesting insights about the performance in the simulator – however alone it was more difficult to make sense of the data. As Pedro explains:

> "By looking at all three of them, it gives me the headline. So, without the heatmap, I would not have guessed I've not been looking that much at the [Pie chart]. Without the heatmap, also looking at the [timeline], then there will also be why they took that much long, long time now

to move the crane between the two lifts and so on. But now when I can see that they have not gone to the containers, OK, that makes sense. So, I'm using the two to tell why. And the [Pie chart], it tells me something about the speed and what they are focusing on" (Pedro, referring to Figure 6).

The above quote explains how the combination of the heatmap, and the Pie chart provides important information about the performance. The temporal development captured by the timeline of the lift and place of the containers also provides important indications, even if the colour of the arrows might be less directional for interpretation. Access to the temporal ordering of the task is important since the time between lifts provides insights into the expertise of the trainees. Combining time stamps with the heatmap makes it possible for the expert trainers to understand why certain lifts might have taken a long time compared to others.

Comparing Heatmap visualization of situational awareness: Safe, Speed, None

We discussed the heatmap data in cross-case comparison: Experiments Nos. 1, 4, 7, and 10 (all safety, Figure 7); Experiments Nos. 3, 6, 9, and 12 (all speed, Figure 8); and Experiments Nos. 2, 5, 8, and 11 (all none condition, Figure 9). We facilitated within-case analysis for each expert in the different conditions.

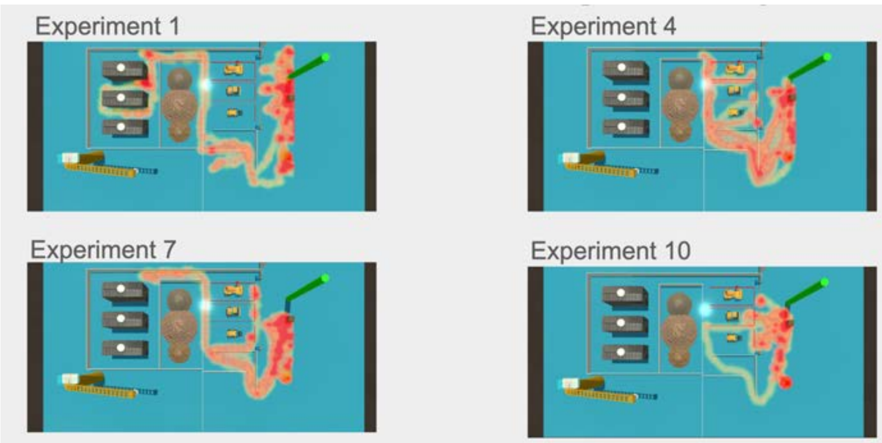


Figure 7: Heatmap Results: Experiments Nos. 1, 4, 7, and 10 (Safety)

Cross-case analysis of the safety condition (Exp. 1, 4, and 7) demonstrates movement as generally taking the longer safer route to the alarm (except Exp. 10), and that participants stayed away from the rope.

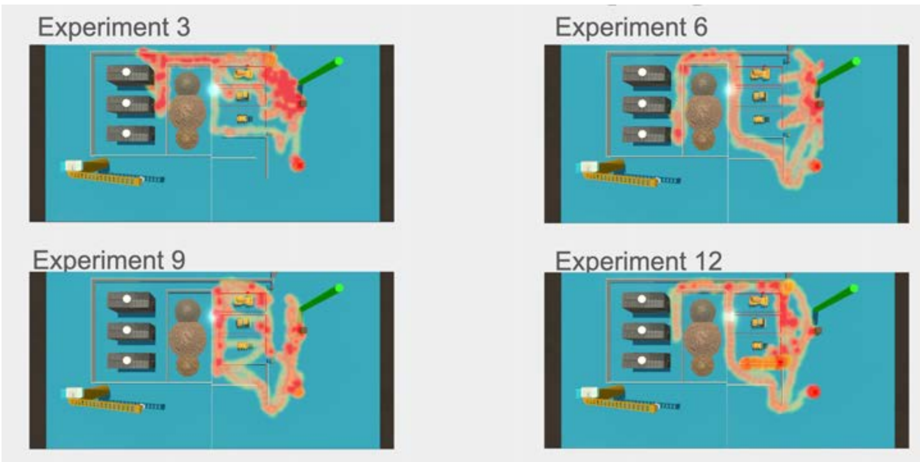


Figure 8: Heatmap Results: Experiments Nos. 3, 6, 9, and 12 (Speed)

Cross-case comparison of heatmap data from the safety condition (Figure 7) to the speed condition (Figure 8), the speed conditions had participants crossing the rope more often (particularly evident in Exp 3, 9, and 12) violating the rule: "*it is very dangerous to cross a rope that is on the ground and should therefore be avoided*". As explained by Leonardo:

> "Well, I definitely see that they are using a route, which is not allowed because it takes a longer time to go down and below and up through the gate. But it also makes it a lot more unsafe because they are working in the vicinity of areas where they're actually not allowed to be" (Leonardo, referring to Figure 8).

Interestingly the quote shows how having access to mobility data which are not directly related to a rule (rope) also produces relevant information about the performance of situational awareness for safety when assessing the results of the simulator training.

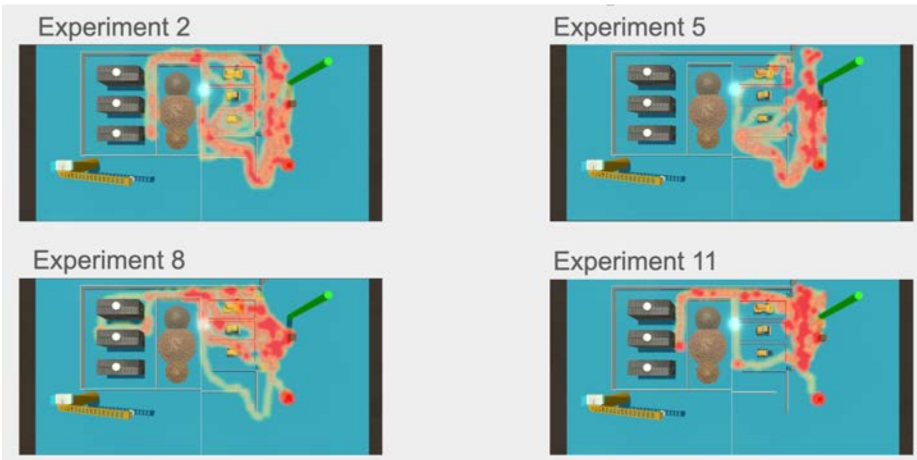


Figure 9: Heatmap Results: Experiments Nos. 2, 5, 8, and 11 (none condition)

The heatmaps from the ‘none condition’ (Figure 9) captured a mixture of bodily movement across all four cases (Exp. 2, 5, 8, and 11), where participants crossed the rope and the person on the ground would even spend time in the dangerous locations (Exp. 2 and 5). As explained by Pedro:

> “the detour is not as red as the other one, so it might be that they have not passed that many times, and they're standing more by the alarm box again. (…) be observant.” (Pedro, Figure 9, none-condition, heatmap).

The interpretation of movement considers how the participants placed themselves in a position which allowed them to observe the situations – an important skill to learn. This shows that capturing body mobility not only allows for data about problematic routes (passing the rope) but also can produce data about safety performance. Finally, we also saw examples where the expert would expect another data point (e.g., Pie chart) when viewing the heatmap, as in the example where Fernando says:

> “I would expect this person to not have focused on safety. They walk over the rope repeatedly. They spend a lot of time in the sit-down area. I would expect the pie chart to have shown they spend a lot of time under the container “(Fernando, referring to Figure 9).

Here the expert points to how he expects the Pie chart to confirm the interpretation of the heatmap (“*I would expect the pie chart to have shown they spend a lot of time under the container*”). This observation demonstrates the usefulness of several data sources – triangulating insights – and how these complement each other.

Comparing Pie chart visualization of situational awareness: Safe, Speed, None

During the cross-case analysis of the Pie chart from Experiments Nos. 1, 4, 7, and 10 (all safety, Figure 10); Experiments Nos. 3, 6, 9, and 12 (all speed, Figure 11); and Experiments Nos. 2, 5, 8, and 11 (all none condition, Figure 12), we discussed within-case data in the Pie charts in the different conditions.

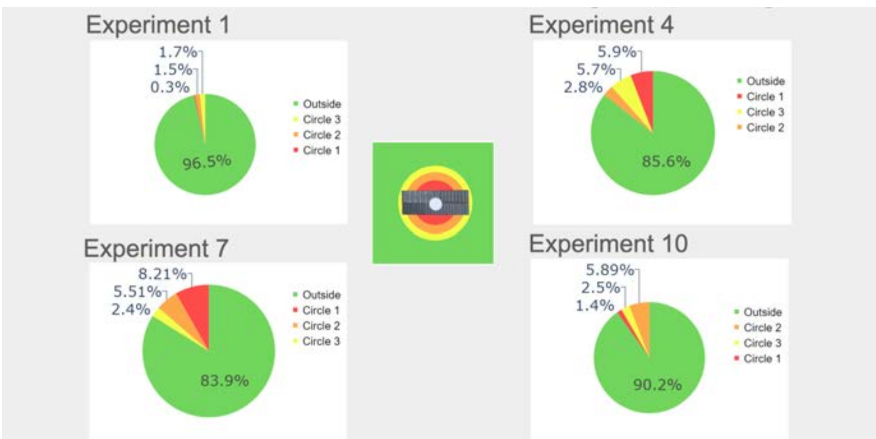


Figure 10: Pie chart Results: Experiments Nos. 1, 4, 7, and 10 (Safety)

The Pie charts focused on the proximity between the person on the ground, and then the container. Assessing how well the person on the ground followed the rule "*Any player should never be directly under or close to a moving container*", the data from the experiments illustrated how staying in the safe area (green zone) was between 96.5% to 83.9% - while staying in the most dangerous area (red zone) was between 0.3%-8.21%. Discussing whether the Pie chart data provide relevant insights into situational awareness and capture the behaviour allowing the trainer to assess and reflect with the participants in the simulators, Fernando explains:

> "it's a good indication of behaviour. It's a (…) direct correlation with where they were on the playing field. (…) you can (…) say, so you were under the lift and there's no arguing against it. (…) it's very useful, I would say" (Fernando, referring to Figure 10).

In the above quote, Fernando points out that the direct correlation and data about their location concerning a dangerous artefact ("*the lift*") provide indication relevant for simulator training. As Fernando expresses it: "*There's no arguing against it*". Being able to point out when and where trainees are demonstrating problematic behaviour is an important part of safety training activities, and thus the situational awareness data related to the artefactual proximity is useful.

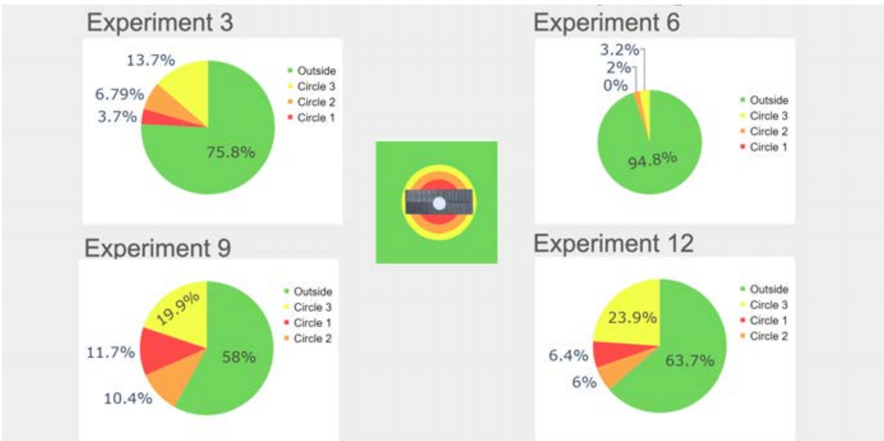


Figure 11: Pie charts Results: Experiments Nos. 3, 6, 9, and 12 (Speed)

Discussing the different types of Pie charts capturing the situational awareness data Leonardo explains:

> "It's (..) obvious to see that there's less green. (…) they have to hurry up, then they don't think about where they position themselves. (…) There's a lot in the yellow zone, but there's also a (…) larger percentage in the red zone. (…) these pie charts are really good to talk about, not so much for the crane operator, because he cannot do so much other than obviously stop the operation if people are too close. But (…) for discussing with the guys working on deck. Why did you decide to get this close to the container in this situation here? Was there a need for that? Could we have avoided that in any way"? (Leonardo, referring to Figure 11).

Considering the range in percentage spending in the red zones, Pedro starts to assess and define the potential criteria for appropriate and inappropriate safety behaviour based on the situational awareness data. Pedro says:

> “(…) what sticks out right away is [Exp. No. 8] that they don't focus on the safety at all. That's the worst safety I guess we have seen, because of the smallest amount of green. And then [Exp. No. 2] is what I would say norm, where I would say where we are focusing on the safety, but not as much with speed as well” (Pedro referring to Figure 12).

Across all three experts, the Pie charts provided important and relevant data to assess situational awareness.

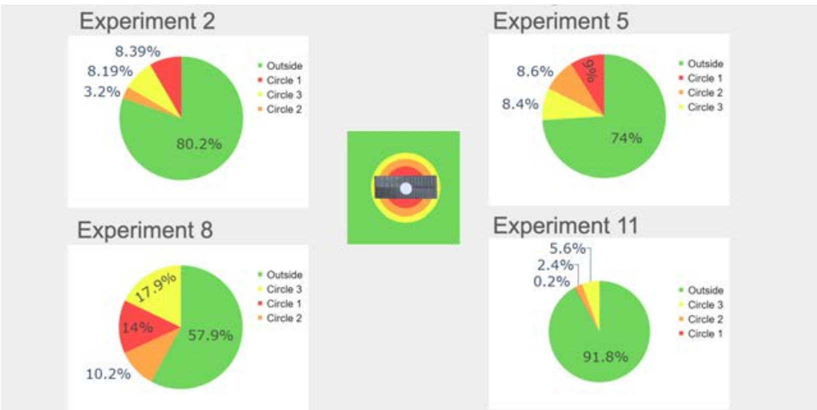


Figure 12: Pie charts Results: Experiments Nos. 2, 5, 8, and 11 (none condition)

Comparing Timeline visualization of situational awareness: Safe, Speed, None

We conducted within-case analysis of the Timeline data in the different conditions followed by cross-case analyses of the Timeline data from Experiments Nos. 1, 4, 7, and 10 (safety, Figure 13); Experiments Nos. 3, 6, 9, and 12 (speed, Figure 14); and Experiments Nos. 2, 5, 8, and 11 (none condition, Figure 15).

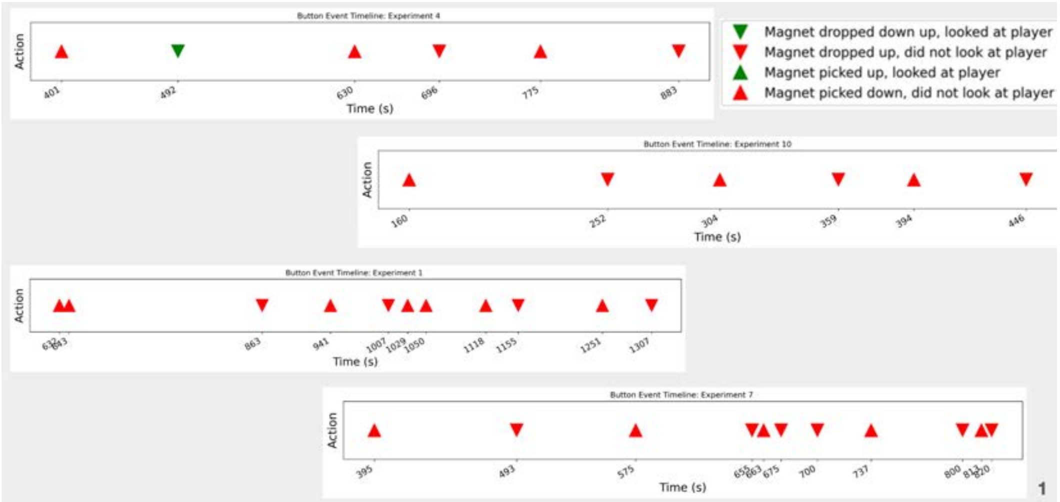


Figure 13: Timeline Results: Experiments Nos. 1, 4, 7, and 10 (Safety)

Despite the reconfiguration of the simulation after evaluation of the prototype in iteration no. 1, (increasing the 'attention span capture') the automatic data collector rarely identified any incidence where the monitoring and movement were done together. This questions whether our automatic data-capturing mechanism was useful. Interestingly, the expert trainers found different relevant uses of the Timeline. As Pedro explains below:

> "[Exp. No. 4] what I (..) notice is that it takes 401 seconds to do the first lift, and then the observant, when they are lowering down, it takes 91 seconds to move. For me, the second lift is much faster, so they are just getting a hang of how to use the crane. But then the last one, they are trying to put it in the correct position or something, because then it takes longer time" (Pedro, Figure 13)

The Timeline data and time indication (as in seconds into the simulation) turned out to provide important information to the expert trainers about the behaviour within the simulation. Below, Leonardo explains:

> "So I (..) see a crane operator that is focused on attaching the magnet. It could be because he's never operated a crane before or something like that, (..) He's actually focused at looking at the magnet because he's not moving his head around at all. (…) he might not need to look at the person on deck. (…) attach[ing] the container, then you will be focused on the magnet and the attachment point" (Leonardo, referring to Figure 14)

The Timeline data allowed the experts to assess the technical skills of the participants, Fernando explains:

> "Well, I'm seeing grinds. Some lifts are fluid motion. Some have done a non-fluid motion. (…) it looks like the lifting operations themselves have been quite fluid. (…) They seem to get better at operating the crane as they go along" (Fernando, referring to Figure 14)

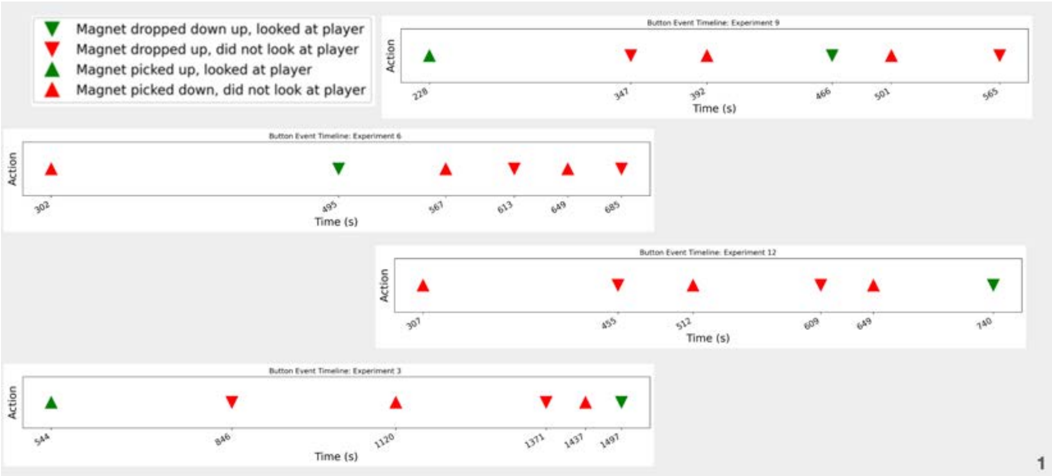


Figure 14: Timeline Results: Experiments Nos. 3, 6, 9, and 12 (Speed)

Interpretations of the Timeline data gave insights into the challenge of the task in relation to the skills of the participants. Fernando explains below:

> "Well, I'm seeing a behaviour that seems to be challenging for many individuals. (…) it seems to be difficult for them to focus on another person at the same time. Maybe they are focusing too much on picking up or putting down the container in itself, that action, (…) They don't have the bandwidth to also monitor the safety of another person" (Fernando, referring to Figure 15).

As the quote demonstrates, it might be too difficult to both monitor *and* operate equipment for a person with less experience, and such challenges are visible in the Timeline data.

Figure 15: Timeline Results: Experiments Nos. 2, 5, 8, and 11 (none condition)

The time stamps for operations provided different types of insights for the experts than expected. Connecting the bodily location with lowering the container (red/green arrows) could be enhanced by bringing in extra information, namely the location of the person on the ground at that moment (Pie chart). As explained by Pedro:

> "when they are sitting [the container] down (..) you can get squeezed underneath, but when they are picking it up it might be, now I know this was a magnet, so lifting it up it will only be if they are stuck in or caught by the container when they are lifting it up. It's more dangerous when lowering it down or moving it that they are not underneath it" (Pedro, Figure 15)

Another interesting observation was referred to as the importance of operating the crane in a 'smooth' or 'fluid' motion. It was mentioned by both Fernando and Leonardo, as the below two quotes show:

> "They have not completed the lift or the sit down on one **fluid motion**. It looks like they've been challenged a bit with the lift. (…) people did not really have the resources to do both at the same time" (Fernando, Figure 15).
>
> "Well, it shows for me, again, the saying from before that **slow is smooth, smooth is fast**, that when you actually think about what you do, then you get a consistent performance and a better performance. Because when you try to run for stuff, then you create something that is actually unsafe (Leonardo, Figure 15).

Thus, capturing temporal patterns facilitated experts in assessing relevant practice. Also, the use of timestamps and symbols allowed the experts to gain insights into the fluidity of motion in the visualization and explore the smoothness of each lift. Yet we should consider which activities for temporal data collection, and potentially make connections with additional data points. Further, colour coding connecting data on visual monitoring, verbal monitoring, participant's location, and machinery operation should be explored more to capture situational awareness data.

Comparing Performance: Safe, Speed, None

All groups in the experiments solved the cooperative task, however, the performance (time to complete) variated. Table 2 summarizes the performance data across all 12 experiments. The average time to complete in the safety condition was 13:25 minutes; the average time to complete in the speed condition was 14:47 minutes; and the average time to complete in the none-condition was 14:58 minutes. Remarkably, the safety condition seems to be faster on average than the speed condition, however Exp. No. 10 was an outlier.

Safety	Time to complete	Speed	Time to complete	None	Time to complete
Exp. No. 1	20:00	Exp. No. 3	21:34	Exp. No. 2	15:06
Exp. No. 4	13:05	Exp. No. 6	15:30	Exp. No. 5	11:44
Exp. No. 7	13:25	Exp. No. 9	08:45	Exp. No. 8	14:56
Exp. No. 10	06:24	Exp. No. 12	10:50	Exp. No. 11	18:10

Average	13:25		14:47		14:58

Table 2: Performance data across all 12 experiments

The experts were surprised about the performance data, as Pedro expressed: "*I'm surprised about the safety is faster than speed*" (Pedro, Table 2). Trying to understand the differences between the simulator experiments, Leonardo suggested that even if a group was asked to be safe, they might still display problematic behaviour – and the fast performance might be "*a lack of safety, because the time doesn't tell. Did they look at each other? Did they actually pass the rope? I can't see that from the timetable*" (Leonardo, referring to Table 2).

The performance data alone does not express much about the safety behaviour in the simulator. However, by combining the individual data types, the automatic data capturing did provide important insights into situational awareness behaviours. Leonardo explains:

> "[The data points] can [be used] in a combination. For the safety, the heatmap is really, really good. And also for talking about safety performance, the pie chart is also really good. The [performance table] shows you just because you think you're fast, you're actually not fast. (..) these arrows, it needs to be better defined at what they actually show, which point in time. But the three others are, from my point of view, they're really good data" (Leonardo).

Combining different data types each providing partial insights into the simulator behaviour can demonstrate "*the human behavior that they actually decide to deliberately break the rules that we actually put out in the beginning"* (Leonardo). It became evident that using the "visual measure" to assess participants' attention span risks neglecting situations of verbal confirmation. Fernando explains: "*you could evaluate this is a verbal confirmation or agreed safe spot that the other person moves to before the container is lifted or put down"* (Fernando). Verbal data triangulated with mobility should be explored further for data capturing.

All three experts discuss how the automatic data capture could not only be used for assessing the performance of certain participants, but instead could be used in terms of first creating a baseline, and then creating a development plan for the individual participant. The development plan could then explicitly state that *"to be able to achieve this certificate, then you need to go through these elements. It could be a new e-learning or something like that. (…) we have we have training here where we do assessment on human behavior, and it could definitely be used to for feedback and also a personal development plan*" (Leonardo). All experts expressed how they saw excellent potential for automatic data collection in cooperative virtual reality simulator training.

Discussion & Conclusion

We sat out to explore how to extract and visualize situational awareness data capturing participants' displayed safety behaviour in virtual reality cooperative training simulators. We wanted to know if the data extraction and visualization could support the trainers in teaching and assessing trainees' safety performance within maritime simulator training and add to research on situational awareness in CSCW.

CSCW research is fundamentally based upon the assumption that it is impossible to 'simulate' cooperative work since hierarchical, motivational, and political circumstances impact cooperative work (Duckert and Bjørn 2024; Grudin 1994; Suchman 1987) and thus not easily introduced into simulation or evaluated outside real-life practices. Cooperative virtual reality is changing the circumstances and especially cooperative simulator training for professional, complex, and high situations is emerging as a new core domain for CSCW research (Bjørn et al. 2021). With our experimentation with data capturing of situational awareness behaviour in cooperative virtual reality simulators, our study demonstrates that automatic data collection is possible and useful when assessing safety training.

We suggest and evaluate three approaches for data capturing of situational awareness in simulators: *Artefactual Proximity; Mutual Monitoring;* and *Body Movement* and find that they are all relevant and useful to capture simulator behaviour. We also identified ways to improve the data collection techniques. Thus, we propose to extend and develop the three design approaches for collecting data about situational awareness. Concretely, we propose 1) to expand Artefactual Proximity to include several artefacts and their internal relations, as well as their relations to the physical environment (walls etc.) as well as moveable artefacts (such as heavy machinery); 2) to extend the design approach for Mutual Monitoring to include the diverse nature of multi-modal interactions such as gestures and verbal communications; and 3) to nuance the collection of bodily movements to include detections of 'smooth' and 'fluid' interaction while leaving behind the dichotomy of fast/slow as a relevant measure. Finally, we also identified a fourth design approach to collect data about situational awareness related to the use of data not as a single point in time, but instead as a temporal pattern we need to identify, creating a context for data interpretation and decision-making directed at future design. Below Table 3 summarizes our design recommendations.

Table 3: Design recommendation for situational awareness data in cooperative virtual reality simulators

Situational Awareness data type	Design recommendations
Artefactual Proximity	Artefactual Proximity data is relevant and important. However new design should explore how to further develop artefactual proximity, by combining different

	proximity measure across artefacts, connect proximity detection of physical layout, and across artefacts
Mutual Monitoring while Interacting with artefacts	Mutual monitoring while interacting with artefacts needs to be expanded to consider the diverse nature of multi-model interaction which can provide monitoring practices in the professional circumstances – including but not limited to visible monitoring, gesture communication, and verbal communication
Body Movement in the Environment	Collecting data about body movement within digital simulators are important and relevant. However new design should experiment with how to collect data about 'smooth' or 'fluid' interactions, while considering leaving behind the dichotomy of fast/slow as a measure
Temporal detection of skills, competences, and expertise progress	The value of simulator training data transcends concrete measuring points, thus collecting training data should consider the temporal nature of learning overtime allowing people to monitor progress and demonstrate effectiveness. Such effort should identify and consider which kind of relevant time stamp could be produced.

Acknowledgments

Thank you to all the participants who agreed to join our experiment at the Human Centered Computing Section, Department of Computer Science, at the University of Copenhagen. We also want to thank the trainers at Maersk Training, who volunteered their time for interviews and reflective conversations.

References

Bardram, Jakob E., Thomas R. Hansen, and Mads Soegaard. 2006. "AwareMedia: A Shared Interactive Display Supporting Social, Temporal, and Spatial Awareness in Surgery." Pp. 109–18 in *Proceedings of the 2006 20th anniversary conference on Computer supported cooperative work*. Banff Alberta Canada: ACM.

Bjørn, Pernille, and Nina Boulus. 2011. "Dissenting in Reflective Conversations: Critical Components of Doing Action Research." *Action Research* 9(3):282–302. doi: 10.1177/1476750310396949.

Bjørn, Pernille, Brian Fitzgerald, and Ada Scopula. 2003. "The Role of Social Awareness in Technology Acceptance of Groupware in Virtual Learning Teams." in *Proceedings of the 26th Information Systems*. Haikko Manor, Finland: IRIS.

Bjørn, Pernille, and Carsten Østerlund. 2014. *Sociomaterial-Design: Bounding Technologies in Practice*. Cham: Springer International Publishing.

Bjørn, Pernille, and Kjetil Rødje. 2008. "Triage Drift: A Workplace Study in a Pediatric Emergency Department." *Computer Supported Cooperative Work (CSCW)* 17(4):395–419. doi: 10.1007/s10606-008-9079-2.

Bjørn, Pernille, Mark Wulff, Mathias Schmidt Petræus, and Naja Holten Møller. 2021. "Immersive Cooperative Work Environments (CWE): Designing Human-Building Interaction in Virtual Reality." *Computer Supported Cooperative Work (CSCW)* 30(3):351–91. doi: 10.1007/s10606-021-09395-3.

Chellali, Amine, Helena Mentis, Amie Miller, Woojin Ahn, Venkata S. Arikatla, Ganesh Sankaranarayanan, Suvranu De, Steven D. Schwaitzberg, and Caroline G. L. Cao. 2016. "Achieving Interface and Environment Fidelity in the Virtual Basic Laparoscopic Surgical Trainer." *International Journal of Human-Computer Studies* 96:22–37. doi: 10.1016/j.ijhcs.2016.07.005.

Ciolfi, Luigina, Myriam Lewkowicz, and Kjeld Schmidt. 2023. "Computer-Supported Cooperative Work." Pp. 1–26 in *Handbook of Human Computer Interaction*, edited by J. Vanderdonckt, P. Palanque, and M. Winckler. Springer International Publishing.

De Souza, Cleidson R. B., and David Redmiles. 2007. "The Awareness Network: To Whom Should I Display My Actions? And, Whose Actions Should I Monitor?" Pp. 99–117 in *ECSCW 2007*, edited by L. J. Bannon, I. Wagner, C. Gutwin, R. H. R. Harper, and K. Schmidt. London: Springer London.

Dombrowski, Lynn, Adriana Alvarado Garcia, and Jessica Despard. 2017. "Low-Wage Precarious Workers' Sociotechnical Practices Working Towards Addressing Wage Theft." Pp. 4585–98 in *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. Denver Colorado USA: ACM.

Dominguez-Péry, Carine, Lakshmi Narasimha Raju Vuddaraju, Isabelle Corbett-Etchevers, and Rana Tassabehji. 2021. "Reducing Maritime Accidents in Ships by Tackling Human Error: A Bibliometric Review and Research Agenda." *Journal of Shipping and Trade* 6(1):20. doi: 10.1186/s41072-021-00098-y.

Duckert, Melanie, and Pernille Bjørn. 2024. "Revisiting Grudin's Eight Challenges for Developers of Groupware Technologies 30 Years Later." *I-Com* 0(0). doi: 10.1515/icom-2023-0039.

Gross, Tom. 2013. "Supporting Effortless Coordination: 25 Years of Awareness Research." *Computer Supported Cooperative Work (CSCW)* 22(4–6):425–74. doi: 10.1007/s10606-013-9190-x.

Grudin, Jonathan. 1994. "Groupware and Social Dynamics: Eight Challenges for Developers." *Communications of the ACM* 37(1):92–105. doi: 10.1145/175222.175230.

Gutwin, Carl, and Saul Greenberg. 2002. "A Descriptive Framework of Workspace Awareness for Real-Time Groupware." *Computer Supported Cooperative Work (CSCW)* 11(3–4):411–46. doi: 10.1023/A:1021271517844.

Heath, Christian, and Paul Luff. 1992. "Collaboration and controlCrisis Management and Multimedia Technology in London Underground Line Control Rooms." *Computer Supported Cooperative Work (CSCW)* 1(1–2):69–94. doi: 10.1007/BF00752451.

Holten Møller, Naja L., Pernille Bjørn, Jonas Christoffer Villumsen, Tine C. Hansen Hancock, Toshimitsu Aritake, and Shigeyuki Tani. 2017. "Data Tracking in Search of Workflows." Pp. 2153–65 in *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing*. Portland Oregon USA: ACM.

Holten Møller, Naja, Gina Neff, Jakob Grue Simonsen, Jonas Christoffer Villumsen, and Pernille Bjørn. 2021. "Can Workplace Tracking Ever Empower? Collective Sensemaking for the Responsible Use of Sensor Data at Work." *Proceedings of the ACM on Human-Computer Interaction* 5(GROUP):1–21. doi: 10.1145/3463931.

Kim, Tae-eun, Amit Sharma, Morten Bustgaard, William C. Gyldensten, Ole Kristian Nymoen, Hasan Mahbub Tusher, and Salman Nazir. 2021. "The Continuum of Simulator-Based Maritime Training and Education." *WMU Journal of Maritime Affairs* 20(2):135–50. doi: 10.1007/s13437-021-00242-2.

Kim, Tae-eun, Are Kristoffer Sydnes, and Bjørn-Morten Batalden. 2021. "Development and Validation of a Safety Leadership Self-Efficacy Scale (SLSES) in Maritime Context." *Safety Science* 134:105031. doi: 10.1016/j.ssci.2020.105031.

Kozlowski, Steve, and Richard DeShon. 2004. "A Psychological Fidelity Approach to simulaUon-Based Training: Theory, Research and Principles." Pp. 75–99 in *Scaled Worlds: Development, Validation and Applications*. Routledge.

Kristiansen, Kristian Helbo, Mathias A. Valeur-Meller, Lynn Dombrowski, and Naja L. .. Holten Moller. 2018. "Accountability in the Blue-Collar Data-Driven Workplace." Pp. 1–12 in *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. Montreal QC Canada: ACM.

Kusunoki, Diana S., and Aleksandra Sarcevic. 2015. "Designing for Temporal Awareness: The Role of Temporality in Time-Critical Medical Teamwork." Pp. 1465–76 in *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing*. Vancouver BC Canada: ACM.

Mallam, Steven C., Salman Nazir, and Sathiya Kumar Renganayagalu. 2019. "Rethinking Maritime Education, Training, and Operations in the Digital Era: Applications for Emerging Immersive Technologies." *Journal of Marine Science and Engineering* 7(12):428. doi: 10.3390/jmse7120428.

Menendez-Blanco, Maria, and Pernille Bjørn. 2019. "Makerspaces on Social Media: Shaping Access to Open Design." *Human–Computer Interaction* 34(5–6):470–505. doi: 10.1080/07370024.2019.1566000.

Menendez-Blanco, Maria, and Pernille Bjørn. 2022. "Designing Digital Participatory Budgeting Platforms: Urban Biking Activism in Madrid." *Computer Supported Cooperative Work (CSCW)* 31(4):567–601. doi: 10.1007/s10606-022-09443-6.

Mentis, Helena M., Madhu Reddy, and Mary Beth Rosson. 2013. "Concealment of Emotion in an Emergency Room: Expanding Design for Emotion Awareness." *Computer Supported Cooperative Work (CSCW)* 22(1):33–63. doi: 10.1007/s10606-012-9174-2.

Sampson, H., N. Ellis, I. Acejo, N. Turgo, and L. Tang. n.d. "The Causes of Maritime Accidents in the Period 2002-2016."

Schmidt, Kjeld. 2002. “The Problem with `Awareness’: Introductory Remarks on `Awareness in CSCW’.” *Computer Supported Cooperative Work (CSCW)* 11(3–4):285–98. doi: 10.1023/A:1021272909573.

Suchman, Lucille Alice. 1987. *Plans and Situated Actions: The Problem of Human-Machine Communication*. Cambridge University Press.

Tenório, Nelson, Danieli Pinto, and Pernille Bjørn. 2018. “Accountability in Brazilian Governmental Software Project: How Chat Technology Enables Social Translucence in Bug Report Activities.” *Computer Supported Cooperative Work (CSCW)* 27(3–6):715–40. doi: 10.1007/s10606-018-9326-0.

Wuertz, Jason, Sultan A. Alharthi, William A. Hamilton, Scott Bateman, Carl Gutwin, Anthony Tang, Phoebe O. Toups Dugas, and Jessica Hammer. 2018. “A Design Framework for Awareness Cues in Distributed Multiplayer Games.” Pp. 1–14 in *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. Montreal QC Canada: ACM.

Léonord Rolland-Blin, Khuloud Abou Amsha and Matthieu Tixier (2024): Tying the policy knot: the Case of an Ongoing Digital Archiving Project for Patient Records. In: Proceedings of the 22nd European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies - Notes, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591), DOI: 10.48340/ecscw2024_n03

Tying the policy knot: the Case of an Ongoing Digital Archiving Project for Patient Records

Léonord Rolland-Blin, Khuloud Abou Amsha, Matthieu Tixier
Université de Technologie de Troyes, LIST3N
{firstname.lastname}@utt.fr

Abstract. Our study delves into the pivotal role of policies in the success of digital transformation initiatives, focusing on a case study of digitizing patient records at a general hospital. We aim to bridge the research gap on how policies are interpreted and applied in such projects, using a qualitative approach to understand the motivations and actions of the involved parties. By transitioning from paper to digital formats for clinical letters and test results, the project sought to optimize space and improve document access. Our findings, drawn from field notes and observations, highlight the diverse interests in digitization, from space management to policy compliance. We conclude with insights on the importance of policies in digital transformations, offering valuable lessons for future projects and digital archiving efforts.

Introduction

Computer-Supported Cooperative Work (CSCW) researchers have significantly contributed to understanding the collaborative nature of healthcare work, primarily through detailed workplace studies (Symon et al., 1996; Munkvold et al., 2007; Bardram & Bossen, 2005). However, the application of CSCW research in healthcare has primarily focused on the level of practices, leaving in the background considerations for the context of policy and regulatory compliance within healthcare environments. Fitzpatrick and Ellingsen (2013) emphasized this gap, pointing out the lack of specific examples of CSCW research addressing conformity with policy and regulations in healthcare settings, especially regarding privacy-related issues in hospitals and collaborative practices.

Accordingly, to truly transform CSCW findings into practical solutions for Electronic Health Records (EHRs) design and deployment, researchers must consider the broader picture encompassing legal and policy-related challenges (Jackson et al., 2014; Centivany, 2016). We need to develop a better understanding of the roles policies play in ongoing digital transformation projects. Current retrospective accounts are missing how the actors interpret and mobilize policies to achieve their project and agenda. This raises interesting and important questions about the possible roles of policies in ongoing digital transformation projects. Do policies support cooperation in digital transformation projects? Do they define a simple set of constraints and non-functional requirements (Sommerville, 2009) stated once and for all for a project? Can we understand policies as boundary objects (Star & Griesemer, 1989), setting up a shared and partially aligned context for the involved actors?

After introducing relevant related work about EHR projects in CSCW and previous analysis of the role of policies, we present our fieldwork and study approach in a digitization project at a general hospital. We present our study site in the Urology department, the work with patients' records, and the organization of the digitization project. The findings of our thematic analysis highlight the project's stakes from the different stakeholders' perspectives. We discuss the current status of this ongoing project and characterize the cooperation between the actors we have followed, the role of policies in the progress of the project and possible learning for future work.

Related Work

Beyond the complexity of integrating digital records into healthcare practices, limited attention has been paid to the policies that impact practices. The policies related to patients' records pose challenges and limits to practices, for instance in relation to the use of records as legal evidence. Research in CSCW has begun to further the analysis of policies in technology development and appropriation. Our study aims to contribute to this emerging corpus of research about the role of policies in ongoing digital transformation projects.

Electronic Health Records for Cooperative Work

Medical documents such as clinical letters, reports, and discharge referral letters are vital information sources heavily relied on by care actors within the healthcare ecosystem (Lovis et al., 2000). They account for a significant part of the medical information stored within EHRs, offering a comprehensive and expressive depiction of the patient's medical history and current condition (Sultanum et al., 2018). The importance of these documents is multi-faceted.

Firstly, medical documents are essential for care actors to gather valuable information about the patient's trajectory, documenting the various steps and milestones in their healthcare journey (Mønsted et al., 2011). They facilitate a comprehensive understanding of the patient's condition, aiding in delivering personalized and supporting coordination for effective care (Bardram & Bossen, 2005; Cabitza et al., 2009).

Secondly, these documents play a crucial role in the legal aspect of medical work. Unlike structured data, which can change over time as the patient's condition evolves, these text-based documents serve as a constant and unchanged record of facts that help to accurately trace the patient's medical history (Lovis et al., 2000). This role is essential for legal compliance and safeguarding the patient's and care providers' rights and interests.

Furthermore, medical documents are integral to billing, auditing, research, and administrative actions within the healthcare setting (Almeida et al., 2012). They serve as a vital resource for the various stakeholders involved in healthcare delivery, including healthcare professionals, administrators, and researchers, enabling them to carry out their respective roles efficiently.

Lastly, these documents foster communication and collaboration among the different care actors, facilitating a seamless exchange of information and insights that can significantly enhance patient care (Winthereik & Vikkelsø 2005; Marref et al., 2022).

While the importance of these documents is well-recognized, it is crucial to note that the design and deployment of technologies such as EHRs often focus on one specific role of the medical document, sometimes at the expense of its other equally important functions. Research in CSCW has significantly contributed to our understanding of the collaborative nature of healthcare work, primarily through detailed workplace studies. These studies have highlighted the importance of coordination across diverse healthcare settings (Symon et al., 1996; Munkvold et al., 2007), the role of collaborative artefacts (Bardram & Bossen, 2005; Cabitza et al., 2009), and the unique challenges posed by large-scale Information and

Communication Technology (ICT) initiatives in healthcare (Ellingsen & Røed, 2010). Such findings are invaluable for designing and deploying technologies that support health professionals and care providers in delivering patient care.

Fitzpatrick and Ellingsen (2013) noted the scarcity of CSCW work at the policy level, essential for significantly impacting larger-scale health IT projects. Addressing these gaps is vital for a comprehensive understanding of the complex nature of healthcare systems and for creating compelling and holistic technologies that support health professionals in delivering patient care.

Digital Archives in Healthcare

Paper-based health records are related to several policy compliance issues; the same goes for EHRs. In a digitization project, a key consideration often revolves around the legal validity of records, which is frequently associated with digital signatures.

Each country has its particularities, like specific documents that still must be created on paper or the level of identity trust required for e-signatures. In the European Union, Iceland, Norway, and the United Kingdom, this question is one of the objects of the Electronic Identification, Authentication, and Trust Services regulation (eIDAS). The regulation defines three levels (simple, advanced, and qualified) corresponding to three degrees of confidence in the author's identity. All levels have legal validity, but only the qualified level is considered equal to handwritten signatures, as detailed in the EU regulation 910/2014. In the USA, this question is addressed by the Electronic Signatures in Global National Commerce Act (eSIGN) described in the public law 106–229. They aim to ensure cross-border validity to facilitate commercial exchanges and specify the conditions for e-signatures to be legally valid.

As the study is conducted in a hospital in France, we will consider the French legal framework in more detail. Since 2000, French legislation (Loi n° 2000-230) has recognized the probative value of digital signatures and digital documents (Wack et al., 2002). This position was confirmed in a 2016 order affirming that digital records are equivalent to paper records, provided their authorship is clear and they are preserved to prevent integrity loss (Article 1366 du Code civil). French law defines "*archives*" as all the documents produced or received by a person while practicing an activity (Article L. 211-1 du Code du patrimoine), which encompasses the English categories "archives" and "records". Under certain circumstances, the archives' status implies a designated document management procedure. For example, French laws indicate mandatory preservation periods for health records (Article R. 1112-7 du Code de la santé publique) that impact the creation and update of the documents and their meta-data. In addition, control of the preservation must be realized for public archives, a procedure often managed by territorial archives. Most healthcare organizations are in this situation, either being public organizations themselves or associated with public services because of their public health missions (Cornu, 2016). Besides an internal management process, they must communicate with territorial archives to transfer them a sample for long-term preservation and obtain authorization to eliminate records after the mandatory preservation periods (Leroy et al., 2017).

CSCW and Policies

While often set as a background element in the study of technology-mediated cooperative practices, the crucial role of policies in the initiation and deployment of technology is better acknowledged (Jackson et al., 2014; Centivany, 2016), and more studies have called for understanding the impact of policies on appropriation and design in CSCW. Fitzpatrick and Ellingsen (2013) especially call for a better understanding at this level in healthcare technology, where an essential part of technology changes and implementation are initiated on behalf of local or national policies aimed at improving healthcare organizations for the benefit of patients (Cormi et al., 2020).

Jackson et al. (2014) propose to look at technology, practices, and policy as interdependent elements of a policy knot. On the ground of two cases of technology-mediated social practices that have been compromised by policymakers, namely *GirlsAroundMe* and *Google Buzz*, they eloquently highlight how policy can shut down a potentially harmful platform as an aftermath or counter the top-down development of a product unduly imposed by a significant firm.

Centivany (2016) supplements this corpus of case studies with a study about a digital library agreement about document sharing. The authors emphasize how, over the long term, initial choices made while policy-making can have a major impact on the spaces opened or closed for technology and social practices later in related project implementation.

These studies clearly show that policies can critically impact socio-technical practices and their technology support. However, the studies so far dealt more with retrospective accounts, and little has been said about the role policies are playing in ongoing digital transformation projects. The precise nature of the relationship between policies, practices, and technology in the "policy knot" is considered open (Jackson et al., 2014) and calls for generating more hypotheses. This raises interesting and important questions about the possible roles of policy in ongoing digital transformation projects.

Fieldwork and Methods

We conducted our fieldwork in a public hospital (Hospital A) for six months, from March to August 2023. The hospital representatives, namely the head of the medical information department (HMInfo) and the head of the archives service (HArch), presented the digitization project in Urology at the first meeting. They presented their objective to suppress all paper-based exchanges of medical records between the archives and urology and replace them with digital exchanges. The HArch then led a tour of the archives.

We participated in eight meetings related to the project and two observations at the urology secretary's office (one three-day observation and another lasting two and a half hours). The aim was to understand the practices surrounding patients' records and the objectives behind digitization for the various stakeholders (Table 1). Notes were taken during the meetings and then summarized in reports. These field notes reports were then used to conduct a collaborative corpus analysis with the Cassandre software (Lejeune, 2010), designed to support a qualitative analysis approach inspired by grounded theory (Strauss & Corbin, 1990; Lejeune, 2019).

Three of the eight meetings were steering committees, occurring every two months throughout the study period. They were held in the office of the HMInfo and attended by the same people as the first presentation meeting.

A **meeting with the chief secretary** has been arranged by the HArch in her office. Discussions focused on the necessary information for finding documents and the practices of secretaries.

The **first observation in the Urology secretariat** was conducted briefly afterward. We followed the tasks the four medical secretaries (MSec) carried out for three days. The aim was to gain an understanding of their work practices and organization.

The HArch's contacts enable an **exchange with another public hospital** (Hospital B). This hospital initiated the digitization of all patients' records a few years ago and reached the end of the project phase. The videoconference occurred in the medical information office and included significant members from Hospital B's digitization project team: three archives personnel and a computer engineer. In Troyes, in addition to the HMInfo and HArch, the Director of the Hospital IT department (ITD) was also present. The digitization project team of Hospital B provided a brief history of their project, guidance on necessary regulations, and feedback regarding their software service provider.

A **meeting with the departmental archives** (DepArch) was arranged due to the hospital's affiliation with public services. The DepArch oversee the scientific evaluation of Hospital A archives. An appointment with a specialist in digital archives has been organized in the HArch office.

A **proposal for an electronic document and records management system (EDRMS)** was presented to the HArch. The software provider initiated the meeting and held a video conference. The DepArch had previously confirmed the need for such specialized software to manage digital records properly.

Following our request for an interview with the head doctor of the urology service (HDUro), a **global meeting** was organized in May 2023 in the staff room on the Urology floor. It brought together representatives of some of the leading project's stakeholders: the HDUro, two MSec, the chief secretary, two nurses, the

HMInfo, and the HArch. During this meeting, the HDUro proposed a new process to reduce the transfer of paper patients' records between archives and his service.

One month after the proposal by the HDUro, a **second observation** was conducted with the MSec. The goal was to observe the new organization, the eventual changes and problems that occurred, and the secretaries' first feedback on the restructuring.

These meetings have allowed us to understand the practices and concerns of the main stakeholders. The table below summarizes their roles and the scope of their concern for digitization.

Table I. Overview of the digitization study involved stakeholders

Stakeholder	Number of Informants	Role	Scope of digitization
Head of the Medical Information Department (HMInfo)	1	Medical information management; Communication with direction	All new medical records
Head of the Archives Service (HArch)	1	In charge of the project's documentation redaction; Resource person for archives regulations	Overall
Head doctor of the urology service (HDUro)	1	End-users of information in medical records	External documents only (exams and letters)
Medical secretaries (MSec)	4	Preparation of the records before consultations and operations; Exchanges of records with the archives and the medical staff; Checking and sorting medical records	External documents only (exams and letters)
Nurses	3	Final users of information in medical records; Transfer of medical records to doctors during consultations	Overall
Information Technology Director (ITD)	1	Medical information and systems security; Software selection, implementation, and maintenance	Overall
Departmental archives (DepArch)	1	Evaluation of the hospital's archives; Guidance and expertise in document preservation	Overall

The Digitization Project Context

In what follows, we present an overall view of the work of the Urology department secretariat. Then, we introduce the key stakes and steps of the archives' digitization project as understood by HArch, who has the project leadership. Both provide essential background information for understanding our analysis.

Document Work at the Urology Department Secretariat

In urology, the four medical secretaries are divided into three positions that are exchanged weekly. One is responsible for preparing hospitalizations, one for preparing consultations, and two are typing assistants.

The preparation role in the Urology Department's secretariat is vital for coordinating patients' admissions for surgeries, treatments, and consultations. The MSec organizes documentation and logistics for a smooth process, including collecting and verifying patients' records, finalizing treatment plans with medical staff, and meeting pre-hospitalization requirements. Their tasks also encompass scheduling surgeries, stays, and patients' transport while considering resource availability, which requires meticulous attention to detail and strong organizational skills.

At Hospital A, patients' records are shared by all departments and contain medical information collected since the patients' first hospitalization. In addition, the services manage the records for patients who have only come for regular consultations with their doctors. As soon as a patient is admitted to hospitalization for the first time, their complete records, including consultations, fall under the hospital's responsibility and are then preserved by the archives service.

Managing paper patients' records for hospitalization and consultation in the Urology department is systematic and crucial. MSec starts by identifying upcoming admissions and consultations and requesting necessary records from the archives. Then, the archives department delivers these files, which MSec inspects, ensuring all relevant data is ready for use. To this end, they add documents recently received and sort them by date. Then, patients' files are sorted by physician, day, and consultation time before being transmitted to the relevant medical personnel.

For hospitalizations, French law specifies that the clinical letter must be sent to the concerned doctors on the day of the patient's discharge (Décret n° 2016-995). In Hospital A, the interns write the letter, which the MSec then edits. A clinical letter also exists for consultations but can be sent the week following the appointment. The two secretaries in charge of the typing task use the physicians' audio recording to type the consultation letters, and a copy is added to the patient's records.

To complete the cycle, MSec returns records to the archives after reordering their content if necessary. The records are placed in a designated office area, where the archives team picks them up on their daily shuttle.

This cycle of requesting, updating, and returning paper records is critical in the secretariat, supporting the hospitalization and consultation processes with comprehensive and current medical information crucial for the hospital's healthcare delivery.

Since HDUro reorganized the secretarial process in May 2023, the number of records requested from archives has significantly decreased. As most urologists agreed to base their decisions solely on recent documents rather than complete patients' files, the records are only ordered for specific situations, such as first urology consultations or cross-cases with the oncology service. In return, the MSec can spend more time typing letters and returning documents to the archives. However, the preparation of hospitalizations has remained unchanged because of the necessary records exchanges with the nurses and the surgical unit.

A Health Records Digitization Project

Launching a digital archiving project within a general hospital has many prerequisites. One central requirement is the production of documents to present the project to the hospital management and, in a way, give it an administrative existence: a project file. This file also acts as a guide throughout the project. In our case, the HArch oversees this aspect. The project file outlines the project's stages and objectives, the stakeholders involved, the existing processes and resources or those that need to be acquired or implemented, and the designation of a steering committee. This last task is crucial, as it will affect the available resources.

As the project file describes the hospital's current resources and processes, such information must be gathered from different stakeholders. In our situation, the HArch knew paper archiving practices and their legal requirements but needed to learn about secretarial practices, digital archiving, and the hospital's IT architecture. For instance, a naming convention for digital documents must be defined with MSec to benefit from a consistent convention when digitizing patient records. The project file must also comply with the hospital's archiving policy, a document that sets out an organization's archiving goals and processes and must be validated by the hospital management. While the Hospital's A archiving policy is only in its drafting stage, it still must be in line with the project file. The HArch is the most suitable person to verify it since she also writes this archiving policy.

This project significantly impacts the hospital's archives and requires exchanges with the DepArch. As previously mentioned, hospital archives are covered by public archives laws. Consequently, their preservation must satisfy the preservation requirements of public archives. Replacing paper records with their digital version in managing the patient situation is allowed. Still, the approval of the DepArch is mandatory to eliminate the paper versions as the hospital wishes. Their veto would be disastrous for the project.

Findings

Our thematic analysis highlights the stakeholders' perspectives about the potential benefits of saving space and time, gaining access and sovereignty on hospital health records, and how tradeoffs about the project scope are achieved considering the issue of conformity to policies.

Digitizing for Saving Space

One of the cross-cutting issues of several hospital stakeholders is space management. During our observations, this concern was more visible in the secretariat and archives and affected medical practices.

For the HArch, space management is an essential task. She must constantly keep under control the space occupied by paper archives at the scale of the hospital. She manages the patients' files and the entire hospital archives, including, for instance, the HR and purchase department, with their legal constraints. It represents about 400 linear kilometers of paper archives split in different rooms across the hospital, and medical records represent 12 linear kilometers. The records' volume is already slightly higher than it should be, leading to storing new files on the highest shelves and causing handling problems.

> "Many [patients' records] are on the highest shelves of the archives. This accessibility problem makes the handling more difficult as they must bring a stepladder to reach them." Field note based on MSec comments.

The archives service aims to reduce the volume of preserved archives, but for now, active work only enables maintaining the current size.

The digitization project for the Urology department is of crucial interest to the HArch as it could prevent the service from producing new paper-based patient files, which brings the promise of free space as old enough patients' files can be progressively destroyed or transmitted to the DepArch. She sees the project as a potential pilot project that can serve as a model for other services.

In the Urology secretariat, the space is mainly used to store medical records prepared for consultations or waiting to be archived (figure 1). As the service has a high activity level, many files are exchanged daily with the archives and kept in the secretariat. At the beginning of the observation, the shelves were insufficient to hold all the documents.

> "[In the Urology secretariat] There are shelves for storing patients' records all along the wall on the corridor side. One of them (further than the others) has been added because of the quantity of records on the floor. They were obstructing movements within the secretariat. Transport trolleys are also used to store them." Field note based on MSec comments.

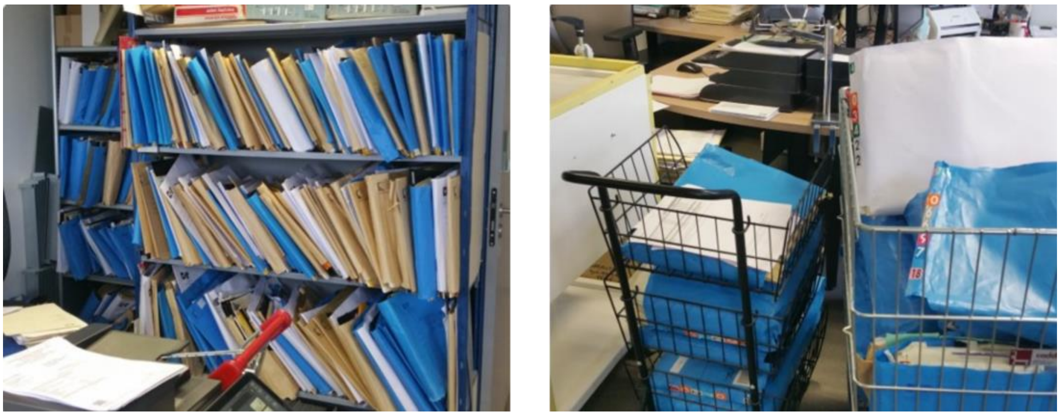


Figure 1. On the left is a view of shelves in the secretariat; the additional shelf is the central one; on the right, there are trolleys filled with patients' records.

In addition to the hospital records exchanged with archives, the urology secretariat also contains medical files for patients who have only seen a urologist for consultation, as they are not under the hospital's responsibility.

> "These files are stored in the secretariat in drawer cabinets and, as there is not enough space in them, in boxes near the desks and in the patients' records shelves." Field note based on MSec comments.

The new process, defined in May 2023, improves this situation as fewer files are requested to the archives and stored in the secretariat.

> "Shelves are much less crowded, and the central area of the secretariat clearer. [...] Eventually, secretaries hope to remove the additional shelf that obstructs the movements of one of them and her visibility of the rest of the secretariat and to reclassify the remaining records." Field notes based on MSec comments.

Physicians have already agreed to limit themselves to fewer documents during consultations in some other medical services. In urology, this practice shift partially happens by applying the process proposed by the HDUro. Moreover, patients' records are kept in the secretariat for much longer than the consultation time to complete them with received documents. In this context, their digitization, or at least of specifically selected papers, was seen as a solution to reduce the flow of records between the archives and the secretariat. It means fewer medical records in the secretariat, thinner files in the archives, and less time spent searching specific files in the secretariat.

The hospital's management, including the HMInfo, the HDUro, and the HArch, has safety concerns with many patients' files in the secretary's office. A few years before the beginning of our research, there was a work hazard in another service where a hospital employee fell due to paper files on the floor.

Nurses and doctors of the Urology department find the paper-based files cumbersome but are not concerned with the lack of space as they scarcely come to the secretaries' offices to pick up patients' files. Most of the time, the secretaries bring the patients' files.

Digitizing for Saving Time

As mentioned earlier, two secretaries are responsible for preparing patients' records, one for the hospitalization journey and one for day consultation. The other role is typing assistant for preparing reports and mail that will end in the patients' files and be posted to the relevant healthcare professionals.

At the beginning of our study, ordering all the patients' files before patients' visits was a regular and required activity. It involves preparing a list of patients to come from the doctors and hospital schedules and checking the location of patients' files, which can already be in the MSec office. After ordering patients' files to the archive, the secretaries in charge manage the reception of the complete files and their consistent ordering in piles according to the day of the visits (half-day for consultation). Fax and mail documents will arrive throughout the days for inclusion in the patients' files, for instance, biology exam results. This preparation activity takes a lot of time daily.

The other secretaries are responsible for typing reports and letters from doctors' audio recordings. The reports and copies of the letters must be printed and included in the patient's files. The secretaries suffered from the increased number of patients' files in the office, which also increased the time needed to find precise information. While cleverly organized by the secretaries as different piles, there is a tradeoff as this organization requires space to save time in looking for patient information.

The secretaries expect that digitizing patients' documents would relieve them from retrieving files from the archives department and the complex management of paper files in their office. To a certain extent, this was achieved with the reorganization decided after the global meeting in May 2023 as, apart from hospitalization cases, the MSecs no longer order patients' files and instead bring the new documents to the archives, where they should sort them back in the corresponding files.

As a mirror, managing patients' files for the Urology department is also heavily time-consuming for the archives department. The archives handle around 100 patients' files daily, and the Urology service is the biggest request provider. The archives staff must process the patients' records requests on one dedicated software, check for their location in another software, get each file in the archives rooms, put and sort in the trolley, and perform a daily shuttle delivery. For the staff, the operation takes the entire morning. The HArch has identified the potential relief from replacing patients' records movements through digitization from the project's onset, especially as other specialized departments work well with far fewer record requests. Another issue comes from the patients' files tending to stay in the Urology department secretary's office long before returning.

From the perspective of the HDUro, one of the main motivations for engaging in the digitization project lies in his search for a better organization for recovering reasonable typing delay. According to his estimates, agreed by the secretaries, a clinical letter might take ninety days to reach its recipient. This considerable delay in typing put the department far out of the legal delay of 7 days for clinical letters to the GP or other hospital services. Thus, the primary expectation from the digitization project is to reduce the time spent ordering and organizing complete patient records in the secretarial office to save time for other jobs.

The HDUro and the HMInfo are expected to improve the organization and save time by digitizing at least part of the patient's files. They hope searching from digital files will be easier and faster than accessing paper records through the multiple mediations of human work.

Digitizing in Compliance with Legislation

The digitization project was initiated to reduce paper circulation between the Urology and Archival departments. However, this project will also affect the work practice of medical document management in both departments, highlighting some challenges related to conforming to the legislation.

For the Archival department, the digital version of the health records must meet certain conditions to have "probative value" in the event of legal disputes as well as set clear delays for elimination.

Moreover, in such digitization projects, the hospital must secure approval from DepArch to transition from paper to digital records, which also involves destroying paper documents post-digitization.

The digitization process should provide the Archival department with information such as the date of the patient's last hospital visit, which is crucial to destroying the medical records, whether in paper or digital form, according to the law.

Hospital A adheres to a specific regulatory framework for retaining medical records. The standard retention period for these records is 20 years following the patient's last visit (with several exceptions). The hospital faces challenges in meeting these retention deadlines, often due to insufficient information and issues with regulatory compliance.

> "Generally speaking, currently, we lack the information needed to apply deadlines and are not compliant with regulations, so we overkeep the documents for safety." Field note based on HArch comments.

The HDUro put forward concerns about delays in document processing exceeding legal limits due to the overload of the secretaries. For the Urology department, the digitization project is one way to free the secretaries and thus make them able to type and send clinical letters within the legal delay.

This project highlights the interdepartmental dynamics and challenges between the Archival and Urology departments. These challenges stem mainly from differing perspectives on document management and digitization. For instance, a proposal from the Urology department suggested that as the digitization project is not taking off soon, the secretaries scan the medical documents by date and put them in boxes. Then, the Archival department employees should classify these documents in patients' records. However, this was declined by the HArch primarily due to confidentiality concerns.

Gaining Access and Sovereignty on Hospital Health Records

Hospital A encounters several challenges in data management and archiving systems. HMInfo has explained difficulties with the existing electronic health records software, particularly concerning data ownership and compliance with the General Data Protection Regulation (GDPR).

> "With our electronic health records software, we don't own our data and must pay to get it back. The publisher refuses to delete the data [according to the legal duration], which also poses a problem regarding the GDPR." Field note based on HMInfo comments.

The hospital is actively exploring neutral archiving options for EHR to address these issues. These alternatives enhance data control and facilitate better integration with other information systems.

> "Neutral archiving gives us total control over our data, independence from publishers, and automated connection with other information systems." Field note based on HMInfo comments.

Hospital A efforts to transition to a "paperless" environment are ongoing, although various regulatory limitations impede them. Developing digital archives that meet the legal requirements is highly complex.

An exploration of electronic signature systems is underway. However, these systems have yet to align with existing regulations fully, indicating a need for further development to ensure compliance. When discussing the implementation of electronic signatures at Hospital A, the HArch mentioned being aware of a system purportedly functioning as an electronic signature in some of the hospital departments. However, upon closer examination, this system did not align with the expectations set by eIDAS regulation. This discrepancy highlights a significant gap between the operational reality within the hospital's departments and the stringent standards required by eIDAS for digital archival, underscoring the challenges in achieving regulatory compliance in digital authentication processes.

The quest for an archiving solution at the hospital reflects the intricate challenge of finding a system that meets the hospital's specific needs and rigorously adheres to regulatory standards. For instance, one EDRMS system vendor presented its software to the project team; the solution revealed significant discrepancies upon closer inspection of the French digital archiving norms (NF Z42-013 of 2020 on digital archival systems and NF Z42-026 of 2023 on document digitization). Initially, though marketed as an EDRMS system, the vendor's software bore more resemblance to a legacy document management system. Key issues included the tracing of operations and the protection of stored data and documents. In the case of Hospital B, the involvement in refining an off-the-shelf brought it up to standard after several years of adjustments. These adjustments included the implementation of server stamps, log caches, chain-of-evidence, and specific storage features. This case underscores the complexity of deploying a digital archiving solution that aligns with legal requirements while also fitting the unique operational context of a hospital.

Discussion

In what follows, we discuss the status of the digitization project and characterize the cooperation between the actors we have followed, in particular, the role of policies in the progress of the project and possible learning for supporting such a digital transformation project.

The Current Statu Quo of the Digitization Project

The archives and the Urology secretariat share the need to save time and space when dealing with patients' records. However, the legal concerns are quite different for each stakeholder. The Urology department aims to meet the minimal legal requirements. Their concerns are, for example, medical responsibility, the accessibility of medical information, and their transmission between health professionals. Meanwhile, the HArch tends to support relatively complete conformity with legislation to guarantee the probative value of the hospital's records. Improvement of the hospital's control over its data brings together the HArch, the HMInfo, and the ITD. However, their main interests differ slightly, as the HArch focuses more on assuring the probative value. In contrast, the HMInfo and the ITD mostly search for interoperability and improve access and sovereignty on the hospital data.

All these topics are highly intertwined; the approach of each stakeholder depends on their perspective on the patient's records. This overview highlights that although each stakeholder's objectives are generally aligned, they are not entirely convergent. As the issues are all related to the hospital's records, the HArch remains crucial in the digitization project. Her expertise and professional relationships are essential in meeting the legal requirements of public records management. HArch is recognized as such and is therefore consulted to verify the validity of the different proposals.

During the study, several tasks were conducted to prepare the digitization project. The HArch initiated writing sections dedicated to the digital records in the archiving policy and the project file, which will be presented to the management. She also organized the first discussions with the DepArch. Furthermore, the chief of the secretaries and the HArch exchanged upon secretaries' practices to create the first naming convention, which specify the naming of the future digitized files.

However, the stakeholders involved do not have enough information about the hospital's IT systems and the capabilities of its current software to complete these tasks. As the project also requires new software able to manage digital records, precise budgetary information and software expertise are needed to pursue it.

Finally, the aim to align the hospital with digital archives and health records policies is still valid. The project is not discarded but suspended until better conditions allow access to the missing information, support, and resources.

Tying Knots and the Role of Policies

In our study, a space and time constraint within the Urology department initiated a project, unfolding complexities in aligning with regulations and necessitating diverse expertise from different stakeholders. Our case study exemplifies the intricacies Jackson et al. (2014) described in the “policy knot” concept, a framework illustrating the entwined nature of design, practice, and policy.

On the side of the relations between policies and technology, we observe how digital archives and health records policies challenge the identification of a software component that matches the requirements at Hospital A. We even see the embedded generativity of policies (Centivany, 2016) at play in the digitization project of Hospital B, where the chosen system has been changed several times to fit the policies and hospital practices.

On the side of the relations between policies and practices, we identify influences at two levels. On the one hand, the requirements of conformity to digital archives and health records policies led the HDUro to escape the complexity of digitization by choosing a new organization for the Urology secretariat work. On the other hand, the digital archives and health records policies are clearly not offering an adaptable and robust scheme of shared categories, a boundary object (Star & Griesemer, 1989), for supporting the cooperation between the involved stakeholders. While we have seen the authority and legitimacy of these policies are not challenged, only HArch and DepArch understand their content. We observe that digital archives and health records policies are rather providing HArch with a roadmap and a set of suggested boundary objects that she has to build and negotiate case by case to secure the alignment of each stakeholder. We identify instances of this work in the project file for cooperation and agreement with the hospital management and DepArch, or in the naming convention for digital records negotiated with MSec.

In our case, the project’s advancement resembles what Engeström and colleagues (1999) call “knotworking”, a dynamic collaboration process transcending conventional boundaries. It involves forming adaptable “knots” of professionals and clients focused on a shared goal, capable of evolving with the project’s needs (Abou Amsha et al., 2021). The global meeting with the urology service gives a good illustration of this knotworking. Due to the presence of health professionals, discussions revolved around concrete medical practices and specific legal constraints such as delays for sending clinical letters. The HArch and the

HMInfo were also present, and were able to guide the choice of the new secretarial process based on its compliance with legal requirements for medical document and data (practices and policy). For example one proposition of the HDUro implied to destroy biological exams results when they can not be used for medical decision anymore but was rejected after the HArch pointed out that they were proof to support medical decisions and so needed to be preserved in patient's files. However, the IT departement was not represented, so topics such as the capabilities of the hospital's software were not discussed further

Our study reflects the continuous adaptation and compromise made by the actors. This approach underscores the project's continuity over the individual participants, allowing for changing involvement as the project progresses. While occasionally paused, the project is ongoing, driven by persistent challenges or evolving regulations. Our study highlights the importance of supporting this continuous process of collaboration, underscoring the dynamic nature of policy implementation and technological adaptation.

Learnings for digital transformation project

The statu quo of the project at the end of our study highlights different practical concerns related to healthcare records policies in a digital transformation project. Observing the project progress dynamic, we can hardly expect implementation and release to be an ideal one-shot go live. As lessons from the field this highlights three important learnings for digital transformation projects in policy-dense environments.

Achieve stepwise project through artefacts: Implementing a digital archives project at a hospital is complex. We have highlighted how policies suggest a roadmap and boundary objects for progressing along knotworking episodes. As illustrated by HArch's work on the hospital archiving policy that is still in the draft stage, she is aware of and expert in dealing with such a dynamic. HArch knows that digital archives projects are a long run. While the project may be paused, she is taking benefit of the progress made at one step to anticipate progress for the next. Here the production of documents and artefacts that can act as boundary objects with part of the stakeholders is especially useful to keep track of the project progress and capitalize advance despite recurrent restart.

Aim at progressive compliance of digital records: Given the importance of the requirements for the digitization of patients' records (i.e., file naming, storage, changes log, signature, and authorization structure), it is hardly expected that digital documents can meet the expectations in one time within such a lively organization as a hospital. A wise option lies probably in progressively increasing the compliance of the records with the policies at each step in the long run of the project (Tosi & Bénel, 2016; Zacklad, 2006). For instance, defining and releasing a naming convention for digitized documents is a passage point in the direction of compliance with digital and health records policies. Such a strategy can mitigate the issue of restarting the digitization from scratch.

Do not neglect relation work: The relation work (Bjørn & Christensen, 2011) involved in tying knots and advancing such complex project appear of special importance. For instance, completing the project file has involved a lot of work from HArch to gather information and get support from different stakeholders. In our situation, HArch knew paper archiving practices and their legal requirements but needed to contact different resource people regarding MSec practices, the hospital's IT architecture, or the departmental archives. Meeting these different stakeholders is essential so that they agree to concur to the project progress.

Conclusion

Our qualitative study highlighted the role policies play in ongoing digital transformation projects. Our analysis highlights the different perspectives of the involved actors concerning compliance with patients' digital records policies and the challenge for their cooperation in the project.

We hope to continue and follow up the hospital digital archiving project for patient records in the coming years and further our analysis of the next steps in tying knots between policies, technology, and practices.

Acknowledgments

We are grateful to the General Hospital of Troyes (CHT), the Medical information department and the Archive department for our exchanges and discussions, as well as the Urology department for welcoming our study. This research has been supported by ISTT (Institut Santé et Technologies de Troyes).

References

Abou Amsha, K., Bossen, C., Grönvall, E., & Lewkowicz, M. (2021): 'Computer-Supported Knotworking: Design Guidelines Based on Two Case Studies from the Healthcare Domain in Europe', *Proceedings of the ACM on Human-Computer Interaction*, vol. 5, no. 1, April 2021, pp. 1-26. https://doi.org/10.1145/3449199

AFNOR (2023): *NF Z42-026: Définition et spécifications des prestations de numérisation fidèle de documents sur support papier et contrôle de ces prestations.*

AFNOR (2020): *NF Z42-013: Archivage électronique - Recommandations et exigences.*

Almeida, M. B., Slaughter, L., & Brochhausen, M. (2012): 'Towards an ontology of document acts: Introducing a document act template for healthcare', *On the Move to Meaningful, Internet Systems : OTM 2012 Workshops*, vol. 7567, 2012, pp. 420-425. https://doi.org/10.1007/978-3-642-33618-8_57

Article 1366 du Code civil (France). https://www.legifrance.gouv.fr/codes/article_lc/LEGIARTI000032042461/2016-10-01/

Article L. 211-1 du Code du patrimoine (France). https://www.legifrance.gouv.fr/codes/article_lc/LEGIARTI000032860025/2016-07-09

Article R. 1112-7 du Code de la santé publique (France). https://www.legifrance.gouv.fr/codes/article_lc/LEGIARTI000036658351/2021-11-09

Bardram, J. E., & Bossen, C. (2005): 'A web of coordinative artifacts: collaborative work at a hospital ward', *Proceedings of the 2005 ACM International Conference on Supporting Group Work*, November 2005, pp. 168-176. https://doi.org/10.1145/1099203.1099235

Bjørn, P., & Christensen, L. R. (2011): 'Relation work: Creating socio-technical connections in global engineering', *ECSCW 2011: Proceedings of the 12th European Conference on Computer Supported Cooperative Work*, September 2011, pp. 24-28. https://doi.org/10.1007/978-0-85729-913-0_8

Cabitza, F., Simone, C., & Sarini, M. (2009): 'Leveraging coordinative conventions to promote collaboration awareness: The case of clinical records', *Computer Supported Cooperative Work (CSCW)*, vol. 18, August 2009, pp. 301-330. https://doi.org/10.1007/s10606-009-9093-z

Centivany, A. (2016): 'Policy as Embedded Generativity: A Case Study of the Emergence and Evolution of HathiTrust', *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing*, February 2016, pp. 926-940. https://doi.org/10.1145/2818048.2820069

Cormi, C., Abou Amsha, K., Tixier, M., & Lewkowicz, M. (2020): 'How the local domestication of a teleconsultation solution is influenced by the adoption of a national policy?', *Proceedings of the 18th European Conference on Computer-Supported Cooperative Work*, 2020. https://doi.org/10.18420/ecscw2020_ep06

Cornu, M. (2016): 'Rapport introductif : Quelles spécificités des archives hospitalières ?', in S. Monnier & K. Fiorentino (eds.): *Les archives hospitalières regards croisés*, L'Harmattan, Paris.

Décret n° 2016-995 du 20 juillet 2016 relatif aux lettres de liaison (JORF 22 July 2016) (France). https://www.legifrance.gouv.fr/jorf/article_jo/JORFARTI000032922486

Ellingsen, G., & Røed, K. (2010): 'The role of integration in health-based information infrastructures', *Computer Supported Cooperative Work (CSCW)*, vol. 19, December 2010, pp. 557-584. https://doi.org/10.1007/s10606-010-9122-y

Engeström Y., Engeström R., & Vähäüho T. (1999): 'When the center does not hold: The importance of knotworking', in S. Chaiklin, M. Hedegaard & U. J. Jensen (eds.): *Activity theory and social practice*, Aarhus University Press, pp. 345-374.

Fitzpatrick, G., & Ellingsen, G. (2013): 'A Review of 25 Years of CSCW Research in Healthcare: Contributions, Challenges and Future Agendas', *Computer Supported Cooperative Work*, vol. 22, June 2012, pp. 609-665. https://doi.org/10.1007/s10606-012-9168-0

Jackson, S. J., Gillespie, T., & Payette, S. (2014): 'The Policy Knot: Re-integrating Policy, Practice and Design in Cscw Studies of Social Computing', *Proceedings of the 17th ACM Conference on Computer Supported Cooperative Work & Social Computing*, February 2014, pp. 588. https://doi.org/10.1145/2531602.2531674

Lejeune, C. (2019): Manuel d'analyse qualitative : analyser sans compter ni classer, De Boeck Supérieur, Louvain-la-Neuve.

Lejeune, C. (2010): 'Cassandre, un outil pour construire, confronter et expliciter les interprétations', *Actes du 2ème colloque international francophone sur les méthodes qualitatives*, 2010, pp. 1-14. https://hdl.handle.net/2268/25352

Leroy, A., Schoenzetter-Laute, J., & Riou, C. (2017): 'Procédure d'élimination des dossiers médicaux', *Journal de gestion et d'économie médicales*, vol. 35, 2017/1, pp. 32-42. https://doi.org/10.3917/jgem.171.0032

Loi n° 2000-230 du 13 mars 2000 portant adaptation du droit de la preuve aux technologies de l'information et relative à la signature électronique (2000, 13 March) (France). https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000000399095.

Lovis, C., Baud, R. H., & Planche, P. (2000): 'Power of expression in the electronic patient record: structured data or narrative text?', *International Journal of Medical Informatics, vol.* 58-59, September 2000, pp. 101-110. https://doi.org/10.1016/S1386-5056(00)00079-4

Marref, R., Abou Amsha, K., & Lewkowicz, M. (2022): 'Practice-Centered Approach to Design Cooperative Healthcare Information Systems: Data, Architectural and Organizational Challenges', *COMPUTING AND INFORMATICS*, vol. 41, no. 1, April 2022, pp. 191-212. https://doi.org/10.31577/cai_2022_1_191

Mønsted, T., Reddy, M. C., & Bansler, J. P. (2011): 'The use of narratives in medical work: A field study of physician-patient consultations', *ECSCW 2011: Proceedings of the 12th European Conference on Computer Supported Cooperative Work*, 24-28 September 2011, pp. 81-100. https://doi.org/10.1007/978-0-85729-913-0_5

Munkvold, G., Ellingsen, G., & Monteiro, E. (2007): 'From plans to planning: the case of nursing plans', *Proceedings of the 2007 ACM International Conference on Supporting Group Work*, November 2007, pp. 21-30. https://doi.org/10.1145/1316624.1316628

PUBLIC LAW 106–229 of 20 June 2000, Electronic Signatures in Global and National Commerce Act (WCPD 20 June 2000) (United States). https://www.govinfo.gov/content/pkg/PLAW-106publ229/pdf/PLAW-106publ229.pdf

REGULATION (EU) No 910/2014 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 July 2014 on electronic identification and trust services for electronic transactions in the internal market and repealing Directive 1999/93/EC (OJEU 23 July 2014) (European Union). https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0910

Sommerville, I. (2009): Requirement Engineering. *Software Engineering* (9th edition), Pearson Education, London.

Star, S. L., & Griesemer, J. R. (1989): 'Institutional ecology, 'translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39', *Social studies of science*, vol. 19(3), pp. 387-420. https://doi.org/10.1177/030631289019003001

Strauss, A., & Corbin, J. (1990): *Basics of qualitative research: Grounded theory procedures and techniques*, Sage Publications, Thousand Oaks.

Sultanum, N., Brudno, M., Wigdor, D., & Chevalier, F. (2018): 'More Text Please! Understanding and Supporting the Use of Visualization for Clinical Text Overview', *CHI '18: Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, April 2018, pp. 1-13. https://doi.org/10.1145/3173574.3173996

Symon, G., Long, K., & Ellis, J. (1996): ‘The coordination of work activities: cooperation and conflict in a hospital context’, *Computer Supported Cooperative Work (CSCW)*, vol. 5, March 1996, pp. 1-31. https://doi.org/10.1007/BF00141934

Tosi, L., & Bénel, A. (2016): ‘L'authenticité à l'épreuve du numérique - Le cas des cahiers de laboratoire’, *19ème Colloque International sur le Document Électronique*, November 2016. https://utt.hal.science/hal-02954835

Wack, M., Cottin, N., Mignot, B. & ElMoudni, A. (2002): ‘Certification et archivage légal de dossiers numériques’, *Document numérique*, vol. 6, 2002/1-2, pp. 145-158. https://doi.org/10.3166/dn.6.1-2.145-158

Winthereik, B. R., & Vikkelsø, S. (2005): ‘ICT and Integrated Care: Some Dilemmas of Standardising Inter-Organisational Communication’, *Computer Supported Cooperative Work (CSCW),* vol. 14 (1), February 2005, pp. 43-67. https://doi.org/10.1007/s10606-004-6442-9

Zacklad, M. (2006): ‘Documentarisation processes in Documents for Action (DofA): the status of annotations and associated cooperation technologies’, *Computer Supported Cooperative Work (CSCW)*, vol. 15 (2-3), June 2006, pp. 205-228. https://doi.org/10.1007/s10606-006-9019-y

Vlachokyriakos, Vasilis, Johnson, Ian, Anderson, Robert, Claisse, Caroline, Zhang, Viana, Briggs, Pamela (2024): Design Implications for a Social and Collaborative Understanding of online Information Assessment Practices, Challenges and Heuristics. In: Proceedings of the 22nd European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies – Notes, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591), DOI: 10.48340/ecscw2024_n04

Design Implications for a Social and Collaborative Understanding of online Information Assessment Practices, Challenges and Heuristics

Vasilis Vlachokyriakos[1], Ian G. Johnson[1], Robert Anderson[1], Caroline Claisse[1], Viana Zhang[1], Pamela Briggs[2]
[1]Newcastle University, [2]Northumbria University
[1]{vasilis.vlachokyriakos1, ian.johnson2, rob.anderson, caroline.claisse, n.zhang10}@ncl.ac.uk, [2]p.briggs@northumbria.ac.uk

Abstract. The broader adoption of social media platforms (e.g., TikTok), combined with recent developments in Generative AI (GAI) technologies has had a transformative effect on many peoples' ability to confidently assess the veracity and meaning of information online. In this paper, building on recent related work that surfaced the social ways that young people evaluate information online, we explore the decision-making practices, challenges and heuristics involved in young adults' assessments of information online. To do so, we designed and conducted a novel digital diary study, followed by data-informed interviews with young adults. Our findings uncover the information practices of young adults including the social and emotional motivations for ignoring, avoiding, and engaging with online information and the ways this is entangled with collaborative arrangements with algorithms as agents. In our discussion we bring these findings in close dialogue with work on information sensibility and contribute rich insights into young peoples' information sensibility practices embedded within social worlds. Finally, we surface how such practices are attuned to prioritise wellbeing over convenience or other commonly associated sufficing heuristics.

Introduction

Recent significant global events, such as pandemics, wars, and climate catastrophes, paired with developments in Large Language Models (LLMs) and Generative AI (GAI) have created a confused and uncertain information landscape (Ehrlén et al., 2023; Flintham et al., 2018), leaving people being increasingly susceptible to online misinformation and disinformation (Scherer & Pennycook, 2020) and other online harms (Mannell & Meese, 2022). Rising social media use, especially by young people (de Groot et al., 2023; Juvalta et al., 2023), is changing the information ecosystem with media organisations increasingly prioritising social media for news dissemination (Juvalta et al., 2023) and adopting their content and 'news values' to increase attention and 'reach' (Mast & Temmerman, 2021; Valaskivi, 2022). In this context, the lines between news and information are blurred, and researchers have developed an understanding of information seeking and assessment as relational (Borgatti & Cross, 2003) and information search as 'social' (Evans & Chi, 2008; Oeldorf-Hirsch et al., 2014).

In this paper, we build on such work by inquiring into how young adults evaluate socially encountered information. To do so, we designed an online diary study, which we conducted with young adults (age 18-35), followed by a set of data-informed interviews. We specifically targeted young adults because of known challenges in misinformation within this demographic (Pérez-Escoda et al., 2021; Qayyum et al., 2010), while also our project collaborator (the BBC), indicated that their audience demographic data point to this age group as being the one with the least engagement with media produced by their organisation across platforms. Extending recent work on 'information sensibility' (Hassoun et al., 2023) that emphasised the social ways information is sought and interpreted by young people, our findings expand insights into the decision-making practices, challenges and heuristics involved in making assessments of information online. Finally, we surface how such practices and heuristics are used to prioritise people's wellbeing, as opposed to simply being 'convenient' and 'good enough' information assessment practices (Connaway et al., 2011; Flintham et al., 2018; Hassoun et al., 2023; Metzger & Flanagin, 2013). Such insights contribute implications for designing social platforms and information ecosystems that account for such social and collaborative assessments of information online; more specifically in collaborative arrangements with algorithms and for preserving young people's wellbeing in engagements with information online.

Background: Online Information Assessment and Sensibility

The rise and promulgation of misinformation and associated social, political, and personal risks (Das & Ahmed, 2021; Fernandez & Alani, 2018; Ruokolainen et al., 2023; Vaccari & Chadwick, 2020) has brought urgency to the challenge of understanding how people assess information online. Research on information evaluation has traditionally looked to support people to make 'better' evaluations through the design of technical interventions (Bauer et al., 2013; Flintham et al., 2018; Yang et al., 2019), focused on the online detection of misinformation (Monti et al., 2019; Shu et al., 2019; Yang et al., 2019) and relatedly, research has focused on user interface design to guide or warn 'users' of misleading information (Bauer et al., 2013; Sharevski et al., 2021) and evaluated the usefulness of online credibility indicators (Clayton et al., 2020; Metzger & Flanagin, 2013; Zhang et al., 2018) including the effect they have on information evaluation and assessment (Menon et al., 2020). However, this work, alongside other interventions, such as those that focus on information and digital literacies (Carmi et al., 2020; Jang & Kim, 2018; Wolff et al., 2016), while being attentive to what should be done to identify 'accurate' and detect 'false' information, pay little attention to complex social and contextual factors that motivate information engagement (Herrero-Diz et al., 2020; Talwar et al., 2019).

In contrast, other work in Human Computer Interaction (HCI) and Computer-Supported Cooperative Work (CSCW) has focused on identifying the factors that contribute to people's information encounters, while also developing a better understanding of how people evaluate such encountered information. Indicatively, work in this space (Connaway et al., 2011; Geeng et al., 2020) has surfaced 'convenience' as a central factor to such information encounters, while also describing the 'good enough' reasoning tactics people employ in information assessments online. Building on this work, more recent research that focused on young people between 13-24 years (Gen Z), has underlined the social practices that influence news consumption, positing such practices as *information sensibility* (Hassoun et al., 2023). Motivated by such insights, in this paper we argue that more research is needed to investigate how young people make socially informed decisions about information they engage with online. As such, we designed and conducted a study to explore the social and relational ways young adults assess information online, and contribute additional insights on young adults' information assessment practices where news is socially encountered (Edgerly, 2017; Koh et al., 2015; Strauß et al., 2021).

Study Design and Methods

Recruitment

The study described in this paper is part of a bigger collaborative project with the British Broadcasting Corporation (BBC). Their audience segmentation data identified young adults (18-35) in the Northeast of England as the group with the lowest engagement with media and content produced across their platforms. We recruited participants for the study through university channels and local collaborators, resulting in 150 people applying to take part in the study by filling out a questionnaire indicating their age, education level, and postcode. We selected 19 people out of this pool of participants by using as selection criteria, the age of the applicants and their postcode – as we wanted to ensure that we covered the demographic criteria of our collaborator. Of the 19 participants (11 women and 8 men) that were selected, only 14 (11 women, 3 men, aged between 21 and 34) took part in both phases of the study (diary and interview). We compensated participants £100 on completion of the study (£50 for taking part in the diary phase and a further £50 for taking part in the interview).

Digital diary

Informed by similar studies in HCI and CSCW (Palen & Salzman, 2002; Saltz et al., 2021) we designed a web-based digital diary that allowed us to capture participants' encounters with information, while also prompting them to reflect on the context where they encounter information, the social processes involved in selecting and assessing information, and its effects. During a two-week diary period, we instructed participants to fill their diaries with information they encounter by sharing news articles, social media posts, blogs, and any other links as they read them. We provided an email address and a phone number that participants could use to share URLs, either by emailing them to us or by sending them through SMS. For any URL participants shared with us, the web-based platform opened a form including a set of questions that could be responded to through text entry, multiple choice, sliders, and added emojis, respectively (see Figure 1). We configured the questions and modes of response to be quick and easy to respond to with the aim of eliciting a mixture of objective (*Where were you? What did you do next?*) and subjective responses (*How much do you trust it? How did it make you feel?*) around the context and the social ways that information was encountered and assessed.

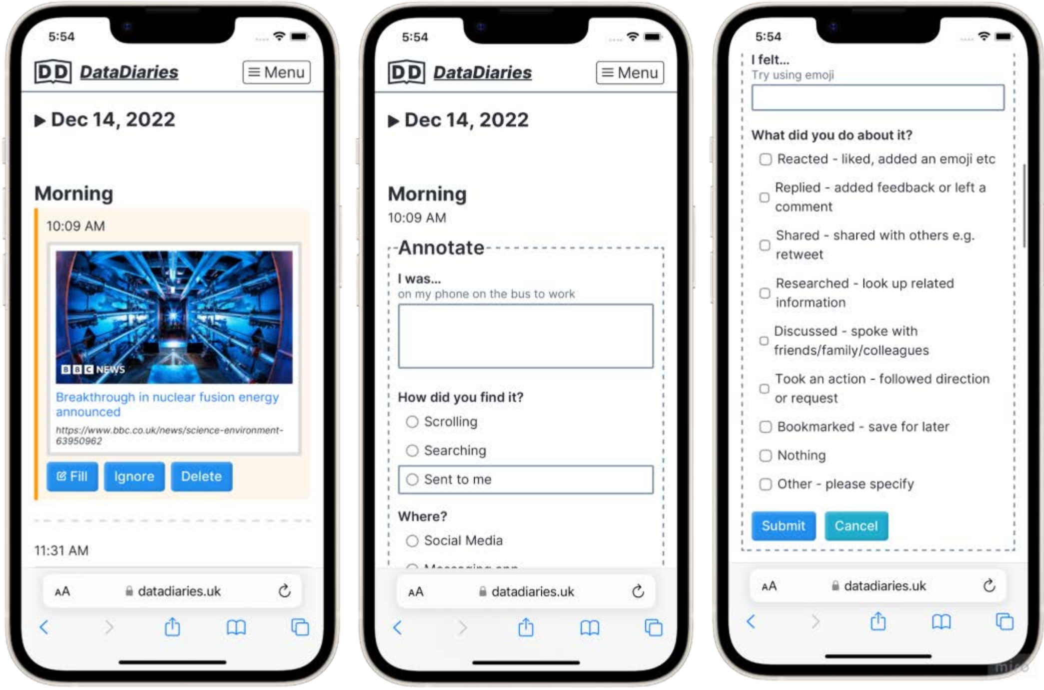


Figure 1. The online diary platform showing diary entry and annotation pages.

Data books and interviews

The data collected through the diary were not considered as primary research data, but rather as a process to sensitise participants to some of the themes of the study, encourage self-reflection in our participants, and used to create personalised Data Books to support participant interviews. The Data Books were inspired by previous design-led methods in HCI, which foster experimental engagement with personal data (Elsden, Chatting, et al., 2017; Ståhl et al., 2009). More specifically, we drew from work on designing documentary informatics (Elsden, Durrant, et al., 2017) that explores documentary uses of quantified data to support reminiscing and sense making about oneself. As such the Data Books we created, were used in conjunction with the interviews as a boundary object or ‘tickets for talk’ (Elsden et al., 2016).

The Data Books represented information collected for each participant during the diary phase, showing in graphic form the times of day participants shared their links with us through the platform, other factual data such as the source of stories (from the URL), information provided through the annotation task, such as whether the information came from a messaging app, social media, etc., the context (see Figure 1, centre) and what they did after (i.e., react, share, discuss, nothing – see Figure 1, right). The Data Books also contained ‘inferences’ about participants based on the titles and metadata as well as other details they provided through their digital diary. We used a Large Language Model (LLM) to generate such inferences and presented this with graphic representations in the Data Books (see Figure 2). For instance, the books contained visual profiles about participants based on the data they submitted in the diary phase: a speculative summary of their interests and values (i.e., ‘Awareness of humanitarian issues’, ‘Pop culture interest’) was visually represented on the fold out centre page of the Data Books (see Figure 2, right). On the last page was also featured a short poem about the participant generated by the LLM based on the other inferences and reported data from the digital diaries. As well as making the Data Books fun and engaging—we took care to create something aesthetically pleasing and presented it as a gift to the participants ahead of the interview—by using the LLM inferences and poems, we intended them to be provocative by embedding questions about privacy, algorithmic logic, and personalization.

Figure 2. Photographs of examples of the Data Books given to participants and used in interviews.

Questions during the interview prompted participants to look at specific pages or graphic representations to offer explanation or provide more context on their information assessment practices. By using the AI generated inferences (e.g., generated poem, inferences about interests etc.) together with visualisations of participants reported data, we aimed to introduce a level of ambiguity in the design of the books as a resource for interpretation and speculation (Gaver et al., 2003) to promote participants’ self-reflection. More specifically, the interviews (11 in person, 3 online) were structured around three themes: the first set of questions focused on the habits and behaviours drawing on what the diary process had captured; a second set of questions enquired into trust and perceptions of information veracity (also drawing on what was included in the Data Book); and a third and final group of questions focused on participants’ perceptions and expectations of online news, the internet, and social media platforms.

Research data and analysis

Over a two-week period, 14 participants shared 920 links in total (range 16 - 371) from an array of sources including social media, newsletters, messaging services and online news websites and apps. The interviews lasted on average 67 minutes (range 48 – 82 mins) and were audio recorded and later transcribed. All participants signed a consent form for data collection for both diary study and interviews and the project received ethical approval by following our university's and our funding body's ethics procedures.

The first two authors of this paper conducted an inductive thematic analysis (Braun & Clarke, 2006, 2020) on the transcribed interviews. The analysis process involved a period of familiarisation with the dataset, which involved both researchers immersing themselves in the interview data, discussing, reflecting on, and making notes and creating memos about data items and the dataset. This was followed by a process of descriptive coding and the generation of initial 'candidate' themes for review and development. What followed was an iterative process of developing and refining themes before the final analytical process of writing up the analysis, as follows. All participant names are pseudonyms.

Findings

Information Sensibility practices

In this theme, we report on the practices that our participants referred to as ways to assess information online. More specifically we report on information validation tactics such as 'sufficing' behaviours (e.g., Simon, 1990), crowdsourcing credibility and using search engines to cross-reference news, as well as the impact of familiarity and alignment with personal worldviews in accepting the veracity of online information. However, we found that this learned behaviour needs to be re-learned and adapted in life transitions that exposed our participants to new sources and types of information.

The people in our study reported spending more time investigating and challenging what they read only if they considered it 'serious' enough, or if it did not fit with their current held worldview. For example, despite reading celebrity news for fun and entertainment, after reading unpleasant rumours about a TV personality that she liked, Hannah engaged in more rigorous research: *"I then spent the time watching more reports and videos about where people were getting their source from, because I was like, Oh, he seems like quite a nice guy."* (Hannah)

Validation tactics included 'sufficing' behaviours (e.g., Simon, 1990), and crowdsourcing (e.g., Evans et al., 2010). For example, Florence relied on the judgements of others, despite not knowing them: *"Maybe if it was something really serious, I would even look at the comments, if anyone's commented on it being a real thing."*. In addition, participants adopted a range of other 'good enough' tactics that relied on how the information 'felt' or 'seemed' – searching for other information on Google or adopting other forms of cross referencing: *"I* *think I would put in quite a general term [on a search engine]. Maybe if what I was looking for didn't come up immediately, I would say, "I'm not that bothered." Then I wouldn't search for it further."* (Lynne)

Validation processes often reflected the extent to which the information was personally relatable: *"I'd be likely to read it and sort of make my judgement from the way that it's written, I think. It would still come down to the article, how it's written, how much opinion I feel is in there."* (Hannah). Familiarity was also important. Corina for example, talks about checking for a familiar (what they consider mainstream) source to validate something seen from a less familiar source on social media: *"If I haven't seen anything in the mainstream media but see something mentioned on Twitter, that's when I think, "Oh that doesn't sound right, that doesn't match up with other things that I've read. And I guess that's kind of the way that I'm likely to check it, is to separately then go onto those other websites- or not- well, the apps, the other apps, and I see, "Oh actually, are they writing anything about it? Or is it just something new that's cropped up?"* (Corina)

People were more likely to trust information from familiar sources or that aligned with their worldview. For example, Aliza talks about how a particular news source creates suspicion based on prior experience: *"And if I look at something that isn't something that I usually go to, I trust it less. Like The Chronicle (local print and online 'newspaper'), which I do occasionally look at, but I am always, kind of, like, "Hmm. We'll see."* Julie, on the other hand shows, while beginning to reflect upon and question their own decision-making, how this familiarity heuristic also applies to the ideas or ideology: *"I don't know why I just assume it's correct. I don't know. I think it's because it's… It's probably because their politics seems to be quite similar to my own. So, because it's backing up what I believe and think, I'm like, "Oh, this must be right," which is probably a bit stupid."*

These tactics, however, must be re-learned anew during certain life transitions or when there is a cause to engage with new forms of information. For example, when becoming a new parent, Fran felt they had become less sure of using existing experiences and tactics to make decisions and judgements: *"I think, at the moment that's something that does happen to me, quite a bit, because I'm going into a new phase of my life where I'm going to be a parent, and therefore I'm more easily click-baited by stuff I like."* (Fran). Trust here is complex and reflects the trustworthiness of the news source, previous expectations around content but also confidence on one's ability to make reliable trust judgements.

Convenience as emotional wellbeing

In this theme, we touch on the reasons why young adults sometimes engage in information that they don't trust, describing the dilemma that shapes such sceptical acceptance and that points to a willingness to accept uncertainty and a loss of control as a price for convenience, enjoyment, and emotional protection from unwelcome information.

Despite showing an awareness of the downsides with social media as a source for news, participants also admitted to being reliant on them: *"I quite like it. I think there's a lot of, "How much are they listening to? How much do they know?" But like at the end of the day it makes my experience more enjoyable."* (Hannah). Most people showed an awareness of the concerns but articulated an acceptance: *"I think as I've grown up with social media being more and more used for everything. I think it makes the news quite polarised. It's quite pessimistic, you see most of the bad things. Inciting hate and wanting people to engage in things, so making them as clickbait-y and controversial as possible. I don't like that's where social media has brought news to, but that is still the place I go to for news."* (Lynne). Part of this awareness was an acceptance that there was a limit to what could be controlled. For example, Julie described a fear of becoming accidently aware of things: *"I think my friend put it best. He said, "Everything I've ever learnt about Meghan and Harry* [i.e. members of the British Royal family] *has been against my own will," which I kind of agree with. It's like, I have never sought out information on those people, but I know more about their marriage than I do about my parents' marriage."* (Julie)

However, people were prepared to accept the negative aspects because they saw value in the information. People had clear ideas about the way they wanted to interact with information: *"An app or a website, it's just set up differently, or in the way that I think of it. Where it has these top five, top ten, it's more likely to have banners relating to what everyone wants to click on rather than what I want to look at."* (Agatha) They recognised that a personalised information 'feed' better catered to their emotional needs: *"I don't think there's a particular forum, at the moment, for me in my life, or enough emotional capacity to deal with some of the bigger topics, and to be having those conversations about bigger topics, at the moment."* (Fran). Participants described feeling shielded and protected, in particular around mental wellbeing: "*I think in a way, it's really good and healthy, because I get the kind of news that I'm interested in, and that's the news that I get to read, and I don't- if there's some kind of news that I don't like to consume, which is maybe about entertainment, or news and things I don't like to think about at all. And then I don't get those recommended, which is something I prefer a lot more."* (Meera).

The algorithm as collaborative agent in assessments of information

Our findings point to how young adults saw algorithms that curate information on social media as unnerving, highly excitable, and "*getting the wrong end of the stick*". Nonetheless they perceived "*their algorithm*" as shielding them from information that they did not want to encounter, protecting their wellbeing, and as such, they tried to configure and 'collaborate' with them for their information needs.

Participants recognised that there were times when the algorithm would get it wrong: *"If I'm doing a lot of searches on food recipes, then I know that my algorithm is going to change to show me lots of other food recipes. That makes me quite happy […] The only time it gets annoying is when I've had enough of that thing, and I can't get rid of it from my algorithm."* (Hannah). They developed hypotheses about the ways in which the algorithm worked. For example, Lynne explained how she disengaged from a court case being followed on TikTok, noting the associated change in curated content: *"I think as I engaged with it less, I got shown it less because the algorithms are like, she's not interested in this video. I think people's opinions started to shift slightly as well, but it probably was because I engaged with it less. Now I'm thinking, "Why did I engage? What shifted that?" I don't know."* Despite, a feeling that one's algorithm could be understood, there were occasions when they over-stepped boundaries and came across as unnerving: *"There have definitely been times where I've noticed something and I'm like, "That is actually really creepy." I'm not massively into the idea that, like, for example, if a friend shared a link with me and then all of a sudden, I'm getting ads for something, I'm like, "That is a little bit creepy."* (Aliza)

Participants developed theories about how to 'game the algorithm': *"There are some articles that I'll see as clickbait that I just will not engage with, […] because that will impact my algorithm and then I'll get more of it. I'm like, "No, do not click that," because it can be on important topics. If it's an important topic I will not, I will not allow myself to be fully click-baited."* (Fran).

Some developed ways to engage with information without letting 'the algorithm' know about it: *"Sometimes, I'll read through the thread, because there are interesting arguments in the comments, but I wouldn't ever click on the news source. Because I don't want to give it the click and give it the validity of having gone into it and looked at the article."* (Julie)

One several occasions participants referred to behaviours designed to 'trick' their algorithm. Hannah, for example, talked about a slight of hand to bemuse her algorithm: *"Try and scroll past it as quickly as, or don't click on it. Yes, just try and not engage with it and hope that it picks up that I've had enough. Which it normally does."* Such ideas of obfuscating behaviours point to a concern about an ever-watching presence of one's algorithm, which must be trained, tamed, and even tricked to assert agency over the configuration of online spaces.

Ultimately, however, participants were prepared to forgive 'their' algorithm because of what they felt it offered them in terms of convenience, protection or shielding from things they did not want to encounter (i.e., a way to select information), as well as finding comfort and familiarity.

Discussion: Expanding Information Sensibility

Challenges: Misrepresentation, Lack of Algorithmic Control, and Harnessing Social Relations

Our participants were aware that their reliance on ‘the algorithm’ to socially curate information was not ideal. Most were resigned to the fact that they would be presented with unreliable or irrelevant information but could adopt information checking or validating tactics when they felt it was important. They expressed frustration with the algorithm when it seemed their feed didn’t ‘speak to them’. This occurred when information had the wrong tone or failed to reflect their interests. Our participants talked about being *misrepresented* if an issue came from an unfamiliar source, adopted an unusual perspective, or was politically unpalatable. However, participants recognised the dangers of a ‘filtered universe’ (de Groot et al., 2023) and understood *the need for a more holistic understanding of events and reality.*

Participants generally seemed to view ‘*their*’ algorithms as over-excited, with a tendency to overreach, but nonetheless they felt ownership towards them. Our participants developed folk theories (Eslami et al., 2016; Medin & Atran, 1999; Toff & Nielsen, 2018) about how to train their algorithm. Tactics included scrolling quickly past ‘irrelevant’ news and engaging more meaningfully with information that reinforced their worldview. Sometimes the algorithm was seen as too effective, leading to participants feeling uncomfortable and ‘creeped out’. In general, our findings point to the *need for more visibility in terms of how algorithmic curation works, and more explicit controls for algorithmic configuration.*

Regarding Hassoun et al.'s (2023) findings on the fear of making social errors, particularly in terms of sharing inaccurate or unpopular information and facing the social consequences of being wrong online, our participants showed less concern about being incorrect. Instead, their primary focus was on how news could *contribute to nurturing existing relationships*, both online and offline. For example, people talked about reading news in-depth to have meaningful conversations with family and friends, while others shared URLs with people to read and discuss together at home. In general, such insights point to very *practical ways that information systems can be designed to support more meaningful social relations.*

Practices: Social, Collaborative, and Algorithmic Sense-Making

Young people adopt a range of practices to overcome their information challenges. For example, Hassoun et al (2023) report on how people seem to privilege lived experience, finding a trusted person as a go-to source, crowdsourcing information credibility, and practicing good enough reasoning. Our findings build on this work, showing how young people's informational practices are informed by a system of values and politics that in many cases are conflicting and are changing.

Our participants recognised that they needed to assess key information for its veracity. For example, our participants talked about doing their own research by searching for keywords of news (e.g., on Google) and checking what news sources are reporting on such news and how – a form of *surrogate thinking* (Toff & Nielsen, 2018). Young adults also talked about reading comments of news posted on social media and having discussions on instant messaging platforms and in-person as a form of *crowdsourcing credibility* (Ellison et al., 2013; Evans et al., 2010). In relation to crowdsourcing credibility, our findings also surface how practices such as reading comments were used as a way of avoiding clicking on news that might train the algorithm inappropriately. As such our data complements related work in this space by further complicating how such practices are shaped by not only informational needs but also the need to configure and 'train' the algorithm to 'behave appropriately'. In alignment with research into users' understandings of and relationship with algorithmic curation (Eslami et al., 2016; Karakayali et al., 2018), we suggest framing this phenomenon as the *algorithm as collaborator* in online information assessment. Such a framing helps us conceptualise the algorithm as an agent in information practices within complex social networks of information evaluation and sharing, while acknowledging that people must learn to collaborate well with their algorithm to better support their role in social networks as well as protect their own wellbeing. Our role as designers should be to make it easier for people to enact such collaborative encounters with curatorial algorithms, by enabling more meaningful bidirectional interaction and communication, though, for example, integrating intelligent agents in more explicitly (rather than through implicit inferences) stipulating how the algorithm learns.

Across our themes we see how these information processing practices are forms of 'sufficing' – *good enough reasoning* tactics used dependent on the context (e.g., news app or social media) and type of information that needs to be assessed. A novel dimension to such *sufficing tactics* used, is that they need to be relearned and *adjusted during life transitions* (e.g., during pregnancy when new types and sources of information are encountered). Such changes to priorities can have an impact on people's susceptibility to engaging with information that is not representative to what they need (e.g., misinformation). People found themselves 'making mistakes' in how they interacted with online information, which adjusted their algorithm in ways that they didn't want to that led to them encountering information that they would not otherwise choose to.

Heuristics: Emotional Wellbeing through Prioritising the Familiar

Work on information sensibility identifies convenience, tone and aesthetic as the applied trust heuristics used to inform assessment practices (Hassoun et al., 2023). Similar to related work (Boczkowski et al., 2018; de Groot et al., 2023; Goyanes et al., 2023; Strandberg et al., 2019), our participants talked about news that "seems" or "feels" right, but when prompted further, they talked about *familiarity of source* and *familiarity of politics and values* as opposed to style and aesthetic. Such familiarity we also found that relates to people's awareness of how such information was algorithmically curated to them (Karakayali et al., 2018; Koenig, 2020; Swart, 2021) – i.e., information that "felt right" was information that made sense to people to appear in social feeds and news apps due to past interaction with the algorithm.

Our findings also indicate that people are both reflexive and reflective in their decisions about the information they encounter (see Kahneman, 2011), not as a matter of convenience, as for example pointed by Hassoun et al., (2023), but rather to protect their *emotional wellbeing* and feel *comforted*. We note, here, that the need for people to protect themselves by disengaging from certain types of news was a core strategy. The emotional weight (tone) of information encountered was one of the most significant factors in deciding whether to engage, but participants employed a range of strategies, sometimes resonating with those observed during the Covid-19 pandemic, when 'news avoidance' was recognised as a key wellbeing strategy (Mannell & Meese, 2022), employing a range of strategies for news avoidance, including the decision to avoid certain channels, avoid particular formats, or configure social media feeds in order to manage the kinds of news information encountered (Das & Ahmed, 2021; Patel et al., 2020). Departing from recent features of social media platforms that allow users to increase or decrease types of information presented to them (e.g., on Facebook, etc.), and in agreement with implications for design from previous work (e.g., Eiband et al., 2019; Rader & Gray, 2015; Swart, 2021; Velkova & Kaun, 2021 and others) we emphasise the need for the design of interfaces that gives more context-specific controls to users in information they encounter, and more transparency to the ways that algorithmic curatorial practice work when deciding implicitly to avoid or engage with certain types of information.

Conclusion

In this paper we build on recent work on 'information sensibility' practices, challenges, and heuristics. We surface the challenges of: (i) *misrepresentation*, (ii) *lack of algorithmic control and transparency*, and the challenge of (iii) *staying informed to care for social relations*. Our findings validate recent work on information sensibility practices, by identifying young people's information assessment practices as highly social and collaborative, while however identifying '*my algorithm'* as an actor within such social and collaborative practices. Finally, our empirical findings point to the way that information sensibility heuristics are used as a means of protecting *emotional wellbeing*, specifically using convenience and tone as a protection against potentially harmful content. Factors such as *source of familiarity* and *value alignment* were considered as critical, as opposed to the secondary consideration of aesthetics. Such findings contribute additional empirical insights into young people's decision-making practices in assessments of information online, and design implications towards systems aiming to address misinformation when embedded in social contexts online.

Acknowledgments

The work reported in this paper is part of the UKRI EPSRC Centre for Digital Citizens (EP/T022582/1). Special thanks to our collaborators from BBC R&D, Rhianne Jones for her continuous support, and Laura Ellis for her involvement at the initial exploratory stages. We would like to thank our participants for the information and news they shared with us, and for their enthusiasm during the interviews. Data supporting this publication are available under a CC BY 4.0 License at https://doi.org/10.25405/data.ncl.25488064.

References

Bauer, Lujo, Bravo-Lillo, Cristian, Cranor, Lorrie, & Fragkaki, Elli. (2013). *Warning Design Guidelines*. CyLab Carnegie Mellon University.

Boczkowski, Pablo J., Mitchelstein, Eugenia, & Matassi, Mora. (2018). "News comes across when I'm in a moment of leisure": Understanding the practices of incidental news consumption on social media. *New Media & Society*, *20*(10), 3523–3539. https://doi.org/10.1177/1461444817750396

Borgatti, Stephen P., & Cross, Rob. (2003). A Relational View of Information Seeking and Learning in Social Networks. *Management Science*, *49*(4), 432–445. https://doi.org/10.1287/mnsc.49.4.432.14428

Braun, Virginia, & Clarke, Victoria. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Braun, Virginia, & Clarke, Victoria. (2020). One size fits all? What counts as quality practice in (reflexive) thematic analysis? *Qualitative Research in Psychology*, 1–25. https://doi.org/10.1080/14780887.2020.1769238

Carmi, Elinor, Yates, Simeon J., Lockley, Eleanor, & Pawluczuk, Alicja. (2020). Data citizenship: Rethinking data literacy in the age of disinformation, misinformation, and malinformation. *Internet Policy Review*, *9*(2), 1–22. https://doi.org/10.14763/2020.2.1481

Clayton, Katherine, Blair, Spencer, Busam, Jonathan A., Forstner, Samuel, Glance, John, Green, Guy, Kawata, Anna, Kovvuri, Akhila, Martin, Jonathan, Morgan, Evan, Sandhu, Morgan, Sang, Rachel, Scholz-Bright, Rachel, Welch, Austin T., Wolff, Andrew G., Zhou, Amanda, & Nyhan, Brendan. (2020). Real Solutions for Fake News? Measuring the Effectiveness of General Warnings and Fact-Check Tags in Reducing Belief in False Stories on Social Media. *Political Behavior*, *42*(4), 1073–1095. https://doi.org/10.1007/s11109-019-09533-0

Connaway, Lynn Sillipigni, Dickey, Timothy J., & Radford, Marie L. (2011). "If it is too inconvenient I'm not going after it:" Convenience as a critical factor in information-seeking behaviors. *Library & Information Science Research*, *33*(3), 179–190. https://doi.org/10.1016/j.lisr.2010.12.002

Das, Ronnie, & Ahmed, Wasim. (2021). Rethinking Fake News: Disinformation and Ideology during the time of COVID-19 Global Pandemic, *11*(1), 146–159. https://doi.org/10.1177/22779752211027382

de Groot, Tjitske, de Haan, Mariëtte, & van Dijken, Maartje. (2023). Learning in and about a filtered universe: Young people's awareness and control of algorithms in social media. *Learning, Media and Technology*, *48*(4), 701–713. https://doi.org/10.1080/17439884.2023.2253730

Edgerly, Stephanie. (2017). Seeking Out and Avoiding the News Media: Young Adults' Proposed Strategies for Obtaining Current Events Information. *Mass Communication and Society*, *20*(3), 358–377. https://doi.org/10.1080/15205436.2016.1262424

Ehrlén, Veera, Talvitie-Lamberg, Karoliina, Salonen, Margareta, Koivula, Minna, Villi, Mikko, & Uskali, Turo. (2023). Confusing Content, Platforms, and Data: Young Adults and Trust in News Media. *Media and Communication*, *11*(4). https://doi.org/10.17645/mac.v11i4.7104

Eiband, Malin, Völkel, Sarah Theres, Buschek, Daniel, Cook, Sophia, & Hussmann, Heinrich. (2019). When people and algorithms meet: User-reported problems in intelligent everyday applications. *Proceedings of the 24th International Conference on Intelligent User Interfaces*, 96–106. https://doi.org/10.1145/3301275.3302262

Ellison, Nicole, Gray, Rebecca, Vitak, Jessica, Lampe, Cliff, & Fiore, Andrew. (2013). Calling All Facebook Friends: Exploring Requests for Help on Facebook. *Proceedings of the International AAAI Conference on Web and Social Media*, *7*(1), Article 1. https://doi.org/10.1609/icwsm.v7i1.14436

Elsden, Chris, Chatting, David, Durrant, Abigail C., Garbett, Andrew, Nissen, Bettina, Vines, John, & Kirk, David S. (2017). On speculative enactments. *Conference on Human Factors in Computing Systems - Proceedings*, *2017-January*, 5386–5399. https://doi.org/10.1145/3025453.3025503

Elsden, Chris, Durrant, Abigail C., Chatting, David, & Kirk, David S. (2017). Designing Documentary Informatics. *Proceedings of the 2017 Conference on Designing Interactive Systems*, 649–661. https://doi.org/10.1145/3064663.3064714

Elsden, Chris, Nissen, Bettina, Garbett, Andrew, Chatting, David, Kirk, David, & Vines, John. (2016). Metadating: Exploring the Romance and Future of Personal Data. *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, 685–698. https://doi.org/10.1145/2858036.2858173

Eslami, Motahhare, Karahalios, Karrie, Sandvig, Christian, Vaccaro, Kristen, Rickman, Aimee, Hamilton, Kevin, & Kirlik, Alex. (2016). First I "like" it, then I hide it: Folk Theories of Social Feeds. *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, 2371–2382. https://doi.org/10.1145/2858036.2858494

Evans, Brynn M., & Chi, Ed H. (2008). Towards a model of understanding social search. *Proceedings of the 2008 ACM Conference on Computer Supported Cooperative Work*, 485–494. https://doi.org/10.1145/1460563.1460641

Evans, Brynn M., Kairam, Sanjay, & Pirolli, Peter. (2010). Do your friends make you smarter?: An analysis of social strategies in online information seeking. *Information Processing & Management*, *46*(6), 679–692. https://doi.org/10.1016/j.ipm.2009.12.001

Fernandez, Miriam, & Alani, Harith. (2018). Online Misinformation: Challenges and Future Directions. *The Web Conference 2018 - Companion of the World Wide Web Conference, WWW 2018*, 595–602. https://doi.org/10.1145/3184558.3188730

Flintham, Martin, Karner, Christian, Bachour, Khaled, Creswick, Helen, Gupta, Neha, & Moran, Stuart. (2018). Falling for Fake News: Investigating the Consumption of News via Social Media. *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, 1–10. https://doi.org/10.1145/3173574.3173950

Gaver, William W., Beaver, Jacob, & Benford, Steve. (2003). Ambiguity as a resource for design. *Conference on Human Factors in Computing Systems - Proceedings*, 233–240. https://doi.org/10.1145/642611.642653

Geeng, Christine, Yee, Savanna, & Roesner, Franziska. (2020). Fake News on Facebook and Twitter: Investigating How People (Don't) Investigate. *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, 1–14. https://doi.org/10.1145/3313831.3376784

Goyanes, Manuel, Ardèvol-Abreu, Alberto, & Gil de Zúñiga, Homero. (2023). Antecedents of News Avoidance: Competing Effects of Political Interest, News Overload, Trust in News Media, and "News Finds Me" Perception. *Digital Journalism*, *11*(1), 1–18. https://doi.org/10.1080/21670811.2021.1990097

Hassoun, Amelia, Beacock, Ian, Consolvo, Sunny, Goldberg, Beth, Kelley, Patrick Gage, & Russell, Daniel M. (2023). Practicing Information Sensibility: How Gen Z Engages with Online Information. *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, 1–17. https://doi.org/10.1145/3544548.3581328

Herrero-Diz, Paula, Conde-Jiménez, Jesús, & Reyes de Cózar, Salvador. (2020). Teens' Motivations to Spread Fake News on WhatsApp. *Social Media + Society*, *6*(3), 2056305120942879. https://doi.org/10.1177/2056305120942879

Jang, S. Mo, & Kim, Joon K. (2018). Third person effects of fake news: Fake news regulation and media literacy interventions. *Computers in Human Behavior*, *80*, 295–302. https://doi.org/10.1016/J.CHB.2017.11.034

Juvalta, Sibylle, Speranza, Camilla, Robin, Dominik, El Maohub, Yassmeen, Krasselt, Julia, Dreesen, Philipp, Dratva, Julia, & Suggs, L. Suzanne. (2023). Young people's media use and adherence to preventive measures in the "infodemic": Is it masked by political ideology? *Social Science & Medicine*, *317*, 115596. https://doi.org/10.1016/j.socscimed.2022.115596

Kahneman, Daniel. (2011). *Thinking, Fast and Slow*. Penguin.

Karakayali, Nedim, Kostem, Burc, & Galip, Idil. (2018). Recommendation Systems as Technologies of the Self: Algorithmic Control and the Formation of Music Taste. *Theory, Culture & Society*, *35*(2), 3–24. https://doi.org/10.1177/0263276417722391

Koenig, Abby. (2020). The Algorithms Know Me and I Know Them: Using Student Journals to Uncover Algorithmic Literacy Awareness. *Computers and Composition*, *58*, 102611. https://doi.org/10.1016/j.compcom.2020.102611

Koh, Kyungwon, Oh, Kyong Eun, Agarwal, Naresh K., & Belkin, Nicholas J. (2015). Information seeking and beyond: Impacts of studying different forms of information behavior. *Proceedings of the Association for Information Science and Technology*, *52*(1), 1–5. https://doi.org/10.1002/pra2.2015.14505201009

Mannell, Kate, & Meese, James. (2022). From Doom-Scrolling to News Avoidance: Limiting News as a Wellbeing Strategy During COVID Lockdown. *Journalism Studies*, *23*(3), 302–319. https://doi.org/10.1080/1461670X.2021.2021105

Mast, Jelle, & Temmerman, Martina. (2021). What's (The) News? Reassessing "News Values" as a Concept and Methodology in the Digital Age. *Journalism Studies*, *22*(6), 689–701. https://doi.org/10.1080/1461670X.2021.1917445

Medin, Douglas L., & Atran, Scott. (1999). *Folkbiology*. MIT Press.

Menon, Sanju, Zhang, Weiyu, & Perrault, Simon T. (2020). Nudge for Deliberativeness: How Interface Features Influence Online Discourse. *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (CHI2020).* https://doi.org/10.1145/3313831.3376646

Metzger, Miriam J., & Flanagin, Andrew J. (2013). Credibility and trust of information in online environments: The use of cognitive heuristics. *Journal of Pragmatics*, *59*, 210–220. https://doi.org/10.1016/j.pragma.2013.07.012

Monti, Federico, Frasca, Fabrizio, Eynard, Davide, Mannion, Damon, & Bronstein, Michael M. (2019). *Fake News Detection on Social Media using Geometric Deep Learning*. https://arxiv.org/abs/1902.06673v1

Oeldorf-Hirsch, Anne, Hecht, Brent, Morris, Meredith Ringel, Teevan, Jaime, & Gergle, Darren. (2014). To search or to ask: The routing of information needs between traditional search engines and social networks. *Proceedings of the 17th ACM Conference on Computer Supported Cooperative Work & Social Computing*, 16–27. https://doi.org/10.1145/2531602.2531706

Palen, Leysia, & Salzman, Marilyn. (2002). Voice-mail diary studies for naturalistic data capture under mobile conditions. *Proceedings of the 2002 ACM Conference on Computer Supported Cooperative Work - CSCW '02*, 87. https://doi.org/10.1145/587078.587092

Patel, Mohan P., Kute, Vivek B., & Agarwal, Sanjay K. (2020). "Infodemic" COVID 19: More Pandemic than the Virus. *Indian Journal of Nephrology*, *30*(3), 188–191. https://doi.org/10.4103/ijn.IJN_216_20

Pérez-Escoda, Ana, Pedrero-Esteban, Luis Miguel, Rubio-Romero, Juana, & Jiménez-Narros, Carlos. (2021). Fake News Reaching Young People on Social Networks: Distrust Challenging Media Literacy. *Publications*, *9*(2), Article 2. https://doi.org/10.3390/publications9020024

Qayyum, M. Asim, Williamson, Kirsty, Liu, Ying-Hsang, & Hider, Philip. (2010). Investigating the News Seeking behavior of Young Adults. *Australian Academic & Research Libraries*, *41*(3), 178–191. https://doi.org/10.1080/00048623.2010.10721462

Rader, Emilee, & Gray, Rebecca. (2015). Understanding User Beliefs About Algorithmic Curation in the Facebook News Feed. *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, 173–182. https://doi.org/10.1145/2702123.2702174

Ruokolainen, Hilda, Widén, Gunilla, & Eskola, Eeva-Liisa. (2023). How and why does official information become misinformation? A typology of official misinformation. *Library & Information Science Research*, *45*(2), 101237. https://doi.org/10.1016/j.lisr.2023.101237

Saltz, Emily, Leibowicz, Claire R., & Wardle, Claire. (2021). Encounters with Visual Misinformation and Labels across Platforms: An Interview and Diary Study to Inform Ecosystem Approaches to Misinformation Interventions. *Conference on Human Factors in Computing Systems - Proceedings*. https://doi.org/10.1145/3411763.3451807

Scherer, Laura D., & Pennycook, Gordon. (2020). Who Is Susceptible to Online Health Misinformation? *American Journal of Public Health*, *110*(S3), S276–S277. https://doi.org/10.2105/AJPH.2020.305908

Sharevski, Filipo, Alsaadi, Raniem, Jachim, Peter, & Pieroni, Emma. (2021). *Misinformation Warning Labels: Twitter's Soft Moderation Effects on COVID-19 Vaccine Belief Echoes*. *17*. https://arxiv.org/abs/2104.00779v1

Shu, Kai, Bernard, H. Russell, & Liu, Huan. (2019). Studying Fake News via Network Analysis: Detection and Mitigation. In Agarwal N, Dokoohaki N, & Tokdemir S (Eds.), *Emerging Research Challenges and Opportunities in Computational Social Network Analysis and Mining. Lecture Notes in Social Networks* (pp. 43–65). Springer. https://doi.org/10.1007/978-3-319-94105-9_3

Simon, Herbert A. (1990). Bounded Rationality. In John Eatwell, Murray Milgate, & Peter Newman (Eds.), *Utility and Probability* (pp. 15–18). Palgrave Macmillan UK. https://doi.org/10.1007/978-1-349-20568-4_5

Ståhl, Anna, Höök, Kristina, Svensson, Martin, Taylor, Alex S., & Combetto, Marco. (2009). Experiencing the Affective Diary. *Personal and Ubiquitous Computing*, *13*(5), 365–378. https://doi.org/10.1007/s00779-008-0202-7

Strandberg, Kim, Himmelroos, Staffan, & Grönlund, Kimmo. (2019). Do discussions in like-minded groups necessarily lead to more extreme opinions? Deliberative democracy and group polarization. *International Political Science Review*, *40*(1), 41–57. https://doi.org/10.1177/0192512117692136

Strauß, Nadine, Huber, Brigitte, & Gil de Zúñiga, Homero. (2021). Structural Influences on the News Finds Me Perception: Why People Believe They Don't Have to Actively Seek News Anymore. *Social Media + Society*, *7*(2), 20563051211024966. https://doi.org/10.1177/20563051211024966

Swart, Joëlle. (2021). Experiencing Algorithms: How Young People Understand, Feel About, and Engage With Algorithmic News Selection on Social Media. *Social Media + Society*, *7*(2), 20563051211008828. https://doi.org/10.1177/20563051211008828

Talwar, Shalini, Dhir, Amandeep, Kaur, Puneet, Zafar, Nida, & Alrasheedy, Melfi. (2019). Why do people share fake news? Associations between the dark side of social media use and fake news sharing behavior. *Journal of Retailing and Consumer Services*, *51*, 72–82. https://doi.org/10.1016/j.jretconser.2019.05.026

Toff, Benjamin, & Nielsen, Rasmus Kleis. (2018). "I Just Google It": Folk Theories of Distributed Discovery. *Journal of Communication*, *68*(3), 636–657. https://doi.org/10.1093/joc/jqy009

Vaccari, Cristian, & Chadwick, Andrew. (2020). Deepfakes and Disinformation: Exploring the Impact of Synthetic Political Video on Deception, Uncertainty, and Trust in News:, *6*(1). https://doi.org/10.1177/2056305120903408

Valaskivi, Katja. (2022). Circulation of conspiracy theories in the attention factory. *Popular Communication*, *20*(3), 162–177. https://doi.org/10.1080/15405702.2022.2045996

Velkova, Julia, & Kaun, Anne. (2021). Algorithmic resistance: Media practices and the politics of repair. *Information, Communication & Society*, *24*(4), 523–540. https://doi.org/10.1080/1369118X.2019.1657162

Wolff, Annika, Gooch, Daniel, Montaner, Jose J. Cavero, Rashid, Umar, & Kortuem, Gerd. (2016). Creating an Understanding of Data Literacy for a Data-driven Society. *The Journal of Community Informatics*, *12*(3). http://ci-journal.org/index.php/ciej/article/view/1286

Yang, Shuo, Wang, Suhang, Gu, Renjie, & Wu, Fan. (2019). Unsupervised Fake News Detection on Social Media: A Generative Approach. In Kai Shu & Huan Liu (Eds.), *Emerging Research Challenges and Opportunities in Computational Social Network Analysis and Mining* (Vol. 33, Issue 01, pp. 5644–5651). AAAI Press. https://doi.org/10.1609/AAAI.V33I01.33015644

Zhang, Amy X., Ranganathan, Aditya, Metz, Sarah Emlen, Appling, Scott, Sehat, Connie Moon, Gilmore, Norman, Adams, Nick B., Vincent, Emmanuel, Lee, Jennifer, Robbins, Martin, Bice, Ed, Hawke, Sandro, Karger, David, & Mina, An Xiao. (2018). A Structured Response to Misinformation: Defining and Annotating Credibility Indicators in News Articles. *The Web Conference 2018 - Companion of the World Wide Web Conference, WWW 2018*, 603–612. https://doi.org/10.1145/3184558.3188731

Torbjørg Træland Meum, Miria Grisot (2024): Reconfiguring collaborative data work. In: Proceedings of the 22nd European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies – Notes, Reports of the European Society for Socially Embedded Technologies (ISSN:2510-2591), DOI: 10.48340/ecscw2024_n05

Reconfiguring collaborative data work

Torbjørg Træland Meum, Miria Grisot
Department of Informatics, University of Oslo, Norway
torbjotm@ifi.uio.no, *miriag@uio.no*

Abstract. Remote care solutions are implemented in primary and secondary care to improve the treatment and follow up of patients with chronic conditions. However, each context of use has specifi characteristics related to the clinical conditions of patients and the work arrangements for providing care remotely. In this paper we explore the data work required in the implementation and scaling of remote care in Norwegian healthcare. Specific lly, we focus on the reconfi uration of data work in various contexts of use. We fi d that implementing remote care requires reconfi uration of collaborative data work to ensure reliable and trustworthy data, to make patient-generated data useful in clinical assessment, and to maintain continuity of care in the illness trajectory. Our fi dings show the continuous confi uration and re-confi uration that takes place.

Introduction

International strategies have brought attention to the need for new care models that enable patient-centered services and a shift from hospital-centered to more integrated care structures (European Commision, 2018). This shift is expected to improve care processes while also reducing healthcare expenditures. Digital technologies have emerged as a potential solution, offering options such as digital remote care to address these concerns. While numerous pilot projects and trials have demonstrated the positive effects of digital remote care (Morton et al., 2017), challenges in scaling these solutions have been identified (Barlow et al., 2012). Researchers are grappling with the challenge of how remote modalities can be maintained beyond pilots (Greenhalgh et al., 2022) and to understand why as digital remote care scales, digital solutions that work well in one practice do not work at all in another (Greenhalgh et al., 2022).

Studies in CSCW have focused on the design and use of technologies to support remote care and have shown how remote care technologies have transformed the patient-physician relationship (Bardram et al., 2005), the importance of aligning the concerns of patients and clinicians (Andersen et al., 2018), and proposed maintenance-centered design as a strategy to design CSCW tools for digital health (Verdezoto et al., 2021). The increasing use of remote care technologies has also illustrated the emerging role of data work in healthcare. Studies have shown for instance that data work plays an even more central role than in traditional care (Grisot et al., 2019), and that frontline care workers are the crux of data-driven configuration (Sun et al., 2023). A recent scoping review on data work in healthcare illustrated that this research stream is emerging and promising (Bertelsen et al., 2024).

The aim of this study is to understand data work in the context of remote care, and the overall research question is: *how is data work configured and re-configured in the scaling of remote care?*

To address this question, we have studied the process of implementing and scaling digital remote care as an integrated part of the health and care service in Norway. Specifically, our study focuses on two contexts (hospital and municipality) where the same remote care technology is implemented and taken into use in novel areas of use. We find that implementing remote care requires reconfiguration of collaborative data work to ensure reliable and trustworthy data, to make patient-generated data useful in clinical assessment, and to maintain continuity in the illness trajectory. We base our understanding of reconfiguration on the notion of human–machine reconfiguration as an ongoing accomplishment (Suchman, 2007). We discuss how reconfiguration of collaborative data work is critical to the implementation and scaling of remote care. We also contribute to the literature on data work by showing how data work emerges and is configured and reconfigured according to the contextual situation.

The paper is structured as follows: first we present relevant research on data work in CSCW, and then present our conceptual framework. Then, we describe the research context and case, and our research methodology. We then present the findings where we show how data work was reconfigured to ensure reliable and trustworthy data, to make patient-generated data useful in clinical assessment, and to maintain continuity in the illness trajectory. Finally, we discuss the contribution of our study in relation to the CSCW literature on data work and to how to support scaling of remote care solutions.

Related research and analytical framework

Data work has for a long time been part of daily practice in healthcare, however increased digitization has led to an increased volume, velocity, and variety of data which has led to more data work in all parts of healthcare ((Bossen et al., 2019). Researchers in the CSCW community have defined data work as “any human activity related to creating, collecting, managing, curating, analyzing, interpreting, and communicating data” (Bossen et al., 2019 p.466). Based on this understanding, a study by Grisot et al. (2019) focused on novel nursing practice in the context of remote care and claimed that data work is crucial in remote care and plays an even more central role than in traditional care. Furthermore, they argued that data work is not only about analyzing the data element accumulated in the system but also includes the work of deciding what is relevant data and “guiding the patients into co-producing these data” (p.615). A similar study on the use of patient-generated health data illustrated how new forms of data collection triggered a shift in the division of work and how patients and nurses translated and recontextualized data during consultation (Cerna et al., 2020). A study on data-driven long-term care identified several types of data work such as: “constructing, maintaining and updating data infrastructures, articulating the distributed and fragmented data, and repairing the breakdown of data infrastructures” (Sun et al., 2023 p.13). The studies presented above show that healthcare data are not passively available to users and emphasizes human effort to produce, maintain and use data in a meaningful way.

In this study, we build on previous research on data work and on the notion of human-machine reconfiguration as an analytical framework to explore how data work is enacted in practice. “Human-machine reconfiguration” is concerns the question of “how humans and machines are figured together – or configured – in contemporary technological discourses and practices, and how they might be reconfigured, or figured together differently” (Suchman, 2012, p.49). Suchman's research has highlighted how situated agency emerges in sociomaterial arrangements that is enacted in particular ways in particular settings. Situated agency is thus not fixed by predefined specifications, but generated through specific human and non-human entities (Suchman, 2007). The notion of “configuration” provides an analytical framework to explore how sociomaterial arrangements have been shaped through being joined together (Grønsund & Aanestad, 2020 p.3), and how arrangements that produce effective forms of agency emerge in ongoing work (Mazmanian et al., 2014). In our study, we are interested in understanding how this configuration is carried out in different practices with attention to data work in remote care implementation and scaling.

Research site and methods

This study is part of a larger research project on the implementation, use, and scaling of digital technologies supporting high-quality remote patient monitoring of care. In this study, we have followed the implementation and scaling of digital remote care in two different settings. The first setting is a municipality that has adopted digital remote care by participating in a national trial that lasted from 2018 and 2021. Target population for the trial has been patients with chronic diseases such as chronic obstructive pulmonary disease (COPD), diabetes, cardiovascular disease, as well as mental disorders and cancer. Based on the experience gained in the national trial, it has been decided to scale the digital solution to more users and user areas in the health and care services. The second setting is a university hospital who underwent a procurement process in 2021 and signed an agreement with a digital remote care provider. The hospital has implemented a remote care solution for the digital outpatient clinic and digital home hospital for children with diabetes and the further strategy is to scale the digital solution to other use areas. The two research settings included in the study use the same digital solution developed by a Norwegian IT company.

The digital solution is an integrated collaborative solution, based on health management cloud platform technology, and connected digital devices. The solution consists of a web-based patient monitoring portal for clinicians, and a patient application, as well as a set of connected measuring devices. The patient monitoring portal for clinicians is developed for healthcare professionals to handle digital home follow-up, which integrates a range of patient-driven medical devices that support home-based care, such as medical measurements, symptom reporting and rehabilitation. The mobile application designed for patients' end is used with digital measuring equipment, which automatically transmits the measurement results via Bluetooth to the patient's tablet or smartphone (for example, measurement of blood pressure, blood sugar levels, weight, temperature, pulse, oxygen saturation, lung function and capacity, etc.). The measurement results are immediately visible to the patient on the tablet, where they can also answer clinical questions and register symptoms and side effects. The results are simultaneously transferred to a web-based patient monitoring portal so that health personnel can follow up the values that come in and provide individual follow-up. The platform enables integration of novel and appropriate measuring devices. The digital user interface also offers video conferencing and chat functionality that enables synchronous and asynchronous communication between patients and health professions.

In this study, we have followed the interpretive approach to case study research (Walsham, 1995). Our aim was to uncover our informants' understanding of how data work is configured and reconfigured across different contexts of use in the context of remote care implementation and scaling. Furthermore, we have emphasized the relational aspect of data and how data work is reconfigured in relation to existing technologies, practices, and habits.

We have collected data conducting semi-structured interviews and collecting archival documents. In the first phase of the study, we collected publicly available documents and internal project reports to gain insight into the historical development of digital remote care in Norway. In the second phase, we carried out 25 interviews with key stakeholders in the project, i.e., health professionals, employees at the IT department and the supplier. Most of the interviews were conducted in the local context in the municipality or at the hospital, while some interviews were conducted on zoom (because of the pandemic). The interviews lasted approximately 45 – 60 minutes, were recorded and fully transcribed.

We analyzed the data according to the hermeneutic circle (Klein & Myers, 1999), which is a process of going back and forth between data collection and analysis to understand the different contexts and the use of digital remote care. Furthermore, the analysis was inspired by a grounded theory approach and the area of enquiry guided the coding process (Charmaz, 2014; Urquhart et al., 2010). The initial step in the analysis was based on open coding to identify incidents related to adoption, use and scaling. All the incidents/events identified in the empirical material were assigned a code and a descriptive label. When all the data had been examined, the initial codes were organized and reassembled in a new way. This involved specifying the properties and dimensions of the initial categories such as condition, action / interaction, and consequences. The axial coding technique provided an analytical lens for moving back and forth between the initial categories, exploring the relationship between data, and re-organizing sub-categories and high-level concepts. NVivo software package (version 12) was used throughout the analysis to code, organize and visualize data.

Findings

Our findings are organized in three parts, corresponding to reconfiguration of data work with the aim to ensure reliable and trustworthy data, to make patient-generated data useful in clinical assessment, and to maintain continuity in the illness trajectory.

Reconfigure data work to ensure reliable and trustworthy data

The digital remote care solution provides some basic functionalities that were developed in collaboration with the vendor and health professionals as part of the national trial. A key issue during this process was to figure out how to ensure reliable and trustworthy data. The target group for the national trial was patients with chronic diseases and in the trial the patients received digital devices for measuring vital signs such as blood pressure, body temperature, heart rate, and blood oxygen. In addition, questionnaires to collect data on the patient's experience of the health condition have become an important part of the digital follow-up, both in the municipality and hospitals. The municipality has mainly chosen to use self-defined questionnaires. One way the municipality worked to ensure data reliability was by developing the questionnaires based on both national guidelines and professional consensus locally. Also, as they over time gained experience with using the questionnaires, they created templates specific to the various diagnoses or clinical issues, and made these available in the digital solution as illustrated in a quote from a nurse:

> "It has probably developed a bit because at first, I used to create questionnaires for each individual patient, but eventually I saw that there were templates which were very useful. And then you can add questions if there is something the user wants you to ask about because the questionnaires have been created by us together with the patient"

This way they ensured a tight relation between the specific clinical conditions of each patient, and the data collected, making the collected data relevant to the condition. A quote from another nurse illustrates how the questions were adapted to the clinical trajectory:

> "you have to make sure that they understand the questions and that the answers make sense to them. If you ask a patient with severe COPD whether they have had phlegm today - Yes/No - then they may always have phlegm, so you have to turn it around and ask in a different way because otherwise it generates red or yellow alerts".

These adjustments were critical to make sure that the collected data were reliable for clinicians. In the same way, the municipality adopted self-care plans, which are a plan for how the patient can manage their condition. A nurse in the municipality emphasized the central role of the self-care plan and stated that "it doesn't help to measure if you don't have any interventions". Like the questionnaires, templates have been created for self-care plans, to make sure that the collected data were the relevant ones for clinical follow up. The templates for the self-care plans are then individually adapted to the patient's condition and needs, as a nurse explains:

> "we have templates for heart failure and COPD and diabetes and the most common clinical cases, and then they are adapted individually …. because it is important to include what is important to the patient... I can focus on something to do with the heart failure and then the user can focus on something completely different that is important. For him, it may be important that he is able to stay healthy for the one week in the summer when his grandson is getting married or something like that".

These quotes illustrate how nurses need to adjust measurement arrangements to ensure that patient-generated data make sense to both patients and healthcare professionals.

As briefly outlined above, configuration of measuring arrangements involved preparatory work to facilitate patient-generated data. However, further scaling of the digital solution involved reconfiguring measurement arrangements. For example, cancer patients have been enrolled in digital remote care and a project nurse in the municipality stated that:

> "Then we had to create new pathways for this group because they had to be followed up by other resources and a completely different arrangement (...)"

In this instance, specialized nurses participated in the preparatory work which involved the use of validated questionnaires. The participation of expert nurses ensured that the configuration for collecting data targeted the relevant data for each patient also in this case. Furthermore, digital remote care has been put into use in various departments at hospitals, which involves further reconfiguration of measuring arrangements. For example, the endocrinology outpatient clinic offers digital follow-up to all patients with diabetes. The preparations began as an innovation project, and they have adopted both standardized and locally adapted questionnaires that patients respond to in advance of the annual consultations. They have put a lot of effort into validating and developing the questionnaires to ensure data reliability. For instance, during the project, they collected questionnaires (PROMs[1]) for diabetes patients, but realized that these needed to be adjusted for more open-ended questions that were adapted to clinical use.

> "(…) we found that many PROM forms, especially those developed for research, were a bit problem-focused, so the nurses were concerned that we must ask more positive, open questions (...).

When preparing locally adapted questionnaires, they have been inspired by other hospitals and professional communities that emphasized the patient perspective and thus invited a user group of patients who gave input to the questionnaires.

As digital questionnaires have gradually been adopted, modifications have also been made to the digital solution as explained by an employee at the vendor:

> "A lot has happened from 2018 - 2021 (...) You can build it up with yes/no questions, multiple choice questions, scales from 1-10 or as free text".

This flexibility in the design of the questionnaire makes it easier to adapt to different user groups; for example, some people find it easier to answer yes/no questions. During the implementations, this flexibility has been critical to ensure data reliability as the solution could be adapted and adjusted (e.g. templates, questionnaires) to collect data specifically relevant to specific patient groups, or even at individual level.

1 Patient-reported outcome measures (PROMs)

Reconfigure data work to make patient-generated data useful in clinical assessments

As briefly outlined above, several self-management tools have been used to ensure that relevant patient-generated data is available in the digital solution. Part of this work included training and guiding patients to ensure that the collection of data is carried out correctly. Health professionals have thus been given a new role that is organized differently in the municipality and the hospital.

The municipality provides health and care services to a large population, and several telemonitoring centers have been established that play a key role in digital follow-up. First and foremost, employees at the telemonitoring center provide guidance to the patients in the start-up phase of digital remote care. Furthermore, they are responsible for the daily follow-up of patients that involves the assessments of patient-generated data. When a new patient has been enrolled in the service, the nurses make a home visit to get to know the patient, deliver equipment and provide training in the use of the digital solution. This is typically the start of a 14-day test period where the patient's measurements are followed carefully to form a basis for threshold values for the measurements as well as the preparation of a questionnaire and self-care plan. Furthermore, threshold values and self-management arrangements are verified and approved by a GP or a doctor at the hospital.

Further work at the follow-up center mainly involves analyzing, filtering, and verifying patient-reported data. An overview of patient-reported data is available in the user interface of the digital platform and enable triage of the measurements' (green, yellow, red). The threshold of the measurement values for the individual patient defined by health professionals enables the automation of the triage. Thus, the nurse can quickly sort out measurements that requires attention and action. However, manual work to verify the measurements is also necessary and if the measurements are in a red or yellow zone, they make a phone or video call to the patient to clarify the situation. The nurses also use various data sources to assess and clarify the situation as explained by a nurse at the follow-up centre:

> "You must have the skills to compare different measurements and different information against each other. As I said, you have measurements, you have the question forms and, in addition, you have previous reports from the electronic patient record (EPR). So you have to be able to combine a lot of information, and work from that. Then you must be very systematic with the assessment you make, and not just, oh, you have high blood pressure, now you have to go to the hospital" (…) You must be able to interpret and be somewhat critical of the measurements. I always ask the user; How did you do the measurements? Did you dry your finger when you measured your blood sugar? Was your finger cold when you used the pulse oximeter? We must remind them of such things all the time".

A statement from the Norwegian Medical Association also illustrates this issue:

> "What does it mean that blood pressure is high? The interpretation differs according to how the pressure is measured, the situation the patient is in and whether it is measured in a special situation or routinely. Context can disappear by focusing only on individual parameters".

These quotes illustrate how different types of data are used to analyze and validate patient-reported data, which in turn forms the basis for decisions in practice. The user interface in the platform provides a graphical overview of measurement data that gives the nurse a good overview of trends that provides an overview of the clinical situation over time. All this type of interpretation and assessment work of data requires both professional knowledge and digital skills:

> "you need the best of the best. Firstly, because you have so many different fields that you should know something about. The second is that you don't see them, you have to communicate with them via chat or phone, so there is something about ... you can't see and feel, and you have to use completely different senses than what you are used to as a clinician (...) I think there will be a specialization within a few years".

Another nurse highlighted a similar issue:

> "I would never put a newly graduated nurse to work on this because it requires experience, you must be able to examine patients and you must be able to recognize symptoms".

As briefly outlined above, digital follow-up includes different types of data work and involves a combination of automated processes and human work. They have gradually configured the new practice and organization of digital follow-up. So far, the municipality has established telemonitoring centers that are located close to home care in the districts that have adopted digital remote care. However, in the further scaling to new districts, they are considering a common telemonitoring center, as explained by a project nurse in the municipality.

> "There are advantages and disadvantages to all types of organization. If you have a common one, it may be cheaper to operate, but then you lose the closeness to the user that you have if it is local, where you may work more interdisciplinary together with physiotherapists and occupational therapists and other groups, which you lose if there is a large common center .... so that is the assessment you have to make, but there is something about the fact that at a larger center you can have nurses who have more specialized expertise."

Digital remote care is used in a similar way in the hospital, but modifications and adaptations of data to many different clinical pathways are an ongoing process in the scaling of the digital solution. A lot of preparation data work is also required in this context and the scaling of digital follow-up at the hospital is organized by a team at the IT department that guides superusers in the various departments as explained by a member of the team:

> (…) we talk about the process and then we have a phase where we discuss how we work today and then we have a phase where we look at how we want to work, and then all the good ideas come to the table and many good discussions".

The superusers play a key role in this process by developing data and care procedures, training employees, and providing input to the team when modifications are needed. The digital follow-up of the patients is carried out by the nurses at the wards and the frequency of the interaction depends on the course of the illness. For example, children with newly diagnosed diabetes are followed up at home hospitals for children. The initial treatment starts when the child is physically admitted to the hospital. They are then offered the opportunity to be transferred to the home hospital for further follow-up until blood sugar level is stabilized. In this case, the patient uses a sensor that continuously measures blood glucose in the tissue under the skin and the values are automatically transferred to an app on the mobile phone. The patient manually enters the blood glucose values from the measuring device into the digital platform, as well as answering a questionnaire about carbohydrate intake and insulin dose. The nurse thus has access to patient-reported data in the digital solution instead of having to travel to the patient's home to collect data. In addition, asynchronous and synchronous messaging is regularly used in this context. For example, chat functionality is regularly used to clarify issues and inform patients about assessments that have been. The messages are also stored in the system and thus provide a historical overview of the interaction between patient and nurse which is used in the further assessment. In addition, synchronous communication such as video is used if the patient/relative needs guidance in the use of medical equipment and so on. The patient and relatives receive close follow-up for several weeks until they are able to manage the disease and are then followed up by the pediatric outpatient clinic until they are 18 years old and then at the endocrinological outpatient clinic.

Traditional follow-up at the outpatient clinic has been two consultations a year; one with a doctor and one with a nurse. One of the main challenges has been that many patients did not attend the agreed appointment, and the digital solution enabled a more needs-driven follow-up instead of calendar-driven consultations. Patient-reported data from measurement devices and questionnaires are also used in this context and they act on yellow and red alerts. In the assessment of patient-reported measurements, a specialized software is also used which provides more detailed data and trends of glucose values. In addition, the chat functionality in the digital solution is used to clarify the situation as stated by a nurse:

> "It works brilliantly and clarifies many things continuously where we would normally receive by phone calls that would have taken much more time".

This example illustrates that, in the various contexts of use of remote care, several self-management tools have been used to ensure that relevant patient-generated data is available in the digital solution, and consequently for clinical assessment. It also shows the configuration and reconfiguration of data work needed to make sure the generated data is adjusted to the contextual conditions of the care situation.

Reconfiguring data work to maintain continuity in the illness trajectory

The digital remote care platform is mainly used by nurses as the follow-up of patients is one of the nurses' primary tasks. However, interdisciplinary collaboration and collaboration across healthcare providers in this context is important to ensure continuity of care as good follow-up of the care pathway. Our informants report for instance that the use of digital remote care has increased the interaction between the municipality, the GPs, and the hospitals. A nurse in the municipality stated that:

> "My experience is that we sit in the middle and fill a gap that has been there for the chronically ill patient".

As mentioned, the nurse collaborates with the GP in preparing self-care plans, questionnaires, and threshold values for measurements. These guide and structure the data generation tasks. However, digital data, once generated by patients and received in the remote care system, are still difficult to share further. While information is shared via electronic messages between the municipality, the GP and the hospital, these are not integrated with the remote care system. The lack of integration results in additional work where data have to be copied and re-entered as explained by a nurse:

> "It is not smoothly to use, to punch in measurements for a month".

Another challenge is the formatting of electronic messages, as explained by a project nurse in the municipality:

> "It works, you get the message across, but even if it looks fine when I send it from our EPR system, there is something about the formatting, the message can look completely different when it is opened at the GP or the hospital. Then it can be messy and very difficult to read, so visually there is room for improvement".

Some of the issues mentioned above illustrate the need to reconfigure data sharing between actors involved in digital remote care to ensure continuity of care. Our informants mentioned an ongoing project in the municipality to figure out how internal and external interaction can be improved in this context. Internal interaction is described as 'almost resolved', as the data produced in the digital remote care solution have recently become available in the EPR system in the municipality. The project is now working on sharing measurement data with GPs and hospitals. This work is quite complex and involves the IT provider, healthcare professionals and lawyers to understand how data can be shared to meet healthcare needs as well as legal requirements. Thus, there is an ongoing reconfiguration of data work for continuity of care among GP, hospitals, and municipal care.

Health professionals at the hospital have experienced similar challenges in ensuring data sharing for continuity of care. For example, clinical notes produced in the digital remote care solution are still transferred manually to the EPR system used at the hospital. Furthermore, several advanced measurement devices are used at the hospital but are not integrated into the digital remote care solution for digital follow-up. For example, sensor technology is used at the endocrinology outpatient clinic to monitor the patients' blood sugar. However, the lack of integration of these devices with the remote care solution means that they use two different types of devices generating data in the follow-up of the patient. To integrate the hospital devices with the remote care solution is a complex effort involving the hospital IT-department and two vendors. An employee at the IT department describes this issue as follows:

> “There is a flora of applications and systems emerging in this area, and it is clear that "packaging" it to both health professionals and patients in a way that means that you do not have 6-7 apps, but that you still have the opportunity to use different types of solutions for different types of use (…) we see this as our foremost task - to be able to stitch this together in some sensible way”.

The implementation of remote care in the municipality and the hospital context is not only about generating data, but also sharing across technologies and contexts of use supporting the collaborative work for remote care. As remote care technologies are novel in this case, the technical integrations are still not in place and data have to manually be copied, pasted, sent and shared to ensure continuity of care for patients.

Discussion

In this paper we address the research question: *how is data work configured and re-configured in the scaling of remote care?* To address this question, we have used the notion of reconfiguration as an ongoing accomplishment (Suchman, 2007) to study the data work of participants in the implementation and scaling of remote care. Our study shows the ongoing reconfiguration process involving modifications and adjustments to ensure the reliability and trustworthiness of data, effectively utilize patient-generated data in clinical assessment, and maintain continuity throughout the illness trajectory.

Through data work reconfiguration, the nurses experiment how to make the solution work in specific contexts of use. Our data show for instance how the nurses adapt and modify the questionnaires to make sure they capture relevant data to inform care decisions. In addition, our study shows how, as the solution is scaled to novel contexts of use, this work varies in different contexts, for instance the way nurses work with configuring the questionnaires varies in the municipality and in the hospital, and for different patient groups. However, this data work is explorative, not given or decided a priori. The nurses experiment data in relation to the data generated by patients and collected and displayed by the system. Data work is thus not just set as the system is taken into use, but data work is experimented upon and transformed by the specificities of the context, of the patients’ group, of the work practices and of the existing sociotechnical arrangements in place. We contribute to the emerging research on data work in healthcare (e.g. Bjornstad and Ellingsen, 2019, Fiske et al., 2019, McVey et al., 2012, Pedersen and Bossen, 2024) with insights into the experimental, context dependent and provisional nature of data work.

We also stress the collaborative aspect of data work by showing how data work is collaborative as it takes place in the collective interpretation and meaning making of data. Collaborative data work refers to the collective efforts and processes involved in managing, analyzing, and utilizing data in the context of remote care. Our findings show the many instances in which nurses strive for data standardization. However our findings also show the tension between standardization and flexibility characterizing data work. On the one side, the nurses recognize the importance of personalizing and adjusting data collection (via e.g. questionnaires) to the specific characteristics of patients, while on the other side sharing data across levels of care and healthcare organizations requires standardization. As Berg and Goorman (1999) point out, health information is entangled with its context of production, and work is required to make data mobile and suitable for accumulation and further re-use and analysis. The nurses work with data both in the context of production, to make sure the generated data are reliable, and for other contexts of re-use for continuity of care. In conclusion, our study emphasizes the critical role of reconfiguring data work in the implementation and scaling of remote care.

Acknowledgments

The research in this paper is conducted in the context of the DigiRemote project (No. 310137) funded by an IKTPLUSS-IKT and digital innovation grant from the Research Council of Norway.

References

Andersen, T. O., Bansler, J. P., Kensing, F., Moll, J., Mønsted, T., Nielsen, K. D., Nielsen, O. W., Petersen, H. H., & Svendsen, J. H. (2018). Aligning Concerns in Telecare: Three Concepts to Guide the Design of Patient-Centred E-Health. Computer Supported Cooperative Work: CSCW: An International Journal, 27(3–6), pp. 1181–1214.

Bardram, J. E., Bossen, C., & Thomsen, A. (2005). Designing for Transformations in Collaboration – A Study of the Deployment of Homecare Technology. Proceedings of the 2005 International ACM SIGGROUP Conference on Supporting Group Work, pp. 294–303.

Barlow, J., Hendy, J., & Chrysanthaki, T. (2012). Scaling-up remote care in the United Kingdom: Lessons from a decade of policy intervention. Assistive Technology Research Series, 30, pp. 223–236.

Berg, M., & Goorman, E. (1999). The contextual nature of medical information. International Journal of Medical Informatics, 56(1–3), pp. 51–60.

Bertelsen, P. S., Bossen, C., Knudsen, C., & Pedersen, A. M. (2024). Data work and practices in healthcare: A scoping review. International Journal of Medical Informatics, pp.184.

Bjørnstad, C., & Ellingsen, G. (2019). Data work: A condition for integrations in health care. Health informatics journal, 25(3), pp526-535.

Bossen, C., Pine, K. H., Cabitza, F., & Piras, E. M. (2019). Data work in healthcare : An Introduction. Health Informatics Journal, 25(3), pp. 465–474.

Cerna, K., Grisot, M., Islind, A. S., Lindroth, T., Lundin, J., & Steineck, G. (2020). Changing Categorical Work in Healthcare: the Use of Patient-Generated Health Data in Cancer Rehabilitation. Computer Supported Cooperative Work: CSCW: An International Journal, 29(5), pp. 563–586.

Charmaz, K. (2014). Constructing Grounded Theory: A practical Guide through Qualitative Analysis (Vol. 2). Sage Publications, Ltd.

European Commision. (2018). Communication from the Commision to the European Parliament, The Counsil, The European Economic and Social Commitee and the Commitee of the Regions "on enabling the transformation of health and care in the Digital Single Marked: empowering citizens and building a healthier society.

Fiske, A., Prainsack, B., & Buyx, A. (2019). Data work: meaning-making in the era of data-rich medicine. Journal of medical Internet research, 21(7), e11672.

Greenhalgh, T., Shaw, S. E., Alvarez Nishio, A., Booth, A., Byng, R., Clarke, A., Dakin, F., Davies, R., Faulkner, S., Hemmings, N., Husain, L., Kalin, A., Ladds, E., Moore, L., Rosen, R., Rybczynska-Bunt, S., Wherton, J., & Wieringa, S. (2022). Protocol: Remote care as the 'new normal'? Multi-site case study in UK general practice. NIHR Open Research, 2, 46.

Grisot, M., Moltubakk Kempton, A., Hagen, L., & Aanestad, M. (2019). Data-work for personalized care: Examining nurses' practices in remote monitoring of chronic patients. Health Informatics Journal, 25(3), pp. 608–616.

Grønsund, T., & Aanestad, M. (2020). Augmenting the algorithm: Emerging human-in-the-loop work configurations. Journal of Strategic Information Systems, 29(2).

Klein, H. K., & Myers, M. D. (1999). A Set of principles for Conducting and Evaluating Interpretive Field Studies in Information Systems. MIS Quarterly, 23(1), pp. 67–94.

Mazmanian, M., Cohn, M., & Dourish, P. (2014). Dynamic Reconfiguration in Planetary Exploration. *Source: MIS Quarterly*, *38*(3), pp. 831–848.

McVey, L., Alvarado, N., Greenhalgh, J., Elshehaly, M., Gale, C. P., Lake, J., ... & Randell, R. (2021). Hidden labour: the skilful work of clinical audit data collection and its implications for secondary use of data via integrated health IT. BMC Health Services Research, 21, pp. 1-11.

Morton, K., Dennison, L., May, C., Murray, E., Little, P., McManus, R. J., & Yardley, L. (2017). Using digital interventions for self-management of chronic physical health conditions: A meta-ethnography review of published studies. Patient Education and Counseling, 100(4),

Pedersen, A. M., & Bossen, C. (2024). Data Work Between the Local and the Global: An Ethnography of a Healthcare Business Intelligence Unit. Proceedings of the ACM on Human-Computer Interaction, 8(CSCW1), pp. 1-28.

Suchman, L. (2007). Human-Machine Reconfigurations: Plans and Situatd Actions. Second ed. Cambridge University Press, New York.

Suchman, L. (2012). Configuration. In : Inventive Methods: The Happening of the Social. Routledge, New York, pp.48-60.

Sun, Y., Ma, X., Lindtner, S., & He, L. (2023). Data Work of Frontline Care Workers: Practices, Problems, and Opportunities in the Context of Data-Driven Long-Term Care. Proceedings of the ACM on Human-Computer Interaction, 7(1 CSCW).

Urquhart, C., Lehmann, H., & Myers, M. D. (2010). Putting the "theory" back into grounded theory: Guidelines for grounded theory studies in information systems. Information Systems Journal, 20(4), pp. 357–381.

Verdezoto, N., Bagalkot, N., Akbar, S. Z., Sharma, S., MacKintosh, N., Harrington, D., & Griffiths, P. (2021). The Invisible Work of Maintenance in Community Health: Challenges and Opportunities for Digital Health to Support Frontline Health Workers in Karnataka, South India. Proceedings of the ACM on Human-Computer Interaction, 5(CSCW1).

Walsham, G. (1995). Interpretive case studies in IS research : nature and method. European Journal of Information Systems, 4(2), pp. 74–81.

Bullard, Julia; Crowston, Kevin; Jackson, Corey B.; Smith, Alexander O.; and Østerlund, Carsten (2024): Folksonomies in Crowdsourcing Platforms: Three Tensions Associated with the Development of Shared Language in Distributed Groups. In: Proceedings of the 22nd European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies - Notes, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591), DOI: 10.48340/ecscw2024_n06

Folksonomies in Crowdsourcing Platforms: Three Tensions Associated with the Development of Shared Language in Distributed Groups

Julia Bullard[1], Kevin Crowston[2], Corey Jackson[3], Alexander O. Smith[2] and Carsten Østerlund[2]
[1] School of Information, University of British Columbia, Vancouver, BC, Canada
[2] School of Information Studies, Syracuse University, Syracuse, NY, USA
[3] The Information School, University of Wisconsin–Madison, Madison, WI, USA
Contact Author: crowston@syr.edu

Abstract. Members of cooperative groups can work together more effectively if they develop a shared language, but distributed groups face barriers to doing so. To better understand how shared language can emerge in and support the work of distributed groups, we review the literature on folksonomies (a kind of shared language) in crowdsourcing systems (one type of distributed work). The review highlights three tensions associated with the development of folksonomies in crowdsourcing. The first problem is who has the power to decide on adopted terminology. Second, different users of the language may have different needs. There might be tension if people tagging objects are not the same as those using these tags to search for content. Finally, projects need to decide when to intervene to maintain a balance between a stable ontology and the ability of the project to accommodate ongoing changes. We illustrate these considerations by comparing how they are handled in the story-sharing site *Archive of Our Own*, the citizen-science project *GravitySpy*, and the photo-sharing site *Flickr*.

Introduction

Members of distributed groups face challenges in achieving coordinated action. In this setting, the development of a shared language (i.e., specialized terminology used to describe the shared work and work situations) plays an essential role in supporting the coordination of group members' practices (Crowston and Kammerer, 1998). Without a common interpretive schema, individuals with different backgrounds may interpret situations and tasks differently, hampering collaboration and communication (Dougherty, 1992). For instance, the citizen-science project Snapshot Serengeti, in which volunteers identify the species of animals in pictures from African camera traps, would not work if every volunteer had their own names and definition of animal species. In this case, the shared language to be used is set by external authorities, i.e., the definition of species is given by zoologists to the citizen science volunteers. In many other cases, though, a shared language needs to emerge from the community's practices, e.g., the description of a novel species from the point of view of working zoologists. However, in highly distributed environments, individuals may have few opportunities for informal discussion and mutual observation that can foster the development of shared language and interpretive schemas.

To explore the bottom-up development and use of shared language in highly distributed work arrangements, we examine a specific kind of shared language, namely folksonomies, in a specific kind of distributed work, namely crowdsourcing. Both terms, crowdsourcing and folksonomy, are portmanteaus, bringing together crowd and sourcing and folk and taxonomy respectively. The notion of crowdsourcing was popularized by Howe (2010), who defined it as outsourcing of functions to an undefined (and generally extensive) network through an open call. Folksonomy refers to user-generated classification methods in which users collaboratively generate open-ended labels (also referred to as "tags") to categorize content (e.g., web resources, photos, citizen science data, and other online material to facilitate retrieval and use (Bullard, 2019; Noruzi, 2006; Trant, 2009). The decentralized nature of crowdsourcing and the bottom-up nature of folksonomy development provides a lens into the development of shared language in distributed work.

The specific goal of this paper is to review different strategies (i.e., what decisions to make and when) for supporting the development of folksonomies to better understand the impact of different decisions for promoting the development of a shared language in crowdsourcing settings. The paper's novelty is to take a project-management perspective by identifying three key questions about how a project is run that need to be addressed and discussing factors that weigh on those decisions. We start by reviewing the existing literature on crowdsourcing and folksonomies as a basis for identifying specific strategic questions to be investigated.

Literature review

Crowdsourcing and shared language

Crowdsourcing is a model for collaboration that uses information and communication technologies to access human effort to solve complex problems. In different settings, crowdsourcing has been called peer production, user-powered systems, user-generated content, collaborative systems, community systems, social systems, social search, social media, collective intelligence, wikinomics, crowd wisdom, smart mobs, mass collaboration and human computation (Doan et al., 2011). Crowdsourcing has been applied in a wide variety of business and academic domains. For instance, in academic research, working scientists employ crowdsourcing (in this setting called citizen science) to harness the efforts of amateur volunteers towards scientific tasks including developing research questions, collecting data, analyzing data and writing up results (Bonney et al., 2009). For example, the Galaxy Zoo citizen science project asks volunteers to review images of galaxies and report on their morphological and evolutionary features (Fortson et al., 2012).

In many crowdsourcing projects, participants work independently. However, when the tasks carried out by different workers are interdependent, a common language is essential to support effective coordination. The literature on shared language reveals that "language practices are instrumental in creating the norms of behavior of particular online groups" and "these norms function to provide sociability, support, information and a sense of collective identity" (Lam, 2008). When shared language is achieved, it provides benefits such as improved language quality, conversational grounding, retention, community sociability and support, and a sense of collective identity (Lam, 2008).

While a shared language is a common need, the characteristics that define many crowdsourcing projects make it challenging to achieve. First, the crowd's composition may influence a project's ability to achieve a shared language. As most crowdsourced projects recruit members through open calls, the resulting "crowd" may have diverse educational attainment and expertise. For instance, a Galaxy Zoo volunteer without the requisite training or educational background may struggle to comprehend the language used by working scientists or more advanced contributors, limiting the types of tasks that they can conduct.

Second, there can be issues with the evolution of a project's language. Participants may learn the language at a different pace, meaning that the language is discordant across the project. Newcomers who join a project during its later stages may struggle to make sense of the project's emergent language. As Feinberg (2006) argues, aggregates of individual language and democratic decision-making processes are not necessarily 'cohesive' collaborations. Feinberg points out that a project's language can become increasingly complex and incoherent as data increases and individual motives and collective goals are accounted for. These challenges will be exacerbated if there are no training materials from which to learn the language.

Finally, the governance structure adopted by projects may lead to uncertainty about the appropriate source of the language to be employed in the community. While some projects may have a hierarchical governance structure in which a few preselected persons fill leadership roles, many members can evolve their responsibilities and take on new roles to sustain the community. If decision-making power about the appropriate language is decentralized, contributors may not know from whom to take linguistic cues or even perceive a need to adapt their language. As a result, projects may lack processes for adjudicating new language in the project.

Folksonomies

A folksonomy is a user-generated classification and information-retrieval method with three characteristics (Peters and Weller, 2008; Bullard, 2019; Trant, 2009). First, folksonomies constitute collaboratively-generated work by large and distributed groups as part of their ongoing tagging of objects, collections and searches in Internet-based platforms. There is a grass-roots element to the production and use of folksonomies where the tagging practices and resulting folksonomies service emerging communal purposes. Second, as a common use of tags is to facilitate search and retrieval, tags need to serve the needs of both individuals trying to organize their own materials and searchers looking for materials, so content created or tagged by one user can be found by others. Third, the set of tags is often open-ended, so the size to which and speed with which folksonomies grow can defy the temporal rhythms of traditional knowledge organization systems.

Folksonomies can be contrasted to formal knowledge organization systems (KOS) and computational approaches to information organization (Bullard, 2019). On the one hand, the controlled vocabulary associated with a formal KOS is developed, applied and controlled by experts and is typically structured and stable (Hjørland, 2008). On the other hand, computational approaches generate search terms algorithmically, which reduces the need for expert labor. These approaches benefit from large corpora for analysis (Zhitomirsky-Geffet et al., 2016). However, a social process is still needed to transfer the generated terms into practice.

Enabling online users to contribute labels or tags for personal and shared information organization and retrieval has gained attention in a range of fields. The library, museum and archives community have experimented with folksonomies in an effort to broaden the voice and engagement of their community and stay current (Trant, 2009; Yi and Chan, 2009; Stewart and Kendrick, 2019; Lu et al., 2010). These communities also have studied existing folksonomies to produce accurate metadata to apply to collections (Dieckman, 2022). Education has also shown interest as part of an effort to improve the searching of networked resources in ways that support both collective and personalized uses (Miller, 2005). Folksonomies have also been studied for geo-spatial mapping (Mocnik et al., 2017), healthcare (Smith and Wicks, 2008), multimedia (Zheng et al., 2016), ecommerce recommendation systems (Mao et al., 2021) and finance (O'Leary, 2015). This broad interest has led to a proliferation of overlapping terms for the concept. Trant (2009) finds other terms describing aspects of this phenomenon, including social tagging and social classification (Landbeck, 2007), community cataloging and cataloging by the crowd (Chun and Jenkins, 2005) and ethnoclassification (Walker, 2005).

Folksonomies in crowdsourcing

Next, we discuss how folksonomies work in crowdsourcing settings to illuminate the processes by which shared language can emerge in distributed work settings. Folksonomies emerge from individual and communal practices that involve the tagging of individual objects and the creation of object collections. Figure 1 summarizes the core elements in this process as conceptualized by Jackson et al. (2018). Starting in the upper left, by tagging (or tagging) individual items, participants seek to assign them meaning. For instance, an author may seek to tag the genre or topic of a story they have read. As they tag multiple items, they may seek to be consistent in the tagging so that the tags can serve to connect related objects, e.g., all of the cozy mysteries in a particular setting. Through this process, individuals gradually create their own 'personomies', that is, a categorization system unique to their own practices (upper right). Multiple purposes can drive the development of personomies, as individual tags do not necessarily refer to the content of the objects but can also denote author, origin, data form, work process or context-dependent characteristics of the object salient to the individual (Macgregor and McCulloch, 2006). Ames and Naaman (2007) find that individuals have four main motivations to tag items in social tagging systems, including self organization, self communication (i.e., to reflect and keep track of daily life), social organization (i.e., creating a shared collection) and social communication (i.e., sharing opinions about a specific item). For instance, it is not uncommon to find self-directed tags, such as "to read."

	Single Objects	Collections of Objects
Individual	Object tagging →	Personomy
	↓	↓
Collective	Object-tagging consensus ↔	↔ Folksonomy

Figure 1. Folksonomy creation process.

At the collective level (lower left quadrant in Figure 1), multiple users examining an object may strive to reach an agreement about the most appropriate tags to describe it. Agreement on tagging may come through discussions about a particular object or more directly when one individual mirrors the observed practices of others and so applies the same tag. When visible to others, individual tagging practices may serve as a guide for other's practices.

Finally, folksonomies (the lower right quadrant) take shape as personomies and collectively-agreed-upon tags accumulate over time. Discussions about these tags may further facilitate consensus by allowing individuals and groups to base their tagging on previously-shared tags. Contrariwise, a developed folksonomy provides the basis for group members to coordinate their tagging and improve retrieval of relevant objects in their searches, meaning that the flow between the lower left and right quadrant goes in both directions.

Unfortunately, the free-tagging practices feeding the production of folksonomies rarely achieve a coherent and structured ontology. Instead, most folksonomies are Peters and Weller (2008) called "tag gardens," each tag like a plant growing wild. A few tags may receive much attention, but others still proliferate (i.e., a long-tail distribution (Munk and Mørk, 2007)), yielding an unruly and overgrown garden. Research has revealed specific shortcomings of folksonomies (Al-Khalifa and Davis, 2007; Lee and Schleyer, 2012; Aurnhammer et al., 2006; Guy and Tonkin, 2006; Spiteri, 2007). Terms may be spelling variants, abbreviations, initialisms or acronyms, synonyms, compound tags where two words are joined or duplicate generic and specific names for a concept. Terms may also be ambiguous by using neologisms, slang, jargon (Spiteri, 2007) or even tangential humor (Price, 2019). A person's or group's use of tagging strategies may change over time (Begelman et al., 2006) or subcultures may form as smaller groups develop vocabularies to serve their particular interests (Rafferty and Hidderley, 2007).

A number of techniques have emerged to manage the messy nature of emerging folksonomies and overcome some of their shortcomings. Peters and Weller (2008) refer to these as "gardening techniques" that re-engineer folksonomies to make them more productive for broader use. These interventions target different parts of the process (see Table I). First, some strategies attempt to guide individuals in tagging (upper left side of Table I). For instance, as a user enters a term, the system can spell check or auto-complete suggestions from the existing folksonomy (Bullard, 2019; Munk and Mørk, 2007). Price (2019) describes a *post hoc* disciplinary technique generated by human domain experts judge tags based on literary, scientific, user or ethical "warrant." Some sites use word clouds to call attention to popular tags to help guide individuals in their selection process, though this approach risks promoting tagging driven by imitation as opposed to thoughtfulness (Munk and Mørk, 2007). Other strategies include computationally-derived suggestions for tags (Razikin et al., 2011), e.g., using centrality in a network of tag co-occurrences (Price, 2019).

Second, strategies can attempt to shape the personomies that feed many folksonomies (upper right quadrant). Curiously, we find few examples of such functionality, beyond simply listing tags used and enabling searches for items that use a tag. One could imagine allowing individuals to easily review and curate their own collection of tags, e.g., to easily change the name of a particular tag. Likewise, it might be useful for people to compare their personomies with other personomies

	Single objects	Collection of objects
Individual	• Autofill • Spell check • Knowledge Organization System (KOS) suggestions • Computationally derived suggestions	• Personomy management
Communal	• Object tagging consensus reached in Talk and Discussion forums embedded in the tagging process	• Expert curated • Computational processes: – Word Clouds and other visualizations – Computational techniques to find clusters, tag-networks, readable dictionaries, etc. • Community curated by: – Any contributor – Curators identified by algorithmic reputation – Volunteer curators selected and trained

Table I. Gardening techniques and the focus of their interventions.

or a shared folksonomy.

Third, a number of efforts strive to facilitate communal consensus as part of the classification process for individual contributions (lower left side quadrant). For instance, on the citizen science platform Zooniverse, participants can see what tags other users have applied to particular objects and engage in a conversation about their tagging in discussions of tags in the Talk and Discussion fora.

Finally, some gardening techniques intervene at the folksonomy level and approach the whole folksonomy as a raw material from which to derive a structured knowledge-organization system (lower right-side quadrant). The folksonomy review can be driven by experts, computational techniques or the user community. An expert-driven approach employs professional knowledge organization designers to review the folksonomy and revise descriptors (Syn and Spring, 2013). Computational techniques attempt to transform folksonomies into coherent taxonomies and ontologies. Clustering, matching algorithms, machine-readable dictionaries and tag networks have all been explored as possible ways to process folksonomies (Tsui et al., 2010). Others take existing tags and apply machine learning algorithms to find similarities *post hoc* (Mao et al., 2021; Dieckman, 2022; Zhou et al., 2023). These computational approaches worked well with large corpora and ongoing changes to folksonomies and reduced the need for expert labor (Zhitomirsky-Geffet et al., 2016).

Finally, on some platforms, the user community structures unruly folksonomies. Bullard (2019) describes three empirical cases that, in different ways, divide up the work to make changes to the folksonomy.

- In the project *LibraryThing*, users not only develop a database of books but also curate a folksonomy of tags applied to the books. Any user can edit tags, for instance, by combining synonymous tags, separating wrongly combined tags or calling a vote to reach a communal decision on important tags. *LibraryThing* keeps track of tag names' provenance so users can review the history of a term and what changes have taken place in the past. Equally important, the revision process does not change the original tags on a book or user's page. Only on site-wide retrieval do the combinations of terms come into play. In other words, personomies and folksonomies maintain separate but interrelated lives.
- In *Stack Overflow*, a question and answer site for programmers (with spinoffs for many other domains), incoming questions can be given tags to describe the topic of the question to help steer them to the right person to answer them. While any phrase can be used as a tag, terms can be noted as synonyms so that divergent terms get replaced. The system assigns the right to edit the folksonomy of tags to users with high algorithmic "reputation" whom the system has judged as good contributors. Members of this group can decide to merge or separate tags (Bullard, 2019, p. 647).
- A more selective approach to who gets involved in folksonomy editing can be found on *Archive of our Own* (AO3), a site that offers a noncommercial and nonprofit host for fanworks (e.g., stories set in fictional universes using those characters, e.g., a story set in the world of Harry Potter). On this site, a few hundred volunteers who have completed a recruitment and training process curate the site's folksonomy. Once appointed, these "tag wranglers" have significant autonomy to manage their assigned section of the folksonomy (Bullard, 2019, p. 647).

Three tensions in folksonomy development

From the literature review, we identify three tensions that arise when promoting development of a folksonomy in a crowdsourcing setting that go to the core of shared language development. A first tension regards who has the power to decide on adopted terminology. As noted above, in many settings, power is centralized and an authoritative shared language can be imposed on group members. In the absence of authority, different users may strive to control the language used. Or, it may be that there is no need for consensus on tagging meaning that there is no movement from individual to collective in Figure 1 beyond simple aggregation.

Second, in distributed work settings, different workers may have different needs for the shared language. In the setting of folksonomies for crowd work specifically, we see a tension between the needs of users who tag content to classify it for their own purposes and those who use the tags to search for content, i.e., between individual and collective needs (upper vs. lower portions of Figure 1).

A final related tension has to do with temporality, i.e., when in the work process shared knowledge plays a role. Does it make more sense to seek to apply shared terminology at the time of tagging an object (left side of Figure 1) or later in the process when there is a collection of tagged objects (right side of Figure 1)? These decisions relate to the needs for stability and dynamism. On the one hand, an advantage of folksonomies is that they can be dynamic, changing as work practices shift and thus accommodating a changing situation. On the other hand, changes can be disruptive to the use of folksonomy terms, so users may prefer some degree of stability.

These tensions led to the three strategic decisions we address: (1) How does a project allocate authority to make decisions about the folksonomy and support that authority? (2) How does a project weigh the support for those who develop terms (i.e., tagging objects) versus those who use the tag? (3) When does a project intervene in the work process to promote the development of a shared language?

Method

We addressed our research questions through a multiple comparative case study of three online communities: Gravity Spy[1], Archive of Our Own (AO3)[2] and Flickr[3]. These three were chosen because they span a range of practices related to folksonomies, as well as addressing different users and different scales.

- Gravity Spy is a citizen-science project hosted on the Zooniverse platform. In this project, volunteers classify "glitches" or noise events from the Laser Interferometer Gravitational-Wave Observatory (LIGO). Most volunteers classify glitches into classes identified by LIGO scientists but advanced volunteers seek to identify novel classes of glitches, tagging them with new terms.
- AO3 is a fanwork sharing site, introduced above. Contributors of stories tag them to identify the content while tag wranglers connect the applied tags to a site-wide folksonomy to facilitate searching for stories.
- Flickr is a commercial site hosting photographs and some video. Photos can be grouped into albums but also tagged by the poster, e.g., for content, setting or some other purpose and these tags can be searched for.

For each site, we provide contextual illuminations of participants' practices through virtual ethnography (Hine, 2008; Østerlund et al., 2020). Virtual ethnography adapts traditional ethnographic methods, such as participant observation and in-person interviews, to studying online communities. Each author has been a participant in one of the projects for several years and has contributed to the project classifying and searching for data, stories or pictures, and reading and posting in discussion fora. As participants, we created user accounts, completed requisite training (if any), created tags, and read and contributed to project discussions over the course of the project. For instance, one author has served for years as a tag wrangler on AO3. We

---

[1] https://www.gravityspy.org/
[2] https://archiveofourown.org/
[3] https://flickr.com/

used our position as observers to build knowledge about how volunteers and site users engage with folksonomies. We analyzed the process we identified to determine how they mapped to the categories in the theoretical framework. In other studies (e.g., Bullard, 2019; Jackson et al., 2018) we interviewed volunteers about their work on folksonomies. Those interviews provide additional background for our investigations rather than being a primary source for this article.

Findings: Tensions and decision points in the development of shared language

From our participant observation, we have identified user practices and system features that indicate how the three different project have addressed our three questions. We discuss each in turn.

Allocation and support of power

Gardening a folksonomy can be trusted to different participants in the community. Assigning gardening tasks allocates the power to shape the communal language. For instance, some projects take a laissez-faire approach where anybody can edit the language, others choose a democratic strategy involving voting and others have a small group of experts who make the final decisions on shared terminology. However, the allocation of power needs to be supported by technical features for exercising it.

In *Gravity Spy* there are two sets of tags and power is exercised differently over the them. Most volunteers classify glitches into the classes defined by the science team, as shown in Figure 2. The science team retain the final decision on what terms get included in the recognized list of tags. If volunteers think a new glitch class should be added, they need to go through an approval process that includes the submission of a document detailing the glitch morphology, tags associated with this glitch on Talk and example images. Science team members then review the proposal to investigate the glitch class further before they decide if it should be included in the classification system (Zevin et al., 2024).

Separately, advanced volunteers tag glitches that do not seem to belong to an existing classes, creating new tags in Talk as they do so. These efforts take place on the Talk board, as shown in Figure 3, and are largely self-managed. A few moderators, selected from the active volunteers by the science team, monitor the discussion and help answer questions and moderate conflicts (what Crowston and Fagnot (2018) would describe as meta-contribution, contributions that enable others to contribute more effectively). However, moderators hold little power to sanction or shape other participants' tagging behaviors. Volunteers are free to develop and maintain their own personomies and to use or ignore the developing folksonomy. Nor have the project scientists organized any effort to garden these tags. As a result, the emerging folksonomy is unruly and suffers many of the shortcomings associated with open folksonomies. Furthermore, the Zooniverse platform does not provide functionality to

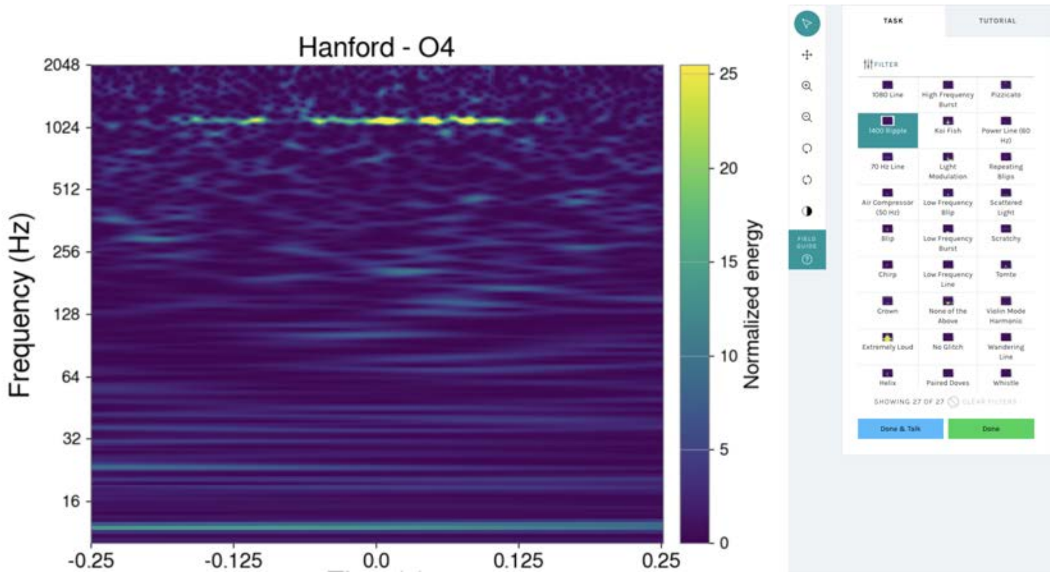


Figure 2. The Gravity Spy classification interface, with a glitch spectogram on the left and the scientist-approved tags on the right.

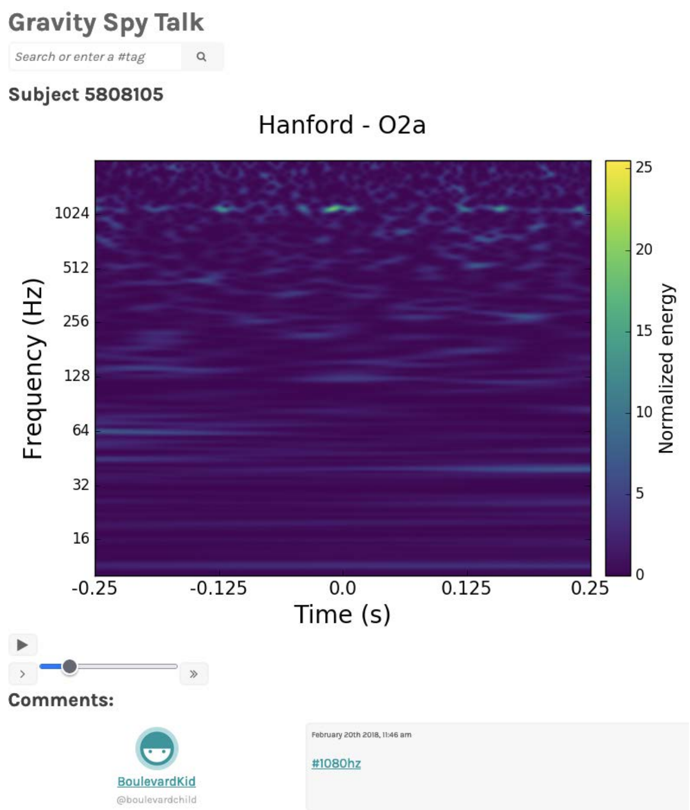


Figure 3. The Talk page for a particular subject showing how a tag (in this case, #1080Hz at the bottom right) can be applied to label glitches that do not seem to fit an existing class. The Zooniverse platform supports searches for discussions including a tag, e.g., by clicking on the link in the comments.

manage a folksonomy. For instance, even if moderators were to settle on a preferred tag, there is no easy way to update tags previously applied to objects, to indicate that tags are synonyms or to mark a tag as preferred or not.

AO3 has bifurcated the power to tag individual objects and to manage the folksonomy. Individual users generate and own the content and the tags they apply and any personomies they develop are not edited by others. However, at the folksonomy level, approximately 200 “tag wranglers” (out of 6,698,000 users) have power to merge, separate and hierarchically organize tags to develop a coherent folksonomy that supports searching. The system provides functionality to support this process, e.g., to indicate which terms are synonyms and which should or should not be auto-completed when tagging, as shown in Figure 4. Further, the project has developed extensive policies to guide the process.

In *Flickr*, contributors are the owner of their data and generally are the only ones who have authority to tag their photos, as illustrated in Figure 5. They may choose popular tags to make their photos more readily searchable by the community or instead use tags with personal meaning. There is no authority nor any specific process or system support to curate the folksonomy or to clean up the tags to maintain controlled vocabularies. In the framework of Crowston and Fagnot (2018), there is no possibility for meta-contribution to Flickr.

Supporting taggers or searchers by developing consensus

Supporting the development and use of a folksonomy must consider who tags objects versus who uses tags to search for objects. If it is the same person tagging and retrieving, different gardening techniques may be more appropriate than if tagging and retrieving are done by different people.

In *Gravity Spy*, most users classify glitches into classes defined by the science team, supporting the science team’s use of the tags for searching for instances known types of glitches. The Zooniverse platform makes building such a classification system straightforward. In contrast, the tags created by advanced volunteers for novel glitches mostly serve these volunteers, as science team members do not engage with them unless called upon to do so. There is some communal usage, e.g., one advanced volunteer looking for images tagged by another, but such activity is limited. The focus for building consensus is the development of proposals for new glitch classes, which a handful of active volunteers undertake through discussion on the “New Glitch Classes” Talk board, which has had 18 contributors out of 33,739 volunteers to the project.

Archive of Our Own (AO3) primarily faces outward. Authors tag contributions and volunteers curate the folksonomy to increase the retrievability of contributed content. For readers, tags are both a retrieval and filtering tool; given diverse tastes in the community, an important application of tags in the folksonomy is the application of the Boolean NOT to eliminate unwanted topics. Similarly, avoiding the gardening technique of editing the tags that individual users assign to a contribution is consistent with the community value of creative freedom. Instead, the tag wranglers attempt

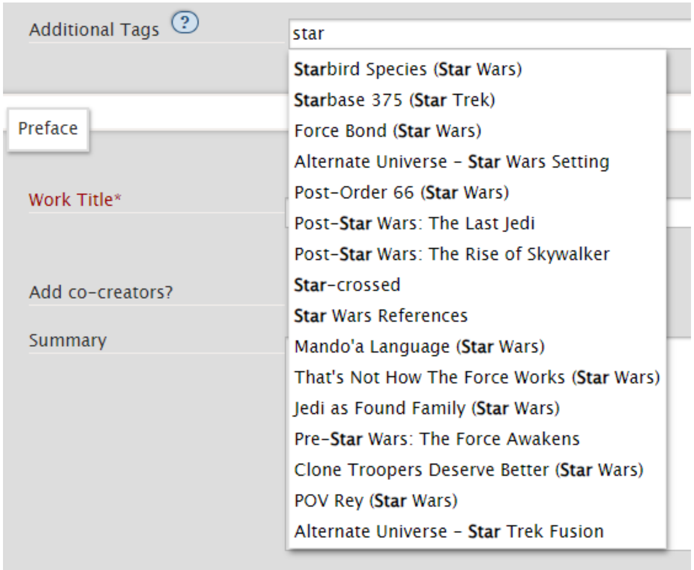


Figure 4. The AO3 new work interface showing autofills populated by tag wrangler-approved tags.

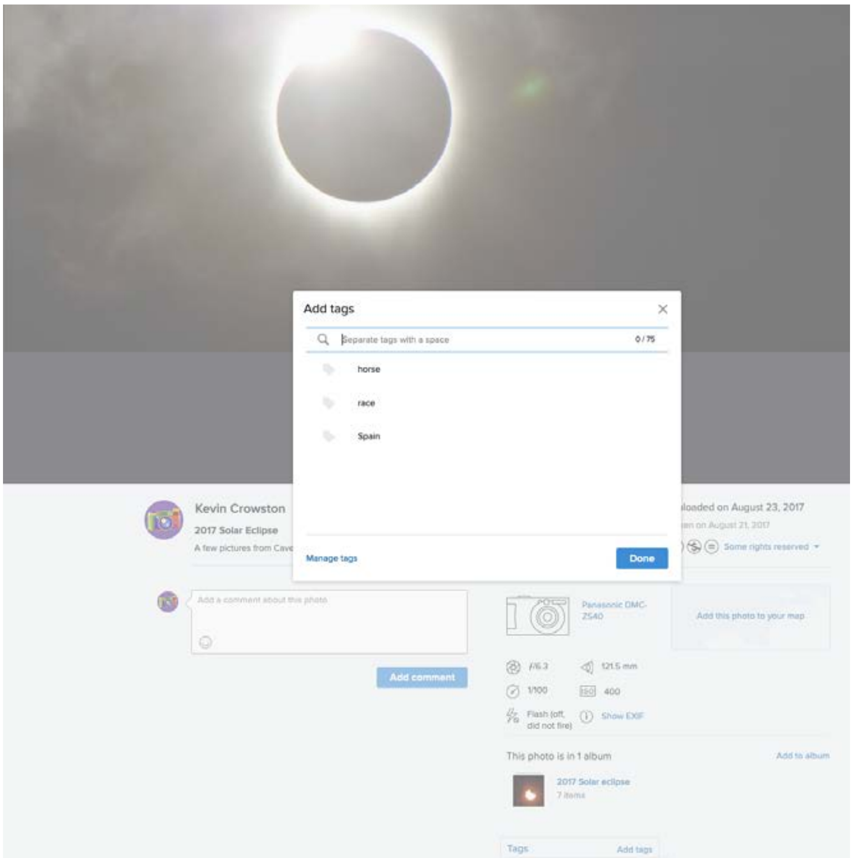


Figure 5. The Flickr interface showing how tags can be applied to a photo. The popup includes previously used tags.

to fit the contribution into the existing folksonomy by equating terms to improve retrieval. Tag wranglers make their decisions independently, but strive to identify the consensus of contributors about the meaning of tags. They can also discuss problematic issues with other tag wranglers in private discussion fora.

In contrast to the previous examples, *Flickr*, a photo sharing site, seems to primarily support individuals' tagging, though with unclear benefit. Individuals can apply tags to organize their collection of uploaded pictures, but they can also sort them into albums. There is little or no attempt to have contributors reach a consensus on tags for a specific photo or to agree on an overall organization scheme. As in Gravity Spy, one can find discussions regarding appropriate tags, but it is likely that few users have seen them or feel motivated to follow them. As a result, the support tags provide for searching is compromised, since there is promise of neither precision (finding only relevant images, since they may be tagged indiscriminately) nor recall (finding all relevant images, since they may not be tagged consistently).

When in the process and how is stability maintained?

Finally, projects face a choice of when to intervene in the process to maintain the stability for the folksonomy. Specifically, a project can promote gardening techniques as new contributions are tagged or later in the process at the collections level.

In *Gravity Spy* project, one finds two levels of stability and temporality. In the Talk and Discussion forums, the speed of change is high and there is little or no attempt to keep a stable folksonomy. However, at the project level, changes to terminology come slowly and effort is put into maintaining a stable and lasting classification system that has been vetted not only by volunteers but also by expert science team members. Unfortunately, the review process is time consuming and so LIGO scientists have been able to examine only a few of the proposals generated. As a result, there is a struggle to keep the recognized list of glitches in line with changes in the detector that fix some glitches but yield some new ones. This being said, the team behind *Gravity Spy* have discussed if they should promote more structured tagging practices at the point where individuals tag an object in Talk. They have considered autofill, spell-check and computationally-derived suggestions that would help volunteers compare their own tags with existing tags. However, the Zooniverse system would need to be updated to support these functions.

During tagging, users in *AO3* do not seem to attempt to maintain stability. Users may infer tagging conventions from autofill suggestions, as only tags established by tag wranglers appear in such suggestions, though there is no obligation to follow them. However, stability is maintained at the folksonomy level, as a select group of trained participants links synonymous terms, differentiates homographs and establishes relationships among terms. As the system preserves users' original tags, the provenance of the terms is maintained.

In *Flickr*, when individuals tag images the system suggests previously used tags, which individuals can choose to accept or decline. In other words, there is limited effort to maintain stability for a particular user, but not across multiple users.

	Gravity Spy	Archives of Our Own (AO3)	Flickr
Power and support	• Contributors generate tag; no enforcement to use particular tags • Scientists have final say on additions to recognized terminology	• At the personomy level, contributors generate and own data and maintain their own tags • At the folksonomy level, tag wranglers are recruited and trained and given permission and support to curate the folksonomy	• Contributors choose and maintain tags; no requirement to use particular terms • There are discussions of appropriate tags, but completely informal
Tagging vs. searching (Individual vs collective)	• Tagging with known tags serves science team • Tagging in Talk mostly serves the person doing the tagging; some use by fellow volunteers	• Curation process does not change user-chosen tags • Terms are linked for retrieval by connecting tags at folksonomy level	• Can be used by both contributors and searchers but doesn't seem to serve either well • Suggests previously used tags for individual object tagging
When in the process	• Intervenes early for known tags and late for novel tags • Only a few new terms get added to the official classification system • Unstable in the short term but seeks stability in the long term	• Intervenes late in the process by managing the folksonomy • Only equates terms at the folksonomy level for retrieval • Maintain provenance of tag history	• Minor intervention early at the time of tagging objects by offering tag suggestions • Fast-changing, with no need for stability

Table II. Central tensions in the development of a shared language.

Our findings are summarized in Table II.

Discussion

The development and maintenance of folksonomies offer a window into the process of building and maintaining a shared language in highly distributed groups and in particular crowdsourcing settings. While many efforts to develop shared terminology take a top-down approach where experts promote official knowledge organization systems, folksonomies allow us to consider bottom-up approaches where the language develops over time and may serve diverse purposes. Furthermore, folksonomies allow us to determine how different crowdsourcing projects may develop different structures of legitimation and authority over the emerging ontology. Different projects face different users and objectives and so make different decisions about how to address challenges in supporting folksonomies. For each of the questions addressed above, we summarize across the projects and identify factors that influence choices.

First, who gets to decide on adopted terminology stands as an important problem. However, it is not a simple choice between a top-down or bottom-up approach. Projects like AO3 allocate power to both individual contributors and a selective group of trained participants but at different points in the process. By doing so, they give individuals free range to name their objects but allow the community to develop authoritative structures facilitating search and retrieval. Other projects like *LibraryThing* permit all participants to edit and vote on tags for the emerging folksonomy. At the same time, they carefully keep track of its provenance so decisions can be debated and reversed at a later stage if the situation or the community call for such interventions. These are just a few options for the division of authority.

There are three important considerations for questions about who manages a folksonomy. First is matching the delegated power to the technical ability to make and enforce decisions. These decisions need to go hand-in-hand, as systems evolve to support desired functions or expectations of folksonomies managers are tempered by limits on their capabilities, as in Gravity Spy. Second, supporting a more developed management process is costly, requiring a lot of mostly unseen labour to make it happen. For instance, AO3 requires continued contributions from its tag wranglers; Gravity Spy needs support and proposal review by LIGO scientists. The motivations for these contributions need to be considered. In the case of AO3, tag wranglers are volunteers, what Crowston and Fagnot (2018) called meta-contributors. They suggested that such contributors are motivated by ideology, social factors such as group identification and and the intrinsic enjoyment of the task, and that projects should recognize and reward those who take on these roles. In contrast, the LIGO scientists involved in Gravity Spy are hoping for data to improve the detector but the connection of the project to their work is at best indirect, reducing the urgency of contributing. Finally, the complexity of the folksonomy may limit who can contribute. The folksonomies in Gravity Spy and Flickr are just lists of terms but AO3's has more structure, requiring more expertise to manage.

Second, the goals of different users of the folksonomy need to be weighed. In particular, tensions can arise if the people tagging objects are not the same as those using these tags to search for content. In this situation, interests might not be aligned between the individuals tagging and the collective need to facilitate retrieval of shared objects. Some projects appear to solve this problem by maintaining two systems. For instance, AO3 allows individuals to develop and maintain their own tags. At the same time, they give a small group the authority to garden the shared folksonomy in ways that facilitate search and retrieval.

Different motivational factor may lead projects to promote gardening techniques that intervene at the individual or the communal level (top or bottom of Figure 1 and Table I). If the purpose of the tagging is driven mainly by individual needs, the project may want to intervene at the personomy level to help individuals achieve consistency in their tagging. Contrariwise, if the goal is to support the work and communication of the community, the project needs to focus on promoting consensus in the tagging situation and developing coherent folksonomies. Of course, these are not exclusive: projects may need to support both individual and collective work.

A key question here is the process for achieving consensus, if any, and what kind of system support is provided. Questions about how to achieve consensus are closely tied to questions of who is involved, since it defines what group needs to come to agreement. In the three cases, we see a range of approaches from discussion to individual decisions to no process at all. In the absence of consensus, the emergent folksonomy will be nothing more than the concatenation of individual personomies. For instance, Flickr is participatory, in that users contribute the tags, but not consensual. It is worth noting that few gardening efforts appear to target personomies and the folding of curated personomies into larger folksonomies. One can imagine projects that help participants develop coherent personomies with high value for the individual that could then serve as the basis for the curation of a folksonomy.

Finally, projects need to decide when in the process of language development they want to intervene in order to maintain a balance between a stable ontology and the ability of the project to accommodate ongoing changes. Considering the different gardening techniques, projects can either intervene at the time of tagging or wait for a folksonomy to develop before cleaning up the classification of contributions (assuming there are tools available to do so). A particular factor to consider is the needs of newcomers to the project. As a project matures, so does the size and complexity of its folksonomy. If thousands of volunteers have added their own tags with little coordination, newcomers will be overwhelmed by an unruly folksonomy with many overlapping and hard-to-interpret terms. To deal with this complexity, they need guidance on how to tag objects as they get started. Only with experience might they later develop an appreciation of the freedom to choose their own tags.

Conclusions

Folksonomies enable groups to use consistent terminology, for instance, to facilitate searches for items. Folksonomies can develop in crowdsourced systems through discussion among contributors and users but it requires considerable effort to make the terminology consistent and it is difficult to make decisions visible or to enforce usage. Our examination of the three identified issues identifies the important link between organizational power and technical capability and raises several questions that project designers should consider as they consider how to manage folksonomies.

This short research note has several limitations that present opportunities for continued research. First, we examined only three sites. Other projects may have identified additional approaches to the issues considered. Future research should map different divisions of power and expanding the toolbox of possible interventions from a broader range of projects. Second, as we noticed in Table II, most attention seems to have been given to gardening techniques that intervene when individuals tag and object (upper left corner) or when a folksonomy has emerged (lower right corner). Little research has considered gardening techniques that help the community reach consensus around a single object (lower left corner) or promote the development of coherent personomies (upper right corner). Intervening at these points could lead to more coherent and useful folksonomies later in the process that promote a strong shared language and easy retrieval of relevant objects.

Acknowledgments

Partially funded by US National Science Foundation grants, INSPIRE 15–47880, HCC 21–06865, and HCC 21-06882. The authors thank the users who contribute to the projects studied in this research.

References

Al-Khalifa, H. S. and H. C. Davis (2007): 'Exploring the Value of Folksonomies for Creating Semantic Metadata'. *International Journal on Semantic Web and Information Systems (IJSWIS)*, vol. 3, no. 1, pp. 12–38.

Ames, M. and M. Naaman (2007): 'Why We Tag: Motivations for Annotation in Mobile and Online Media'. In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. San Jose California USA, pp. 971–980, ACM.

Aurnhammer, M., P. Hanappe, and L. Steels (2006): 'Integrating Collaborative Tagging and Emergent Semantics for Image Retrieval'. In: *15th International World Wide Conference (WWW)*.

Begelman, G., P. Keller, and F. Smadja (2006): 'Automated Tag Clustering: Improving Search and Exploration in the Tag Space'. In: *Collaborative Web Tagging Workshop at WWW2006, Edinburgh, Scotland*. pp. 15–33.

Bonney, R., C. B. Cooper, J. Dickinson, S. Kelling, T. Phillips, K. V. Rosenberg, and J. Shirk (2009): 'Citizen Science: A Developing Tool for Expanding Science Knowledge and Scientific Literacy'. *BioScience*, vol. 59, no. 11, pp. 977–984.

Bullard, J. (2019): 'Curated Folksonomies: Three Implementations of Structure through Human Judgment'. *Knowledge Organization*, vol. 45, no. 8, pp. 643–652.

Chun, S. and M. Jenkins (2005): 'Cataloguing by Crowd; A Proposal for the Development of a Community Cataloguing Tool to Capture Subject Information for Images (A Professional Forum)'. In: *Museums and the Web*. p. 6.

Crowston, K. and I. Fagnot (2018): 'Stages of Motivation for Contributing User-Generated Content: A Theory and Empirical Test'. *International Journal of Human-Computer Studies*, vol. 109, pp. 89–101.

Crowston, K. and E. E. Kammerer (1998): 'Coordination and Collective Mind in Software Requirements Development'. *IBM Systems Journal*, vol. 37, no. 2, pp. 227–245.

Dieckman, C. (2022): 'Comparisons of Aboutness of OCLC FAST Headings and IMDb "Plot Keywords" for Documentary Films'. *Journal of Library Metadata*, vol. 22, no. 1-2, pp. 135–148.

Doan, A., R. Ramakrishnan, and A. Y. Halevy (2011): 'Crowdsourcing Systems on the World-Wide Web'. *Communications of the ACM*, vol. 54, no. 4, pp. 86–96.

Dougherty, D. (1992): 'Interpretive Barriers to Successful Product Innovation in Large Firms'. *Organization science*, vol. 3, no. 2, pp. 179–202.

Feinberg, M. (2006): 'An Examination of Authority in Social Classification Systems'. *Advances in Classification Research Online*, pp. 1–11.

Fortson, L., K. Masters, R. Nichol, K. Borne, E. Edmondson, C. Lintott, J. Raddick, K. Schawinski, and J. Wallin (2012): 'Galaxy Zoo: Morphological Classification and Citizen Science'. In: M. J. Way, J. D. Scargle, K. M. Ali, and A. N. Srivastava (eds.): *Advances in Machine Learning and Data Mining for Astronomy*. CRC Press.

Guy, M. and E. Tonkin (2006): 'Tidying up Tags'. *D-lib Magazine*, vol. 12, no. 1, pp. 1082–9873.

Hine, C. (2008): *Virtual Ethnography*. SAGE Publications Ltd.

Hjørland, B. (2008): 'What is Knowledge Organization (KO)?'. *Knowledge Organization*, vol. 35, no. 2-3, pp. 86–101.

Howe, J. (2010): 'Crowdsourcing: Why the Power of the Crowd Is Driving the Future of Business'. *American Journal of Health-System Pharmacy*, vol. 67, no. 18, pp. 1565–1566.

Jackson, C., K. Crowston, C. Østerlund, and M. Harandi (2018): 'Folksonomies to Support Coordination and Coordination of Folksonomies'. *Computer Supported Cooperative Work (CSCW)*, vol. 27, pp. 647–678.

Lam, W. S. E. (2008): 'Language Socialization in Online Communities'. In: N. H. Hornberger (ed.): *Encyclopedia of Language and Education*. Boston, MA: Springer US, pp. 2859–2869.

Landbeck, C. (2007): 'Folksonomies: Trouble in Paradise: Conflict Management and Resolution in Social Classification Environments'. *Bulletin of the American Society for Information Science and Technology*, vol. 34, no. 1, pp. 16–20.

Lee, D. H. and T. Schleyer (2012): 'Social Tagging Is No Substitute for Controlled Indexing: A Comparison of Medical Subject Headings and CITEULIKE Tags Assigned to 231,388 Papers'. *Journal of the American Society for Information Science and Technology*, vol. 63, no. 9, pp. 1747–1757.

Lu, C., J.-r. Park, and X. Hu (2010): 'User Tags Versus Expert-assigned Subject Terms: A Comparison of LibraryThing Tags and Library of Congress Subject Headings'. *Journal of Information Science*, vol. 36, no. 6, pp. 763–779.

Macgregor, G. and E. McCulloch (2006): 'Collaborative Tagging as a Knowledge Organisation and Resource Discovery Tool'. *Library Review*, vol. 55, no. 5, pp. 291–300.

Mao, M., S. Chen, F. Zhang, J. Han, and Q. Xiao (2021): 'Hybrid Ecommerce Recommendation Model Incorporating Product Taxonomy and Folksonomy'. *Knowledge-Based Systems*, vol. 214, no. Journal Article, pp. 106720.

Miller, P. (2005): 'Web 2.0: Building the New Library'. *Ariadne*, vol. 45, no. 30, pp. 10.

Mocnik, F.-B., A. Zipf, and M. Raifer (2017): 'The OpenStreetMap Folksonomy and Its Evolution'. *Geo-spatial Information Science*, vol. 20, no. 3, pp. 219–230.

Munk, T. B. and K. Mørk (2007): 'Folksonomy, The Power Law & the Significance of the Least Effort'. *Knowlege Organization*, vol. 34, no. 1, pp. 16–33.

Noruzi, A. (2006): 'Folksonomies: (Un)Controlled Vocabulary?'. *Knowledge Organization*, vol. 33, no. 4, pp. 199–203.

O'Leary, D. E. (2015): 'Crowdsourcing Tags in Accounting and Finance: Review, Analysis, and Emerging Issues'. *Journal of Emerging Technologies in Accounting*, vol. 12, no. 1, pp. 93–115.

Østerlund, C., K. Crowston, and C. Jackson (2020): 'Building an Apparatus: Refractive, Reflective, and Diffractive Readings of Trace Data'. *Journal of the Association for Information Systems*, vol. 21, no. 1, pp. 10.

Peters, I. and K. Weller (2008): 'Tag Gardening for Folksonomy Enrichment and Maintenance'. *Webology*, vol. 5, no. 3, pp. 1–18.

Price, L. (2019): 'Fandom, Folksonomies and Creativity: The Case of the Archive of Our Own'. *The Human Position in an Artificial World: : Creativity, Ethics and AI in Knowledge Organization*, pp. 11–37.

Rafferty, P. and R. Hidderley (2007): 'Flickr and Democratic Indexing: Dialogic Approaches to Indexing'. In: *Aslib Proceedings*, Vol. 59. pp. 397–410.

Razikin, K., D. H. Goh, A. Y. Chua, and C. S. Lee (2011): 'Social Tags for Resource Discovery: A Comparison between Machine Learning and User-centric Approaches'. *Journal of Information Science*, vol. 37, no. 4, pp. 391–404.

Smith, C. A. and P. J. Wicks (2008): 'PatientsLikeMe: Consumer Health Vocabulary as a Folksonomy'. In: *AMIA Annual Symposium Proceedings*, Vol. 2008. p. 682, American Medical Informatics Association.

Spiteri, L. F. (2007): 'The Structure and Form of Folksonomy Tags: The Road to the Public Library Catalog'. *Information Technology and Libraries*, vol. 26, no. 3, pp. 13–25.

Stewart, B. and K. D. Kendrick (2019): "'Hard to Find": Information Barriers among LGBT College Students'. *Aslib Journal of Information Management*, vol. 71, no. 5, pp. 601–617.

Syn, S. Y. and M. B. Spring (2013): 'Finding Subject Terms for Classificatory Metadata from User-generated Social Tags'. *Journal of the American Society for Information Science and Technology*, vol. 64, no. 5, pp. 964–980.

Trant, J. (2009): 'Studying Social Tagging and Folksonomy: A Review and Framework'. *Journal of Digital Information*, vol. 10, no. 1, pp. 1–44.

Tsui, E., W. M. Wang, C. F. Cheung, and A. S. Lau (2010): ‘A Concept–Relationship Acquisition and Inference Approach for Hierarchical Taxonomy Construction from Tags’. *Information Processing & Management*, vol. 46, no. 1, pp. 44–57.

Walker, J. (2005): ‘Feral Hypertext: When Hypertext Literature Escapes Control’. In: *Proceedings of the Sixteenth ACM Conference on Hypertext and Hypermedia*. Salzburg Austria, pp. 46–53, ACM.

Yi, K. and L. M. Chan (2009): ‘Linking Folksonomy to Library of Congress Subject Headings: An Exploratory Study’. *Journal of Documentation*, vol. 65, no. 6, pp. 872–900.

Zevin, M., C. B. Jackson, Z. Doctor, Y. Wu, C. Østerlund, L. C. Johnson, C. P. L. Berry, K. Crowston, S. B. Coughlin, V. Kalogera, S. Banagiri, D. Davis, J. Glanzer, R. Hao, A. K. Katsaggelos, O. Patane, J. Sanchez, J. Smith, S. Soni, L. Trouille, M. Walker, I. Aerith, W. Domainko, V.-G. Baranowski, G. Niklasch, and B. Téglás (2024): ‘Gravity Spy: Lessons Learned And A Path Forward’. *The European Physical Journal Plus*, vol. 139, no. 1, pp. 100.

Zheng, T., P. Seetharaman, and B. Pardo (2016): ‘SocialFX: Studying a Crowdsourced Folksonomy of Audio Effects Terms’. In: *Proceedings of the 24th ACM International Conference on Multimedia*. Amsterdam The Netherlands, pp. 182–186, ACM.

Zhitomirsky-Geffet, M., B. H. Kwaśnik, J. Bullard, L. Hajibayova, J. Hamari, and T. Bowman (2016): ‘Crowdsourcing Approaches for Knowledge Organization Systems: Crowd Collaboration or Crowd Work?’. *Proceedings of the Association for Information Science and Technology*, vol. 53, no. 1, pp. 1–6.

Zhou, K., C. Yang, L. Li, C. Miao, L. Song, P. Jiang, and J. Su (2023): ‘A Folksonomy-Based Collaborative Filtering Method for Crowdsourcing Knowledge-Sharing Communities’. *Kybernetes*, vol. 52, no. 1, pp. 328–343.

Syed, H. A.; Schorch, M.; de Carvalho, A. F. P.; Meisner, K.; Pipek, V.; Wulf, V. (2024): Impacts vs Implications: Rushed Technology Adoption in Small and Medium Enterprises due to Covid-19 Pandemic. In: Proceedings of the 22nd European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies - Notes, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591), DOI: 10.48340/ecscw2024_n07

Impacts vs Implications: Rushed Technology Adoption in Small and Medium Enterprises due to Covid-19 Pandemic

Hussain Abid Syed[1], Marén Schorch[2], Aparecido Fabiano Pinatti de Carvalho[3], Konrad Meisner[1], Volkmar Pipek[1], Volker Wulf[1]
[1]University of Siegen, Germany; [2]Bielefeld University of Applied Sciences and Arts, Germany; [3]University of Oslo, Norway
{hussain.syed, konrad.meisner, volkmar.pipek, volker.wulf}@uni-siegen.de, maren.schorch@hsbi.de, fabiano.pinatti@ifi.uio.no

Abstract. The surge of digitalization during the pandemic has long-lasting impacts on business organizations: small and medium enterprises (SMEs) rushed towards digitalization to continue operations with the ever-changing local and international implications of the pandemic. This caused these businesses to adopt digital technologies for work and interconnection, often overlooking the necessary use innovations and skills required for long-term usage, with the aim of becoming agile and resilient against the pandemic. To understand the long-term impacts and implications of rushed technology adoption in SMEs, we used case-oriented qualitative comparative analysis (QCA) and content analysis over a collection of thirty semi-structured interviews with SMEs based in Germany. The preliminary findings of our long-term study reveal the haphazard and impulsive decision making in SMEs, rushing towards digitalization to be resilient and agile to the changing work conditions which led to a high demand for technology-related skillset in employees. Through this study we contribute to the understanding of technology adoption, use and appropriation for work in SMEs elaborating the necessity for long-term processual nature which is similar to notion of infrastructuring.

Introduction

The pandemic crisis (2019-2022) exposed many vulnerabilities in organizational infrastructures, especially exposing the small and medium enterprises (SMEs) with limited resilience and inability to stay operational due to inadequate/insufficient technology, skills and usage (Alaqra & Kitkowska, 2021; Priyono et al., 2020). One of the reasons SMEs were unprepared for such an emerging situation was their unwillingness to recognize and rectify gaps in inter and intra-organizational digital connectivity (Chang et al., 2010; Lecerf & Omrani, 2020). It reaffirmed the perception about SMEs being fragile against emergent situations as they do not hold the resources and technical systems often equated with resilience capabilities (Sullivan-Taylor & Branicki, 2011). Technology adoption as means of interconnectivity has positive impacts on business operations, directly and indirectly, and has immense potential to support resilience in organizations making them agile towards changes providing alternate mediums for working (Ollo-López & Aramendía-Muneta, 2012). Interconnectedness via the usage of information and communication technologies also supports articulation work and collaboration for crisis in business organizations (Pipek et al., 2014; Robertson & Wagner, 2015; Tarutė & Gatautis, 2014). Many empirical investigations have been vested in grounding the theoretical foundations, usability, use cases and design implications of individual digital technologies (Ciolfi & Lockley, 2018; Dabbish & Kraut, 2006; Koch et al., 2015; Lewkowicz & Liron, 2019; Nauwerck & Forssell, 2018; Schmidt, 2011). Still, the implications and impacts of rushed digitalization for resilience, especially in the context of SMEs, are not explored expansively and deserves further attention from the computer-supported cooperative work (CSCW) community (Hespanhol, 2017; Ludwig, Kotthaus, et al., 2018; Pipek et al., 2014).

Resilience focused organizations are both proactive and agile where the focus is on both developing long-term plans for predicted disruptions, but at the same time ensuring that the right skills and resources are in place to deal with the unexpected (Burnard et al., 2018). The usage and adoption of digital technologies have become a pinnacle of interest in many research communities since the advent of the enduring pandemic, discussing the voluntary and involuntary rush of digitalization in the business world (Akpan et al., 2020; Kimuli et al., 2021; Priyono et al., 2020; Thorndahl & Frandsen, 2020). Rushed technology adoption means that a company has discovered the lack of digital technologies to continue operations and is rushing to adopt digital technologies for interconnection as a means of survival in times of crisis (Faraj et al., 2021). The impacts of technology adoption during the pandemic will also continue in the post-pandemic period (Fletcher & Griffiths, 2020; Sein, 2020). A focus in SMEs is timely and relevant given how these organizations have massively been contributing to the economy – as is the case of Germany, SMEs are considered crucial as they incarnate scope for innovation, job creation, and integration of local communities (European Union, 2015). SMEs are also distinct due to their elementary organizational structures, constrained financial capital, centralized decision making, organizational customs and cultures, top-down organizational policies, and the high reliability of employees' skills for business operations (Blatz et al., 2018; Tarutė & Gatautis, 2014). These peculiarities and expertise in their respective areas of operation tend to keep them in their 'comfort zones' and hence sometimes hinder the adoption of digital technologies (Bos et al., 2002). In this contribution, we draw attention to organizational resilience and its relations with the adoption and usage of digital technologies for interconnection and cooperative work. In so doing, we try to answer the following research question: *How did the pandemic influence technology adoption in SMEs, and what are the implications and long-term impacts on technology usage as a result?*

To this objective, we conducted thirty semi-structured interviews in SMEs to assess the impact of the crisis and the inclination or aversion to digital technologies. We analyzed the interviews using case-oriented qualitative comparative analysis (QCA) and content analysis to identify the trends in technology adoption during the pandemic. Direct and calibrated quantification of qualitative data was done for case-based comparison using QCA to unveil the extended dimension of technology adoption during the crisis and expected usage after crisis. The following sections will first illustrate the related work on technology adoption and resilience from multidisciplinary perspectives. Then we will discuss the applied research methods for data collection and analysis and present our results, and finally, discuss the contribution based on the results for CSCW research.

Related Work

Technology Adoption and Usage for Resilience

The concept of organizational resilience claims it to be the fundamental ability of an organization to adjust its functioning before, during, or after changes in the environment to successfully (1) manage both expected and unexpected disturbances, and (2) exploit both expected and unexpected opportunities (Burnard & Bhamra, 2011). Resilience is an acquired trait for an organization that becomes an intrinsic property when the adopted resources can reduce vulnerability and improve the agility and speed of the organization to manage crises effectively (Bhamra et al., 2011; Burnard et al., 2018). Resilience through technology adoption and usage is considered to ensure agile work practices, as the ability to repair old practices and develop new practices when old ones are no longer possible (Junker et al., 2021; Mark & Semaan, 2008). This also holds for digital technologies in SMEs as means to provide infrastructure for interconnectivity between different faculties of a business organization with capabilities to support operations, work and collaboration in normality and crisis (Ludwig, Kotthaus, et al., 2018; Mark et al., 2009; Mark & Semaan, 2008; Pipek et al., 2014; Semaan et al., 2016; Syed et al., 2021).

The pandemic has acted as a natural breaching experiment that challenged the taken-for-granted expectations about digitalization and revealed the issues with digital infrastructures, the persistence of the analog in digitalization, and the brittleness of unchecked digitalization in business organizations (Faraj et al., 2021). The notion of infrastructure in CSCW and related fields is defined by the entirety of devices, tools, technologies, standards, conventions, and protocols on which the individual worker or the collective rely to carry out the tasks and achieve the goals assigned to them (Pipek & Wulf, 2009). Infrastructures emerge because of long term and processual endeavors embedded in and learnt as practices and are invisible only surfacing or crystalizing upon breakdown (Star & Bowker, 2018; Star & Ruhleder, 1994).

To cope with the pandemic, the world retreated towards digital work practices and building technology infrastructures rapidly that led to rushed technology adoption in businesses, enforced work from home, and shifting technological affordances resulting in positive and negative effects on work in general and collaborative work in particular (Cho et al., 2020; Waizenegger et al., 2020). However, organizational resilience through the adoption of digital technologies cannot be established without interconnecting all focus areas of business as a measure of strategic priority. To their disadvantage, SMEs were found to be unprepared to accept the evolving digitalization trends even before the pandemic (Burnard et al., 2018; Koch et al., 2015; Manochehri et al., 2012; Tarutė & Gatautis, 2014), hence resulting in non-processual technology adoption, rushed digitalization and infrastructural breakdowns (Alaqra & Kitkowska, 2021; Kimuli et al., 2021).

Technology Adoption and Usage in SMEs

Ackerman et al., (Ackerman et al., 2007) argue that for users to adopt technology, they must both understand its capabilities and have scaffolding mechanisms for collectively discovering, structuring, iterating, and enacting practices that enable the technology to become a resource. For SMEs, factors like skillset, innovativeness, organizational support, business strategy, leadership, as well as company culture and orientation towards technology adoption also hold relevance (Acar et al., 2005; Blatz et al., 2018). Whereas limited funds, lack of skills, expensive technological transition, and inadequate infrastructure are the key barriers to adopting digital technologies (Ongori, 2009; Ongori & Migiro, 2010). Due to lean administrative hierarchies and centralized decision making, the decision for technology adoption is mostly an executive or a management driven endeavor in SMEs (Aidah et al., 2017; Priyono et al., 2020).

Digital technologies for interconnection spans throughout an organization; they further specify the abilities of an organization, including collaboration among employees, between departments and with suppliers and customers (Nguyen, 2009; Ongori, 2009). The usage of digital technologies of interconnection makes SMEs adaptive and flexible when dealing with crises and are effective means of realizing the coping strategies necessary to build organizational resilience (Etemad, 2020; Falkner & Hiebl, 2015; Priyono et al., 2020). The interview study employed for this research does not examine the adoption of individual digital technologies; instead, we orchestrate the results from a descriptive and qualitative lens by considering the digital technologies for interconnection as a broad category for SMEs. It provides a critical account for multidisciplinary research by analyzing the impacts of rushed technology adoption in SMEs and implications for long-term usage and organizational resilience.

Methods of Data Collection and Analysis

The interview study is based on thirty semi-structured interviews conducted in local SMEs based in Germany's second biggest industrial region during the years 2021-23. The interview topics were derived from former studies of our team and literature and covered: past experiences with crisis, their crisis management and resilience strategies, handling of the pandemic so far, experiences with technology adoption for staying operational in business, and short- and long-term impacts on policies and usage of digital technologies. Interview participants included representative from companies (SMEs) from a wide range of branches, as diverse as bakeries, material production companies, chemical manufacturers, textile etc., and services like procurement, training, logistics, wholesale, distribution etc. The interview partners were primarily in executive or management positions because technology adoption is typically a top-down initiative in such firms, as discussed in the related work. All interviews were conducted via digital media like Zoom or Skype in single sessions (lasting forty-five to sixty minutes in duration) and were transcribed later for analysis. Informed consent was obtained before the interviews, formally, which is also part of the trust-building process with the participants – please refer to Table II for a complete list of the participants and metadata.

The data collected via interviews were analyzed using qualitative analysis methods in two stages: Firstly, we employed content analysis (Mayring, 2022), which involved the classical process of coding the transcripts and determining the strength of prominent codes in the data. The most prominent codes identified during the analysis include crisis definition, long and short-term strategies against the pandemic, usage of technologies before pandemic, technology adoption during pandemic, and effects of technology adoption. The authors collaborated in group data analysis sessions consisting of two to three researchers from multi-disciplinary backgrounds, which contributed to validating interpretations, analyses and gaining intersubjectivity of the interpretations. MaxQDA© was used for the qualitative data analysis, and codes were developed inductively from data material through active listening and reading the transcripts. The coded data has ultimately been summarized in the key findings that are presented across the results section.

While coding for content analysis, we also employed direct quantifiable measures and calibration techniques following the qualitative comparative analysis (QCA) method by Ragin (Ragin, 1989). This allowed us to create dimensions for case-oriented analysis. Quantification via calibration in QCA complemented the content analysis technique, enabling the examination of cross-case patterns across different SMEs. This approach provided us with a form of meta-analysis, unveiling underlying implications and impacts that transcend individual case specificity. The following section illustrates both parts of the study with further methodological explanations and results.

Analysis and Findings

In the following sections, we elaborate on the findings from both parts of our study, namely the results from the interview study using case-oriented QCA and content analysis. Findings from both analyses are analytically developed with the assistance of the literature and through interpretation of the results.

Case-Oriented Qualitative Comparative Analysis of SMEs

To enrich our findings from the more descriptive and interpretative content analysis and to add a meta layer of analysis, we quantified some details in the interviews while coding, that resulted in identifying six relevant variables for a case-oriented comparison (as shown in Table I). We recorded the direct, quantifiable measures, where possible, for the identified variables during the in-depth content analysis. For instance, the hypothetical duration of the crisis as anticipated by the SME (HDC), as well as the anticipated financial survival (FS) amid the pandemic, are the directly found measures that are quantified in years. Similarly, the amount and variety of digitalization projects (ADil and VDil), defined by the total number of projects were also mentioned by the interview partners as digitalization initiatives taken up by the company during the pandemic.

More subtle notions were also found during the analysis which were quantified using the calibration technique of the case-oriented qualitative comparative analysis (QCA) (Ragin, 1989), which uses the calibration of categorical answers into quantifiable measurements by assigning the values to the categories. For example, in Table I, the investments made during the pandemic for digitalization (IiC) has been quantified via calibration. More specifically, we looked at the type of investments and assigned them values using the calibration scale, i.e., no investments are '0', minor investments equal '0.3', complete projects are represented by a score of '0.7', and a total renewal of a business would be classified as a '1'. A similar calibration scale was used to describe the reaction of the pandemic (RC) on the work practices before the pandemic. Ranging between no to severe reactions, '0' shows no change in practices, and '1' would describe drastic reactions like full closure of a business. In between the reaction scale, '0.3' describes minor reactions like implementing the disinfection and physical distance like strategies on-site, while '0.7' would be a substantial reaction with (partial) change of practices like allowing employees to work remotely in the home office, less hours or alternate days of work.

Table I. Dimensions of case-oriented comparative analysis

Variable	**Description**	**Measurement**
HDC	Hypothetical Duration of Crisis	In years (0.25 = quarter a year, 0.5 = half a year, 0.75 = three quarters of a year and so on)
FS	Financial Survival	In years (0.25 = quarter a year, 0.5 = half a year, 0.75 = three quarters of a year and so on)
RC	Reaction to Corona	Intensity of reaction to crisis as change in work practices (0=No Reaction, 0.3= Minor Reaction, 0.7= Substantial Reaction, 1=Drastic Reactions)
IiC	Investments during Crisis	Investments in new projects (0=No Investments, 0.3=Minor Investments, 0.7=Project-specific Investments, 1=Complete Business Renewal)
ADiI	Amount of Digitalization projects in Crisis	Number of projects via the adoption of digital technologies (indications of rushed digitalization)
VDiI	Variety of Digitalization projects in Crisis	Number of different projects; adoption of various digital technologies for interconnection between faculties of business (aligned with technology groups mentioned in Table 1, Section 3.1)

These dimensions were applied throughout the interviews to build a basis for case-oriented analysis. The individual case-oriented results (meta-analysis), along with interview metadata, are shown in Table II. Additionally, we have calculated the respective means and standard errors for each dimension across all the cases to show an accumulative trend as per these dimensions from thirty SME representatives. The aim of the comparative and content analysis is not to generalize the phenomenon of technology adoption for SMEs, but to perform an intersubjective evaluation of the expected technology adoption and impacts amid and after the pandemic in these SME cases.

Trends in Comparative Analysis

The overall trend in the comparative analysis suggests that the interviewed SMEs, on average, started at least one new project associated with technology adoption for digital interconnection during the crisis within their specific fields of operation. It points out the reactive nature of SMEs as organizations (Blatz et al., 2018; Burnard et al., 2018), because the adoption of technologies was influenced by the need to mitigate crisis. This contrasts with the resilience focused organizations which are proactive ensuring the right skills and resources are in place to deal with the unforeseen situations.

Table II. Quantified Results of Interviews and Interview Metadata

Metadata of the interview partners and SMEs				**Case-oriented quantified dimensions**					
Firm	**Case (Business Sector)**	**Total Employees**	**Interview partner**	**HDC**	**FS**	**RC**	**IiC**	**ADiI**	**VDiI**
F1	Fitness-Health	1-10	CEO	0.25	1	0.3	0	2	1
F2	Training	10-20	CEO	1	>3	0.3	0	2	1
F3	Construction	1-10	CEO	2	0.5	0.7	0.3	0	0
F4	Hunting-Leisure	1-10	CEO	1.25	2	0	0.3	0	0
F5	Consultancy	1-10	CEO	1	1	0.7	0.7	3	3
F6	Print-Stationery	1-10	CEO	1	>3	0.7	0.7	2	2
F7	Retail	10-20	Manager	0.5	0.5	0.3	0.7	0	0
F8	Consultancy	10-20	CEO	2	1	0.3	0	1	1
F9	Retail	10-20	CEO	0.75	>3	0.7	0.7	3	2
F10	Planning	20-30	CEO	1.25	>3	0.3	0	2	2
F11	Photo-Media	1-10	CEO	1	0.25	0.5	0	1	1
F12	Wine	10-20	CEO	2.25	>3	0.3	0	0	0
F13	Chemical	80-90	CEO	1	0.25	0.7	0.7	0	0
F14	Prof. Services	40-50	CEO	0.5	0	0.7	1	1	1
F15	Hotel	1-10	Manager	0.5	0.5	0.7	0.7	1	1
F16	Advertisement	1-10	CEO	1	>3	0.3	0.7	3	2
F17	Food-Beverages	20-30	CEO	1	0.5	0	0	3	3
F18	Wholesale	30-40	CEO	1	0.25	0.7	0	1	1
F19	Textile	30-40	Manager	1	0	0.7	0	3	3
F20	Mechanical	1-10	CEO	1	0.25	0.3	0	0	0
F21	Prof. Services	10-20	Manager	0	>3	0.3	0.7	1	1
F22	Sanitation	1-10	Manager	2	>3	0.7	0.7	0	0
F23	Planning	1-10	CEO	2	>3	0	0	0	0
F24	Fitness-Health	1-10	Employee	0.25	>3	0.7	0.3	2	2
F25	Restaurant	1-10	CEO	2	1	0.3	0	1	1
F26	Painting-Decor	10-20	Employee	0	>3	0.3	0.7	0	0
F27	Food-Beverages	90-100	CEO	3	0.25	0.3	0.3	0	0
F28	Construction	1-10	CEO	0	2	0	0	0	0
F29	Restaurant	140-150	CEO	2	3	0.7	0.7	1	1
F30	IT	210-220	Manager	2	1	0.7	0.3	1	1
Mean				1.15	1.61	0.44	0.34	1.13	1
Standard Error				0.14	0.22	0.05	0.06	0.20	0.18

However, some of the interviewed SMEs did not consider adopting new technologies during the pandemic due to the type of business sector and nature of business operations like companies from construction, hunting and planning etc. Some companies, however, used the crisis more intensively than others. Five companies started at least three technology adoption projects also with a variety of digital technologies from the earlier identified groups of digital technologies. It is also worth mentioning that a direct relation between the amount or variety of digitalization projects and the potential resilience of an SME cannot be found directly within our sample. To find this relation with resilience, we used the calibrated variables like the investments during the crisis in digitalization projects (IiC), and the reaction to the crisis (RC).

The comparative analysis using calibrated measures revealed that the businesses that report an expected long financial survival even with a crisis (like sanitation, planning, construction companies) are not always keen to invest in new digitalization projects considering no substantial impact of crisis or even an increase in business due to crisis. However, this also cannot be taken as a generalization because there were also companies like print, retail and planning which started digitalization projects amid the pandemic and reacted to crisis with substantial measure viewing the crisis as an opportunity to digitalize work processes. Even the companies belonging to the same business sector reacted differently to the crisis and towards technology adoption like retail and planning companies show inconsistent patterns which also demonstrates that generalization is not possible to actualize the behavior of companies within one business sector.

On the other hand, the pandemic affects some businesses sectors more as compared to others, which is revealed by low levels of financial survival period and reacting substantially to crisis by changing work practices to stay afloat. Interestingly, these companies also show multiple new digitalization projects during the crisis and in the near future, which is their anticipated measure to increase resilience against crisis through rushed technology adoption. This is not the case for all the businesses as can be seen from the comparison by investment during crisis, reaction to crisis and digitalization projects.

The comparison identifies organizations with not drastic reaction to crisis but still investing in digitalization which means that these companies have means to survive and are operational amid the pandemic but view it as a chance to adopt technology (like food-beverages and advertisement). However, there are also companies which expect a prolonged crisis and must react substantially or drastically to the crisis by changing work practices to alternate days of work or less hours need to adopt technologies as a mean to survival (for example print, wholesale and restaurant). It can be explained by the industrial sector in which an SME is operational and the type of business model they employ for business organizations. Companies that are typically more traditional and work in manufacturing or services requiring hands-on personal involvement seem to invest less into digitalization. This would hold true for sectors like construction, offline trading, supermarkets, and chemical suppliers. On the other hand, sectors like media, online trading, health, training, or consultancy seem to be, on the one hand, rushed into digitalization and, on the other hand, use the pandemic as an opportunity to enhance the potential applications of digitalization within their respective fields of activity.

It seems obvious that the business sector has an influence, but it is one of the factors, among others like size, environmental changes, peer pressure, consumer demands, and above all, the need to have a continuous business. This also signifies the notion of organizational resilience that affirms the behavior of an organization to mitigate the change in order to reach stability after turbulence (Burnard & Bhamra, 2011). The adoption of digital technologies in some sectors, more than others, finds the demand for digital technologies of interconnection as a resilience-boosting measure to mitigate turbulence caused by the pandemic. We do think, nevertheless, that the decision when to and how to adopt digital technologies is not driven just by disruptions or crises. Strategies, personal decisions, innovation, use dependencies, and underlying premises, among others, also act as contributing factors for technology adoption (Aidah et al., 2017; Hoffmann et al., 2019). The results presented in terms of the differences from a case-oriented comparative analysis of the interviewed SMEs will be further elaborated with the content analysis to understand the importance and variability of reasons for technology adoption for digital interconnection in SMEs as a measure to boast resilience and agility.

Content Analysis Findings

Implications of the Pandemic for Technology Adoption

The content analysis reveals, with the start of the pandemic in March/April 2020, followed by restrictions for on-site work, which quickly snowballed into lockdown, resulting into different reaction from the companies from full scale business closure for some days to remote work or alternate working days, restricting only the selected employees at workplaces. This was followed by implications like supply-chain disruptions, declining customer base, problems with order completion, decreased production, and services due to 'physical distance' restrictions etc. The uncertainty interrelated with the rapidly changing situation caused multiple updates from the business organizations to employees, customers, and other stakeholders. This triggered a severe lag in communication, and the spread of false information was inevitable. As mentioned by an interview partner:

> Shortly after this crisis broke out, an employee wrote to us and offered that she would waive her salary, if we were not doing well. And that's when we noticed that there was a lag in communication. So, we immediately reacted that we were fine. We can pay the salaries. You don't have to worry about that (F21, Prof. Services).

The analysis also revealed that the business organizations that were already using digital technologies at the start of the pandemic had a competitive advantage and went into a smoother transition during the various stages of lockdown and restrictions. These companies showed resilience and agility to the rapidly deteriorating business scenarios during the pandemic. Technologies which were already a part of organizational infrastructure became were prominent during the crisis and allowed these businesses to remain operational. These organizations felt less need to resort to new technologies, as shared by an interview partner:

> We have no new digitalization projects planned, especially because of Corona. We are currently represented on social media and also have a WhatsApp business profile. We already have a few projects going on, before Covid, such as developing an app for smartphones and more. We don't feel the need to rush into new technologies because we are working as normal (F27, Food-Beverages).

Likewise, another participant mentioned that they are adopting digital technologies not to keep their business alive but to increase the efficiency of their business operations during the pandemic. This identifies a managed approach to technology adoption, where the agenda behind technology adoption is not to meet the essential business operations but to improve the performance of the business. They also said that:

> There are for sure additional topics we work on now for our efficiency. Our web-shop is to be named here. Additionally, we should mention the direct connection to our marketplaces that we are building through digital means (F9, Retail).

It also reflects the type of business model a business organization follows to operationalize its business. A business model with flexibility, agility and proactiveness is more resilient and this agility comes with an already existing technological infrastructure which is proactive to changes in the business environment (Burnard et al., 2018). An interviewee explained that their existing technologies make them flexible during the pandemic and they can make their business more proactive by adding more straightforward measures. They further elaborated that:

> Our strategy does not require any additional measures. We don't want to extend our advertising efforts to get sustain our business during pandemic, but we want to make the homepage more SEO capable. We also have a second homepage in mind with a different domain and staff is working on that right now. (F2, Training).

Some companies went a step further in technology usage and did use innovation with their adopted technologies to turn the crisis into an opportunity. This kind of use innovation triggering from a breakdown is synchronous with the concept of use innovation in the CSCW literature on infrastructures (Ludwig, Pipek, et al., 2018; Pipek & Wulf, 2009). As an interviewee explained that in addition to continuing everyday work in digital form, they have taken up the opportunity to reach out to their customers and reassure them of their services and that they will be taken care off even during the crisis. They added that:

> We have intensified and improved a new form of communication with our existing customers as well as addressing potential new customers and we have ramped up the pace. That we push ourselves using our customer base and history with them and say 'Hello, we're still in contact

with you! We are not cutting work hours. We can perform at full capacity', and we try to communicate that to our customers. (F14, Prof. Services).

Our findings also highlight that business organizations used the pandemic crisis to experiment and learn about different digital technologies which can aid them during emergent situations. The learning through coping part of resilience (Burnard & Bhamra, 2011; Egner et al., 2015a), was also found in the analysis, and this learning has led to technology adoption in some SMEs. This further emphasize the need for a processual mechanism for technology adoption for resilience, where digital technology adoption improves resilience by building adaptive capacity and presenting multiple coping strategies against crises. Reciprocally, the acquired resilience resulting in technology adoption by experience and learning gained by coping after and during crisis mitigation while using technology. As expressed by an interview partner:

> The working landscape is changing, and we have certainly learned a lot here in this Corona period. We have learned how to work in a home office and still keep in touch with our colleagues. We have learned how to make decisions in video conferences, and these will certainly be topics that will continue beyond Corona […] we have used these to work further, um, in particular in E-commerce and other technologies […] we also used the time to deal with topics that have been pushed back again and again in the past […] taking the next steps and are certainly much further ahead with these topics after Corona than before Corona (F7, Retail).

The phenomenon of rushed technology adoption

Unlike some businesses where technology usage led to increased resilience and potential for improvement, the pandemic crisis had other consequences for some of the interviewed firms. Some companies were rushed to adopt and use digital technologies to virtualize the business operations in a non-processual manner, specifically, for inter- and intra-digital interconnection of an organization i.e. collaboration, communication and external digital interconnection with customers. As explained by an interviewee,

> Then, of course, a faster transfer of information was needed. Despite everything, we have now set up a WhatsApp group with all employees, in which it is also, yes, as far as it is possible for someone, obligatory to be inside […] However, given these unique circumstances, it is far simpler to tell everything to everyone (F19, Textile).

Organizations that were rushed to use digital technologies, pertaining to restrictions at large, also expressed concerns like lack of knowledge and lack of experience with technologies, which made it not an easy transition for them considering the type of industrial sector and the business model of those organizations. A small business executive expressed this dilemma that he lacks the knowledge and know-how of these technologies (F1). He further explained that they know the need to adopt several technologies for interconnection because it is a matter of survival for them now in times of crisis. Still, their lack of experience and knowledge about digital technologies and their usage will affect their business, making it not a decision of choice but something they must do. The analysis also revealed that the lack of knowledge and experience is directly proportional with the skills of employees to use the adopted technologies. An interviewee from a different company reciprocated this notion and further added to this insight as:

> I try to convince my employees to get involved in the new projects. That's essential but the problem is that most of them are not very familiar with digitalization and new technologies (F2, Training).

As, using technology in day-to-day business operations requires learning to use the technology and developing a skillset for the technology (Kinnula et al., 2018; Piccolo & Pereira, 2019), that cannot be generated overnight in employees, even if the organization wants the employed personnel to learn and adopt digital technologies. Due to changing operational dynamics in SMEs with the forced and rushed adoption of digital technologies, the demand for potential employees with technology-related skills increased. A medium-sized hiring agency expressed these concerns related to the change in the expectations of SMEs for new employees:

> For us it will certainly also be a challenge to conduct the discussion with medium-sized companies about what the position profiles will look like in the future and also the framework conditions for them […] companies that were extremely conservative in the past and are now more or less forced to open-up to topics such as home office with flexible working hours, shift models also in the commercial area and administrative structures […] of course, the collaboration changes: Which tools does someone has to master, which communication technologies, where or how competent does someone has to be with different technologies? (F8, Consultancy).

The results emphasize on the processual mechanism for technology adoption with a mechanism to iteratively increasing the technology-related skillset within an organization by giving learning opportunities and experience with technologies required by the business. This long term and processual mechanism correlate with the notion of infrastructure in the CSCW literature which illustrates the longevity in reach and scope required for the establishment of practices and technologies, embedded and emerging from the existing conventions of practice to be learned as a part of membership to the process (Karasti et al., 2010; Karasti & Blomberg, 2018; Star & Ruhleder, 1994). Infrasturcturing efforts are required within SMEs, as it was found in the analysis that this processual construction of technology infrastructure is means to achieve resilience, as we can interpret from the insights shared by an interviewee:

> So, the online store was now the first thing that we just created so. That's of course the easiest thing for the customers to do, just click on it and get delivered […] we want to be more active on social media, to remain in contact with the customers and of course also not to fall into oblivion […] Then we offer so-called video consulting. So, that you call us via WhatsApp and then video call, and that you then make a personal shopping with your favorite shopping consultant quasi via videotelephony […] It is a long process, and we have a long way to go (F19, Textile).

This processual adoption of digital technologies as perceived by business organizations is not just logical but also strongly resonates with the concept of resilience: Organizational resilience is an acquired characteristic that is developed through a long-term process by initiating coping strategies, building adaptive capacity, and coping with an actual crisis and – in the long run – by evaluating past experiences of coping as part of a learning process (Burnard et al., 2018; Egner et al., 2015b). Also, as expressed by an interviewee:

> About digitalization, as we honestly said earlier, we took the first steps, but only what you had to do […] And now we've really made great strides again in the area of digitalization […] So, we now use the time to experiment and then draw upon our learnings, what worked? What didn't work? What can we use for our future? (F13, Chemical)

The content analysis of the interview dataset, showed patterns of technology adoption which are dissimilar to the trends from the pre-pandemic expectations, specific for the interviewed SMEs. Our findings suggest that the interviewed SMEs strived for internal digital interconnectivity and work articulation at the start of the pandemic, because the pandemic crisis was an unforeseen and unexpected situation for these organizations. The efforts for crisis mitigation through rushed digitalization were undertaken by some of the analyzed organizations because of the lack of technologies in-use, uncertainty and evolving scenarios arising since the start of the pandemic and related restrictions. Organizations searched for ways to continue collaborative work and task coordination and build cooperation between distinct units of a business organization through digital means.

As the pandemic crisis prolonged and the customer base started to decline, the necessity arose for digital means to reach the customers directly. The companies with established digital means to reach the customers had a competitive advantage as they could still sell their products and services. Some of the companies did not have means to digitalize their market spaces. These companies specifically went into rushed digitalization by setting up profiles in available digital marketplaces or started using the technologies for external interconnection with customers. However, the expected increase in the usage of advanced technologies for information processing was not found in the analysis of the interviewed SMEs. This can be interpreted as the SMEs were striving to stay afloat by adopting the required technologies for internal and external interconnection, the advanced technologies were not adopted. This can also point to one of the limitations of our study, as the interviewed set consist of only thirty SMEs from a rural industrial region in Germany and not from all business sectors.

Discussion

The pandemic crisis disrupted the ways of working and collaborating, affirming that there are hidden, unforeseen, and emergent factors with the potential to alter the usage and adoption of work practices and technologies. The learning opportunity for CSCW research post pandemic times, with the context of SMEs, broadens the horizon of action research by breeding novel focuses for emergent scenarios like organizational resilience that have the tendency to alter work practices and the technologies for supporting cooperative work. Organizational resilience is a concept heavily researched in management and business studies that talks about building adaptability and agility in an organization against changes and disruptions (Burnard et al., 2018; Burnard & Bhamra, 2011; Lee et al., 2013). This requires the appropriation of work practices, tailoring the adoption and usage of digital technologies and fixing the technological infrastructure in modular increments (Pipek & Wulf, 2009; Syed et al., 2021).

Different crises have unique impacts on business activities in SMEs, and our research highlights that the adoption of digital technologies for interconnection before a crisis, through a processual mechanism, is a crucial factor for crisis preparedness and organizational resilience (Pipek et al., 2014; Syed et al., 2021). In our research, we explored the state of technology adoption in SMEs for impacts to implications. First, there are the SMEs in the interviewed set that adopted technologies for digital interconnection and demonstrated agility in dealing with crises and enhanced organizational resilience through a smooth transition of work practices during the pandemic. These organizations showed a faster reaction to the crisis, and they expect to recover from the impacts of the crisis in a shorter duration of time. These organizations viewed the pandemic crisis as an opportunity to appropriate work practices through technology-induced use innovations and invested in further technology adoption post pandemic.

Second, there are the SMEs in the interviewed set that did not digitalize interconnection between business faculties before the pandemic crisis. With the advent of the pandemic, the organizational infrastructures and process scrambled without or with the breakdown of the technological infrastructure binding the organization. These organizations rushed into technology adoption for interconnection and had to make hefty investments in digital technologies (Faraj et al., 2021). These businesses demonstrated less expected financial survival and expectations to stay in crisis for a longer period. The results also pointed out the disparity in the perceived usefulness of digital technologies indicates the incoherence in the technology-related skillset of an organization, before the pandemic crisis for adopting the much-needed technological interventions. However, the rushed digitalization phenomenon established new requirements for employees and organizations demanding rapid skill development to understand, plan and use digital technologies for interconnection and cooperative work. It also increased the demand for personnel with the required skillset for the usage of adopted technologies.

The disparity between SMEs' and the rushed technology adoption due to the pandemic also identified the lack of processual technology adoption in SMEs. We identify this as a need for infrastructuring for resilience through processual technology adoption by recursively increasing the usage of technologies for interconnection and the technology-related skillset in an organization. This evolutionary process aims at embedded resilience in an organization to adapt and continue in the changing environment and resonates with the infrastructure and infrastructuring discourses in CSCW and related fields (Karasti et al., 2010; Karasti & Blomberg, 2018; Ludwig, Pipek, et al., 2018; Syed et al., 2021). This widens the research lens on technology adoption and resilience with prospects to study infrastructuring ethnographically in SMEs. The long-term processual nature of technology adoption and the relationality of ontological dimensions required for organizational resilience, when considered under the lens of infrastructure and infrastructuring, present interesting arenas for further research in CSCW.

Limitations and Conclusion

In addition, our study comes with limitations that also suggest opportunities for future research. First, the interview studies used in this research are done in the context of German SMEs, which may also differ from the SMEs in other parts of the world. Second, our study draws from the theory of organizational resilience (Burnard & Bhamra, 2011; Pries-heje & Baskerville, 2021) and technology adoption is considered as means to enhance resilience (Liu et al., 2008; Mark & Semaan, 2008; Semaan et al., 2016), but there can be other factors that contribute to organizational resilience in SMEs. The findings of the qualitative study are rigorous to the extent that the results are validated using in-depth content and comparative analysis but understanding the technology adoption under the lens of infrastructuring requires a longitudinal ethnography over extended time, which is also an agenda of our further research. The Covid-19 pandemic generated burgeoning complications for SMEs which tried to mitigate the effects of the pandemic by introducing technologies for digital interconnection and cooperative work. However, this rushed digitalization constricted the organizations further due to the inadequacy of the skillset and resources to support this change. The content analysis and the comparative analysis with QCA's calibration on the qualitative dataset unveiled the state of technology adoption and use in SMEs in-and-post pandemic. The analyses identified two types of business organizations, i.e., ones that were resilient through advancements in technology adoption and the ones that had to do rushed technology adoption for survival. The analyses further revealed that technology adoption depends on the acquired skillset of an organization and the processual evolution of technology used to achieve organizational resilience. We found that SMEs have an ad-hoc approach to technology adoption and lag in building organization resilience by adopting digital technologies for interconnection.

References

Acar, E., Koçak, I., Sey, Y., & Arditi, D. (2005). Use of information and communication technologies by small and medium-sized enterprises (SMEs) in building construction. *Construction Management and Economics*. https://doi.org/10.1080/01446190500127112

Ackerman, M. S., Halverson, C. A., Erickson, T., & Kellogg, W. A. (2007). *Resources, Co-Evolution and Artifacts: Theory in CSCW (Computer Supported Cooperative Work)*. Springer-Verlag.

Aidah, M., Ngemba, H. R., & Hendra, S. (2017). A study of barriers to e-commerce adoption among small medium enterprises in Indonesia. *Proceedings of the 2017 International Conference on Education and Multimedia Technology - ICEMT '17*, 75–80. https://doi.org/10.1145/3124116.3124124

Akpan, I. J., Udoh, E. A. P., & Adebisi, B. (2020). Small business awareness and adoption of state-of-the-art technologies in emerging and developing markets, and lessons from the COVID-19 pandemic. *Journal of Small Business and Entrepreneurship*. https://doi.org/10.1080/08276331.2020.1820185

Alaqra, A. S., & Kitkowska, A. (2021). Impact of Intrinsic Factors and COVID-19 Pandemic on the Use of Technology. *Conference on Human Factors in Computing Systems - Proceedings*. https://doi.org/10.1145/3411763.3451669

Bhamra, R., Dani, S., & Burnard, K. (2011). Resilience: The concept, a literature review and future directions. In *International Journal of Production Research*. https://doi.org/10.1080/00207543.2011.563826

Blatz, F., Bulander, R., & Dietel, M. (2018). Maturity Model of Digitization for SMEs. *2018 IEEE International Conference on Engineering, Technology and Innovation, ICE/ITMC 2018 - Proceedings*. https://doi.org/10.1109/ICE.2018.8436251

Burnard, K., & Bhamra, R. (2011). Organisational resilience: Development of a conceptual framework for organisational responses. *International Journal of Production Research*, *49*(18). https://doi.org/10.1080/00207543.2011.563827

Burnard, K., Bhamra, R., & Tsinopoulos, C. (2018). Building organizational resilience: Four configurations. *IEEE Transactions on Engineering Management*, *65*(3). https://doi.org/10.1109/TEM.2018.2796181

Chang, S. I., Hung, S. Y., Yen, D. C., & Lee, P. J. (2010). Critical factors of ERP adoption for small- and medium- sized enterprises: An empirical study. *Journal of Global Information Management*, *18*(3). https://doi.org/10.4018/jgim.2010070104

Cho, S., Suh, B., & Lee, J. (2020). Not too much, nor too less: Investigating which information should be shared for awareness between remote workers. *Proceedings of the ACM Conference on Computer Supported Cooperative Work, CSCW*. https://doi.org/10.1145/3406865.3418308

Ciolfi, L., & Lockley, E. (2018). From Work to Life and Back Again: Examining the Digitally-Mediated Work/Life Practices of a Group of Knowledge Workers. *Computer Supported Cooperative Work: CSCW: An International Journal*, *27*(3–6), 803–839. https://doi.org/10.1007/s10606-018-9315-3

Dabbish, L. A., & Kraut, R. E. (2006). Email overload at work: An analysis of factors associated with email strain. *Proceedings of the ACM Conference on Computer Supported Cooperative Work, CSCW*. https://doi.org/10.1145/1180875.1180941

Egner, H., Schorch, M., & Voss, M. (eds). (2015a). Learning and calamities: Practices, interpretations, patterns. In *Learning and Calamities: Practices, Interpretations, Patterns*. Routledge 2015. https://doi.org/10.4324/9780203794678

Egner, H., Schorch, M., & Voss, M. (eds). (2015b). Learning and calamities-What have we learned?: Steps towards an integrative framework. In *Learning and Calamities: Practices, Interpretations, Patterns*. Routledge 2015. https://doi.org/10.4324/9780203794678

Etemad, H. (2020). Managing uncertain consequences of a global crisis: SMEs encountering adversities, losses, and new opportunities. In *Journal of International Entrepreneurship* (Vol. 18, Issue 2). https://doi.org/10.1007/s10843-020-00279-z

European Union. (2015). User guide to the SME Definition. *Publications Office of the European Union*. https://doi.org/10.2873/782201

Falkner, E. M., & Hiebl, M. R. W. (2015). Risk management in SMEs: a systematic review of available evidence. In *Journal of Risk Finance* (Vol. 16, Issue 2). https://doi.org/10.1108/JRF-06-2014-0079

Faraj, S., Renno, W., & Bhardwaj, A. (2021). Unto the breach: What the COVID-19 pandemic exposes about digitalization. *Information and Organization*, *31*(1). https://doi.org/10.1016/j.infoandorg.2021.100337

Fletcher, G., & Griffiths, M. (2020). Digital transformation during a lockdown. *International Journal of Information Management*, *55*. https://doi.org/10.1016/j.ijinfomgt.2020.102185

Hespanhol, L. (2017). More than smart, beyond resilient: Networking communities for antifragile cities. *ACM International Conference Proceeding Series*, *Part F128532*. https://doi.org/10.1145/3083671.3083683

Hoffmann, J., Frölian, H., Morin, A., & Bleider, M. (2019). Development of an Industrie 4.0 software platform for SMEs. *ACM International Conference Proceeding Series*. https://doi.org/10.1145/3312714.3312715

Junker, T. L., Bakker, A. B., Gorgievski, M. J., & Derks, D. (2021). Agile work practices and employee proactivity: A multilevel study. *Human Relations*. https://doi.org/10.1177/00187267211030101

Karasti, H., Baker, K. S., & Millerand, F. (2010). Infrastructure time: Long-term matters in collaborative development. *Computer Supported Cooperative Work*, *19*(3–4). https://doi.org/10.1007/s10606-010-9113-z

Karasti, H., & Blomberg, J. (2018). Studying Infrastructuring Ethnographically. In *Computer Supported Cooperative Work: CSCW: An International Journal* (Vol. 27, Issue 2). https://doi.org/10.1007/s10606-017-9296-7

Kimuli, S. N. L., Sendawula, K., & Nagujja, S. (2021). Digital technologies in micro and small enterprise: evidence from Uganda's informal sector during the COVID-19 pandemic. *World Journal of Science, Technology and Sustainable Development*, *18*(2). https://doi.org/10.1108/wjstsd-02-2021-0017

Kinnula, M., Iivari, N., Isomursu, M., & Laari-Salmela, S. (2018). 'Worksome but Rewarding' – Stakeholder Perceptions on Value in Collaborative Design Work. *Computer Supported Cooperative Work: CSCW: An International Journal*, *27*(3–6), 463–494. https://doi.org/10.1007/s10606-018-9328-y

Koch, M., Schwabe, G., & Briggs, R. O. (2015). CSCW and Social Computing. *Business & Information Systems Engineering*, *57*(3), 149–153. https://doi.org/10.1007/s12599-015-0376-2

Lecerf, M., & Omrani, N. (2020). SME Internationalization: the Impact of Information Technology and Innovation. *Journal of the Knowledge Economy*, *11*(2). https://doi.org/10.1007/s13132-018-0576-3

Lee, A. V., Vargo, J., & Seville, E. (2013). Developing a Tool to Measure and Compare Organizations' Resilience. *Natural Hazards Review*, *14*(1). https://doi.org/10.1061/(asce)nh.1527-6996.0000075

Lewkowicz, M., & Liron, R. (2019). The Missing "Turn to Practice" in the Digital Transformation of Industry. *Computer Supported Cooperative Work (CSCW)*, 1–29. https://doi.org/10.1007/s10606-019-09347-y

Liu, P.-J., Laffey, J. M., & Cox, K. R. (2008). *Operationalization of technology use and cooperation in CSCW*. 505. https://doi.org/10.1145/1460563.1460644

Ludwig, T., Kotthaus, C., Stein, M., Pipek, V., & Wulf, V. (2018). Revive Old Discussions! Socio-technical Challenges for Small and Medium Enterprises within Industry 4.0. *Proceedings of 16th European Conference on Computer-Supported Cooperative Work - Exploratory Papers*.

Ludwig, T., Pipek, V., & Tolmie, P. (2018). Designing for collaborative infrastructuring: Supporting resonance activities. *Proceedings of the ACM on Human-Computer Interaction*, *2*(CSCW). https://doi.org/10.1145/3274382

Manochehri, N. N., Al-Esmail, R. A., & Ashrafi, R. (2012). Examining the impact of information and communication technologies (ICT) on enterprise practices: A preliminary perspective

from Qatar. *Electronic Journal of Information Systems in Developing Countries*, *51*(1). https://doi.org/10.1002/j.1681-4835.2012.tb00360.x
Mark, G., Al-Ani, B., & Semaan, B. (2009). Resilience through technology adoption: Merging the old and the new in Iraq. *Conference on Human Factors in Computing Systems - Proceedings*, 689–698. https://doi.org/10.1145/1518701.1518808
Mark, G., & Semaan, B. (2008). Resilience in collaboration: Technology as a resource for new patterns of action. *Proceedings of the ACM Conference on Computer Supported Cooperative Work, CSCW*, 137–146. https://doi.org/10.1145/1460563.1460585
Mayring, P. A. E. (2022). Qualitative content analysis. In *International Encyclopedia of Education: Fourth Edition*. https://doi.org/10.1016/B978-0-12-818630-5.11031-0
Nauwerck, G., & Forssell, R. C. (2018). The Digital Work Environment–a Challenge and an Opportunity for CSCW. *Proceedings of 16th European Conference on Computer-Supported Cooperative Work*, 1–18. https://doi.org/10.18420/ecscw2018
Nguyen, T. U. H. (2009). Information technology adoption in SMEs: An integrated framework. *International Journal of Entrepreneurial Behaviour and Research*. https://doi.org/10.1108/13552550910944566
Ollo-López, A., & Aramendía-Muneta, M. E. (2012). ICT impact on competitiveness, innovation and environment. *Telematics and Informatics*, *29*(2), 204–210. https://doi.org/10.1016/j.tele.2011.08.002
Ongori, H. (2009). Role of Information Communication Technologies Adoption in SMES: Evidence from Botswana. *Research Journal of Information Technology*. https://doi.org/10.3923/rjit.2009.79.85
Ongori, H., & Migiro, S. O. (2010). Information and communication technologies adoption in SMEs: literature review. *Journal of Chinese Entrepreneurship*. https://doi.org/10.1108/17561391011019041
Piccolo, L. S. G., & Pereira, R. (2019). Culture-based artefacts to inform ICT design: foundations and practice. *AI and Society*, *34*(3), 437–453. https://doi.org/10.1007/s00146-017-0743-2
Pipek, V., Liu, S. B., & Kerne, A. (2014). Crisis Informatics and Collaboration: A Brief Introduction. In *Computer Supported Cooperative Work: CSCW: An International Journal* (Vol. 23, Issues 4–6). https://doi.org/10.1007/s10606-014-9211-4
Pipek, V., & Wulf, V. (2009). Infrastructuring: Toward an integrated perspective on the design and use of information technology. *Journal of the Association for Information Systems*, *10*(5), 447–473. https://doi.org/10.17705/1jais.00195
Pries-heje, J., & Baskerville, R. (2021). Achieving Resilience through Agility. *42nd International Conference on Information Systems*, 2196.
Priyono, A., Moin, A., & Putri, V. N. A. O. (2020). Identifying digital transformation paths in the business model of smes during the covid-19 pandemic. *Journal of Open Innovation: Technology, Market, and Complexity*, *6*(4). https://doi.org/10.3390/joitmc6040104
Ragin, C. C. (1989). *The Comparative Method : Moving Beyond Qualitative and Quantitative Strategies.* 206.
Robertson, T., & Wagner, I. (2015). CSCW and the Internet of Things. In *ECSCW 2015: Proceedings of the 14th European Conference on Computer Supported Cooperative Work, 19-23 September 2015, Oslo, Norway*. https://doi.org/10.1007/978-3-319-20499-4_15
Schmidt, K. (2011). The concept of "work" in CSCW. *Computer Supported Cooperative Work*, *20*(4–5), 341–401. https://doi.org/10.1007/s10606-011-9146-y
Sein, M. K. (2020). The serendipitous impact of COVID-19 pandemic: A rare opportunity for research and practice. *International Journal of Information Management*, *55*. https://doi.org/10.1016/j.ijinfomgt.2020.102164
Semaan, B. C., Britton, L. M., & Dosono, B. (2016). Transition resilience with ICTs: "Identity awareness" in veteran re-integration. *Conference on Human Factors in Computing Systems - Proceedings*, 2882–2894. https://doi.org/10.1145/2858036.2858109
Star, S. L., & Bowker, G. C. (2018). How to Infrastructure. In *Handbook of New Media: Social Shaping and Consequences of ICTs*. https://doi.org/10.4135/9781848608245.n12
Star, S. L., & Ruhleder, K. (1994). Steps towards an ecology of infrastructure: Complex problems in design and access for large-scale collaborative systems. *Proceedings of the 1994 ACM*

Conference on Computer Supported Cooperative Work, CSCW 1994, 253–264. https://doi.org/10.1145/192844.193021

Sullivan-Taylor, B., & Branicki, L. (2011). Creating resilient SMEs: Why one size might not fit all. *International Journal of Production Research*, *49*(18). https://doi.org/10.1080/00207543.2011.563837

Syed, H. A., Schorch, M., Ankenbauer, S. A., Hassan, S., Meisner, K., Stein, M., Skudelny, S., Karasti, H., & Pipek, V. (2021). Infrastructuring for organizational resilience: Experiences and perspectives for business continuity. Infrastructuring for organizational resilience: Experiences and perspectives for business continuity. *Dl.Eusset.Eu*. https://doi.org/10.18420/ecscw2021-wsmc02

Tarutė, A., & Gatautis, R. (2014). ICT Impact on SMEs Performance. *Procedia - Social and Behavioral Sciences*, *110*, 1218–1225. https://doi.org/10.1016/j.sbspro.2013.12.968

Thorndahl, K. L., & Frandsen, L. N. (2020). Logged in While Locked Down: Exploring the Influence of Digital Technologies in the Time of Corona. *Qualitative Inquiry*. https://doi.org/10.1177/1077800420960176

Waizenegger, L., McKenna, B., Cai, W., & Bendz, T. (2020). An affordance perspective of team collaboration and enforced working from home during COVID-19. *European Journal of Information Systems*, *29*(4). https://doi.org/10.1080/0960085X.2020.1800417

Laura Stojko, Lin Lin, Roman Soucek, Klaus Moser, Michael Koch (2024): Introducing a Gamification Element in Enterprise Collaboration Platforms: Only a Flash in the Pan or a Lasting Effect? In: Proc. of the 22nd European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies - Notes, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591), DOI: 10.48340/ecscw2024_n08

Introducing a Gamification Element in Enterprise Collaboration Platforms: Only a Flash in the Pan or a Lasting Effect?

Laura Stojko[1], Lin Lin[2], Roman Soucek[3], Klaus Moser[2], Michael Koch[1]

[1] University of the Bundeswehr Munich, Germany; [2] Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany; [3] MSH Medical School Hamburg, Germany

Abstract. Enterprise collaboration platforms are expected to facilitate effective information exchange by supporting employee sociability, i.e., finding communication partners and building common ground. However, they often suffer from low user engagement, requiring the implementation of additional design elements to encourage user participation. Though previous research found evidence for the effectiveness of introducing new features, particularly gamification elements, to such platforms, the question remains whether it represents more than a flash in the pan and creates some sustainable effects over time. Therefore, the current longitudinal quasi-experimental field study investigates the effectiveness of introducing one exemplary gamification element, a progress bar to encourage profile completion, as a new feature within a digital collaboration platform in a large public sector organization across time. We collected data before (t1 – t3) and after (t4 – t6) implementation of the progress bar. We analyzed the data using linear mixed-effects models, enabling the assessment of time effects and interaction effects of time and progress bar implementation. Profile completion rates increased over time, and introducing a progress bar significantly impacted users' profile completion behavior. More importantly, we found both short-term effects and, after an interim decline, a sustainable change in user behavior after the progress bar implementation over time. Thus, this study presents quantitative evidence of the long-term effectiveness of introducing a gamification element in enterprise collaboration platforms over time.

Introduction

Enterprise collaboration platforms support communication and knowledge exchange within organizations. User profiles are an essential basis of such platforms. They enable connections and sociability within the knowledge exchange process (Nonaka and Takeuchi, 1995; Nonaka et al., 1996) as users can more easily identify persons with the knowledge they want to connect with (Schubert and Glitsch, 2016). But, given that enterprise collaboration platforms are organization-driven, the profiles often lack completeness probably because users are only formally required to use the platform due to institutional obligations, e.g., a profile is created when they enter the organization by default, the internal management communication is handled via the platform, they have to use the platform to complete some mandatory training (for example on data privacy or IT security), etc. In contrast to other social platforms that are used privately, such as LinkedIn for job search and career networking, employees may not accept the full potential of the enterprise collaboration platform and lack intrinsic motivation for using it; consequently, filling out the profile is not prioritized (Trier et al., 2017; Nielsen and Razmerita, 2014; Greeven and Williams, 2017). To tackle this problem, one promising approach is to use a gamification element, such as a progress bar, to enhance users' motivation to complete their profiles and increase user engagement with these platforms. Though we have some evidence of the effectiveness of such changes, data is often based on case study approaches or experimental designs with a limited scope. This is a problem because we cannot rule out that new features get some interest, but their effects are quickly in vain. Whether an intervention may help to change user engagement, for example, by increasing profile completion and changing user behavior on a platform in the long run, is an open issue and a question we want to investigate within one specific enterprise collaboration platform.

Before diving into the details of the platform, we analyzed and described our research objective. We reviewed related work on understanding a progress bar as a gamification element on enterprise collaboration platforms.

Related Work

An enterprise collaboration platform can be understood as "[...] complex, large-scale information infrastructures comprising an ecosystem of highly integrated tools and functionality to support collaborative work and information sharing in organizations" (Schubert and Williams, 2022). It is a system with "A purposefully developed selection of applications/tools that are fully integrated and provided to the user in a workspace under a uniform interface." (Williams et al., 2020)

The following characteristics are common for such platforms (Nitschke, 2021, p.23-25):

- *Users*: Users are part of an organization but do not necessarily participate voluntarily on the platform. Consequently, the extent of usage is a matter of discretion for individuals. Some research shows that increasing the number of users may increase platform value and adoption (Herzog and Richter, 2016; Herzog and Steinhuser, 2016) and that user profiles are essential for finding an expert and networking (Schubert and Glitsch, 2016).
- *Access and ownership*: Enterprise collaboration platforms are internal, used within the organization and only accessible by authorized employees (Schubert and Williams, 2013; Schwade and Schubert, 2017).
- *Integration and socio-technical relations*: Often, enterprise collaboration platforms are large-scale heterogeneous platforms (De Reuver et al., 2018) that are geographically distributed across various contexts, cultures, and time zones.
- *Structure*: Each organization adjusts and builds its enterprise collaboration platform for its specific context and needs. Generally, Williams and Schubert (2018) found three levels of structure for such platforms: Platform level, community level, and content level.
- *Functionalities*: Gewehr et al. (2017) state that a platform's flexibility in integrating new functionalities will be more relevant in the future and requires involving users of the platform to address their needs.

Enterprise social media is a closely related category. It can be defined as follows: "Web-based platforms that allow workers to (1) communicate messages with specific coworkers or broadcast messages to everyone in the organization; (2) explicitly indicate or implicitly reveal particular coworkers as communication partners; (3) post, edit, and sort text and files linked to themselves or others; and (4) view the messages, connections, text, and files communicated, posted, edited and sorted by anyone else in the organization at any time of their choosing." (Leonardi et al., 2013) Research about enterprise social media investigates ways to increase user participation on such platforms (Chin et al., 2020; Meske et al., 2019; Hacker et al., 2017; Schiller and Meiren, 2018). For example, Van Osch et al. (2015) report in their study that the functionalities' uniqueness and relevance to the employee's daily work and clearly describing the system's benefits and purpose are required to increase its adoption and use, whereas Schwade and Schubert (2019) defines various user types that differ in motivations for participating in such systems.

While the previously mentioned research considered individual differences in user participation in enterprise collaboration platforms, the more intriguing problem is that many platforms suffer from low user participation in general. One answer has been to ask why certain features are not well accepted. For example, the problem of profile completion has been studied in different contexts and from various perspectives: How can we predict missing profile information using a feature-oriented analysis? (Haghir Chehreghani, 2017) What are the appropriate methods to analyze and investigate user profiles on online social networks? (Hazimeh et al., 2019) Another and probably even more promising approach is to introduce gamification elements to enhance user experience in general and motivate users to contribute to the platform in particular. Gamification is defined as "[...] the use of game design elements in non-game contexts" (Deterding et al., 2011). A detailed discussion of gamification elements is provided by Sailer et al. (2013) and Reeves and Read (2009). One example of such an element is progress bars. Note that in gamification, a progress bar used is not one showing the progress of a loading program or system interaction (Windows updates, file transfer,...) but an achievement-based feature, for example, profile completion with elements to motivate users to fill in their profiles (Werbach and Hunter, 2012). As noted by Mazarakis and Bräuer (2020); Mazarakis and Bräuer (2023), progress bars are rarely investigated gamification elements and thus require further investigations in various contexts, especially as studies also show a positive influence on task performance. One example is Mekler et al. (2017), who conducted a study using a progress bar to increase intrinsic motivation and performance within a specific task, levels in this case, reporting promising results on its influence on task performance.

Gamification elements and profiles have also been studied in various papers on social media like Facebook or LinkedIn (van Dijck, 2013; Daniels et al., 2021). However, these research findings cannot be applied to an enterprise context, as the individuals' motivations differ (Yousaf et al., 2022; Laitinen and Sivunen, 2021). Research findings regarding gamification within enterprise systems show the importance of analyzing such approaches within this specific context (Suh and Wagner, 2017; Meske et al., 2016, 2017). Schubert et al. (2014) and Greeven and Williams (2017) specifically mention progress bars as a gamification element for enterprise systems but do not show whether and how they are effective in the long run.

In summary, enterprise collaboration platforms aim to connect people and foster knowledge exchange. Thus, users have to share information about themselves. However, usage intensity is often low, which might be tackled by introducing gamification elements, such as a progress bar for completing the user profile.

Evaluating the effects of gamification elements often happens in controlled laboratory settings, such as in the work of Mekler et al. (2017) and Mazarakis and Bräuer (2020). This kind of setting allows us to investigate the specific potentials of the elements. Still, it fails to evaluate the effectiveness of gamification elements in the long term and in real-field settings where we can observe whether they have a lasting influence on user behavior. So, field studies may have a lack of control but enable the observation of user behavior changes over a longer time period, which also takes into account the novelty effect, which can blur the actual efficiency of changes to the user interface.

Research Questions and Exploratory Hypothetical Model

Our study aims to understand and examine user behavior change in the context of enterprise collaboration platforms by analyzing the change of user profile completions within the platform over a certain period, considering one gamification element, a progress bar. Therefore, we specify our research questions as follows:

RQ1 What is the effectiveness of implementing a progress bar on users' profile completion behavior on enterprise collaboration platforms?

RQ2 How does users' profile completion behavior develop over time, particularly after a progress bar has been implemented?

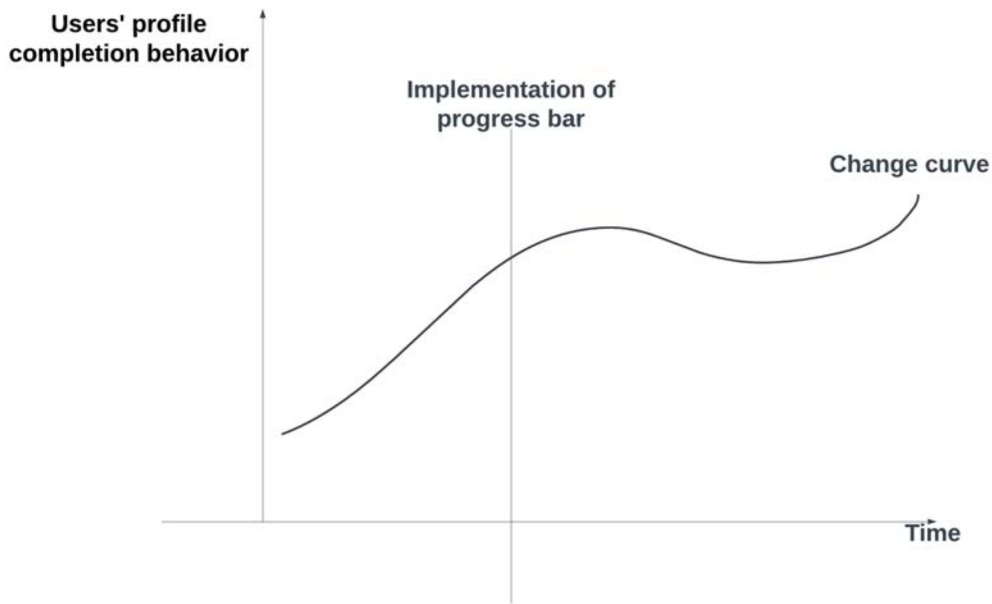


Figure 1. Exploratory hypothetical model of the users' profile completion behavior change across time by implementing a progress bar based on the technology change curve and organizational performance change curve.

Figure 1 shows our exploratory hypothetical model based on the technology change curve (Foster, 1986; Nikula et al., 2010) and the organizational performance change curve (Schneider and Goldwasser, 1998), indicating how we investigated our research questions. In this model, we predict the time effect on users' profile completion, especially the time effect after implementing a progress bar. We also explore the interaction effect of time and progress bar implementation on users' profile completion. A specific description of how we address these research questions is covered in the next section.

Methodology

This section presents our methodology and how we analyze the implementation of a progress bar in a real-world collaboration platform.

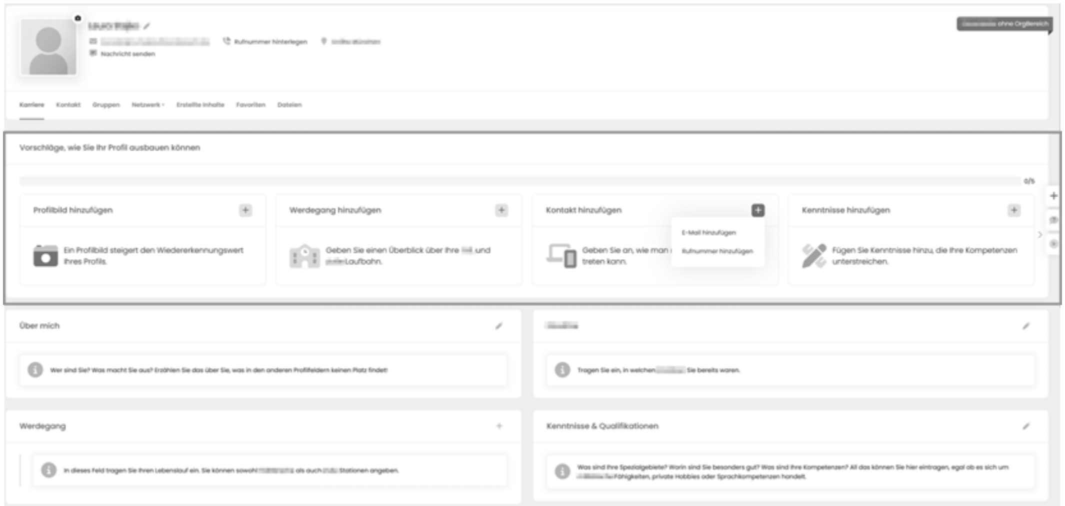


Figure 2. Screenshot of a sample profile on the enterprise collaboration platform with the uncompleted progress bar (highlighted the frame).

The platform we are looking at is an in-house development of a platform for collaboration, learning, coordination, and communication in a large public sector organization. The COVID-19 pandemic required the organization to look for a digital collaboration tool. An already existing platform for education and collaboration was relaunched in January 2022, and its use was extended and made available throughout the whole institution. Subsequently, more and more users from different parts of the institutions within the organization started participating on the platform for various purposes, namely offering online training sessions, arranging meetings, offering documentation, publishing internal job offerings, etc. However, the user profiles on the platform lacked completeness. Hence, the platform development team introduced a new feature, a progress bar, to increase user motivation to add information to their profiles. This new gamification feature was launched on the 17th of January, 2023. Figure 2 shows a sample profile with an uncompleted progress bar, and figure 3 displays a profile where two profile components proposed by the progress bar have been filled out, and consequently, the progress bar recorded this completion progress.

All platform users agreed to the terms of use and accepted the organization's data privacy policy, which covers all relevant aspects of ethics and data privacy. The platform stores and processes the users' personal data in a way aligned with the general data protection regulation (GDPR). As stated in the terms of use, the evaluation of the user data is only done for statistical purposes in an anonymized and aggregated format. We cannot analyze the users' content and demographic

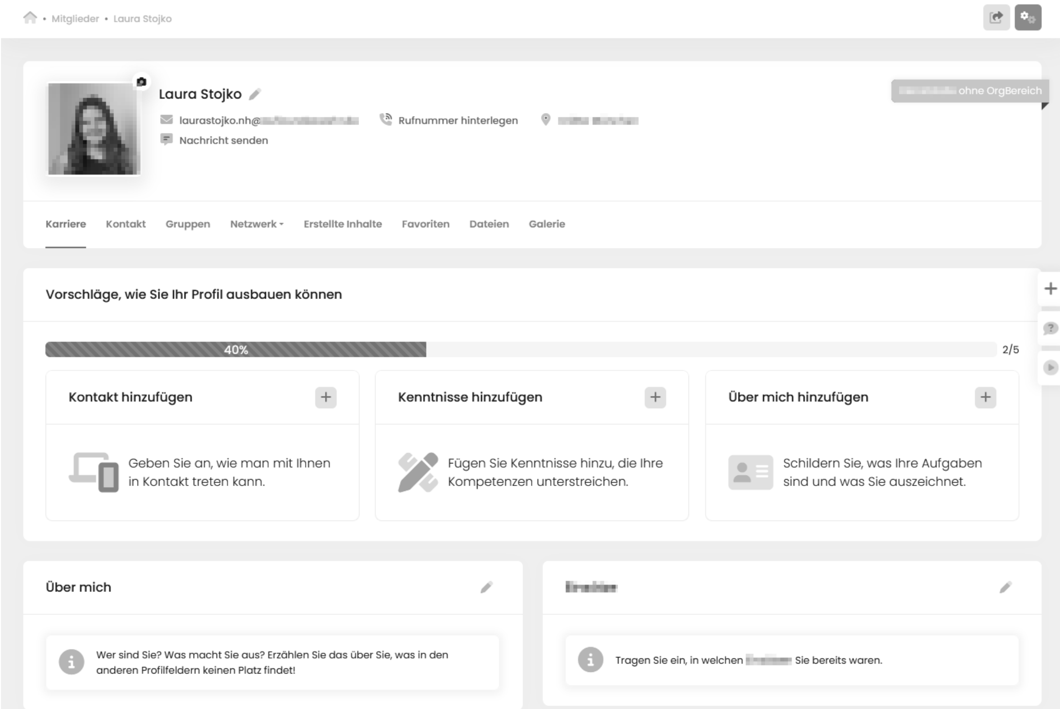


Figure 3. Screenshot of a sample profile with a profile completion rate of 40%, indicated by the progress bar, extended view.

information. Due to the organization's privacy regulations that prohibit the disclosure of user data to a third party, we cannot share the raw data.

In this study, we adopted a quasi-experimental design to investigate our research questions. Quasi-experimental designs have several benefits, such as improved feasibility and practicality of implementation, especially when participant randomization is challenging or even not feasible (Handley et al., 2018). Moreover, quasi-experimental designs frequently incorporate pre-existing conditions, which enhances the study's external validity by replicating real-world scenarios (Reichardt, 2009). Of note, a simple pretest-posttest-comparison (profile completion before vs. after implementation of the progress bar) would have three important disadvantages: Composition between the samples could differ, for example, due to participant attrition, history effects could occur (parallel to the introduction of the feature), and simple reactivity might result. However, and even more importantly, the design we use here has two important advantages. First, we collect several waves of data both before and after the implementation, and thus, we can analyze differences in change scores. Second, these data also allow us to discern the short-term and long-term effects of implementing a new platform feature.

Data Collection

We collected data at six evaluation times. The following list provides an overview of the evaluation dates in the yyyy-mm-dd format. It includes the total number of profiles we gathered information from at that specific time:

- $t1_{(before)}$ 2022-03-29: 8,001 profiles
- $t2_{(before)}$ 2022-07-12: 13,996 profiles
- $t3_{(before)}$ 2022-10-11: 19,054 profiles
- $t1_{(after)}$ 2023-02-01: 28,573 profiles
- $t2_{(after)}$ 2023-05-01: 37,915 profiles
- $t3_{(after)}$ 2023-08-01: 45,882 profiles

At each evaluation time, the data export included all profiles of the individuals who were registered on the platform at that specific time. The data describes whether the respective profile components were part of the profile (0 - no data, 1 - data available), e.g., "1" if the profile contained a profile picture or "0" if there was no profile picture. The six profile components comprised phone, E-Mail, about, picture, career, and knowledge and competencies. The profile sum score was calculated by adding the scores of all six profile components of each user on the platform, indicating their profile completion.

As evidenced by the number of profiles, the number of users has increased. Consequently, the number of profiles we analyzed in our study varied at the evaluation dates. The reason for the extreme changes in user numbers was that several parts of the organization used the enterprise collaboration platforms consecutively when they identified the need to improve collaboration, learning, and communication. For instance, one part of the organization determined that it was necessary to organize internal training through self-training and online and offline sessions. Subsequently, they added all relevant business unit employees to the platform and used it to manage and communicate their specific training possibilities. In the end, we analyzed the profile completion of 46,530 participants over our evaluation period of more than a year, which is more than the number of profiles of our last evaluation time, 2023-08-01, as it also includes profiles deleted during our study. This means that not all profiles have been subject to the analysis at all evaluation times. The baseline time of our research, $t1_{(before)}$, consisted of 8,001 profiles migrated predominantly from the previous platform and used exclusively for one organization's business unit.

Data Analysis

We scrutinize whether users' profile completion behavior changed over time and whether the progress bar implementation affected this change process. Since profile completion was assessed at several points in time, we computed multilevel models with the measurement points of the profile completion on level–1 and the participants on level–2 (Singer and Willett, 2003). Furthermore, linear mixed-effect models are flexible in terms of data structure. In particular, the timing of observations can differ between subjects, and the distance between adjacent time points can vary (Long, 2012).

First, we defined the six evaluation times using the number of weeks that had passed after t1 as follows: $t1_{(before)} = 0$ [baseline], $t2_{(before)} = 15$, $t3_{(before)} = 28$, $t1_{(after)} = 45$, $t2_{(after)} = 57$, $t3_{(after)} = 70$. Following that, we examined which time moment best corresponds to the data. Note that our data spanned six different times; a nonlinear curve might help select the appropriate time predictor. Subsequently, we applied polynomials, which were power transformations of the original time predictor, to represent nonlinear trends (Long, 2012). The model fits of the linear, quadratic, cubic, and quartic models were compared by the deviance statistic (Singer and Willett, 2003), which are 132070.6, 131798.2, 131793.9, and 131814.6, respectively. Thus, the cubic model had the smallest value, indicating the best-fitting time moment with the data. Next, we computed linear mixed models with linear, quadratic, and cubic effects of time. Additionally, we included the main effect of the progress bar and the interaction effect of time and the progress bar. The models included random intercepts and slopes on level–2.

	profile sum score		
	Model 1	Model 2	Model 3
	fixed effects		
(intercept)	1.00^{***}	1.00^{***}	0.99^{***}
level 1 (within subjects)			
time	0.01^{***}	0.01^{***}	0.01^{***}
$time^2$	-0.00^{***}	-0.00^{***}	-0.00^{***}
$time^3$	0.00^{***}	0.00^{***}	0.00^{***}
progress bar		0.02^{***}	-0.08^{***}
time × progress bar			0.00^{***}
level 2 (between-subjects)			
	random effects		
level 1 (within-subject)			
residual variance	0.03^{***}	0.03^{***}	0.03^{***}
level 2 (between-subjects)			
intercept	0.58^{***}	0.58^{***}	0.58^{***}
slope	0.01^{***}	0.01^{***}	0.01^{***}
intercept/slope (correlation)	-0.44^{***}	-0.44^{***}	-0.44^{***}
	model fit		
deviance (*-2LL*)	131793.93	131782.71	131772.23
change in deviance (Δ*-2LL*)		11.22^{***}	10.47^{**}
AIC	131809.93	131800.71	131792.23
BIC	131889.45	131890.17	131891.64

Table I. Overview of the different statistical models applied for data analysis. N = 46530; coefficients are unstandardized; *$p < .05$; **$p < .01$; ***$p < .001$ *Note*: AIC = Akaike Information Criterion, BIC = Bayesian Information Criterion, both are ad hoc criteria to compare the relative goodness-of-fit of the models. Lower AIC values or higher BIC values indicate a model is considered better.

Results

Table I summarizes the results of the hierarchical linear mixed-effect models. We analyzed three models, each in one column in Table I: Model 1 included the linear, quadratic, and cubic effects of time. In Model 2, we also included the progress bar's main effect; finally, in Model 3, we added the interaction effect of time and implementing the progress bar to examine whether the effect of progress bar implementation changes over time. Table I first shows the estimated coefficients for the fixed effects in each model. Fixed effects are the estimated average relationships between time and profile sum score, progress bar implementation, and profile sum score, as well as between the interaction of time and progress bar implementation and profile sum score. The significance of time and its squared and cubed terms indicates that the effect of time on profile completion is not linear. The main effect of progress bar implementation, which mainly verifies the effect of introducing the progress bar, is significant in Model 2, and its interaction with time is significant in Model 3, suggesting that the progress bar implementation has a differential impact on profile completion over time. Table I also shows the estimates for the random effects, which are effects that can vary across individuals or levels. Random effects indicate significant variation at both the within-subject and between-subject levels. Slope suggests that the slope of time can vary between participants. The negative and significant correlation between intercepts and slopes indicates that participants with a higher starting point may have a slower rate of change or vice versa. Model fit provides statistics used to compare the models. Significant change in deviance suggests improvements in model fit.

As a visual representation, Figure 4 and Figure 5 present these main effects of time on the change of profile completion and the interaction of time and progress bar implementation on users' profile completion behavior. The x-axis is the evaluation time calculated in weeks. A vertical line on the x-axis marks the time point of implementing the progress bar. The y-axis is the profile sum score that runs upwards, showing how complete a user's profile is. The cubic change curve line represents the effect of time, indicating changes in users' profile completion over time with an increase directly after implementing the progress bar, subsequently a decrease and a slow increase again (Figure 4). In Figure 5, the dotted line demonstrates the timeline of change of profile completion without progress bar implementation, and the straight line represents the timeline of change of profile completion with a progress bar implementation. The increase in profile completion indicates a more considerable change in slope, suggesting the interaction effect between time and the progress bar.

Our findings present the positive effect of implementing a progress bar on users' profile completion behavior, with increased profile completion rates through introducing a progress bar. A positive relationship exists between time and users' profile completion, especially a more substantial positive effect after implementing a progress bar. These results implicate the effectiveness of implementing a progress bar on users' profile completion behavior on enterprise collaboration platforms and the impact of time on the change in user behavior, which answers our research questions as it shows that it is a long-lasting effect and not just a flash in the pan.

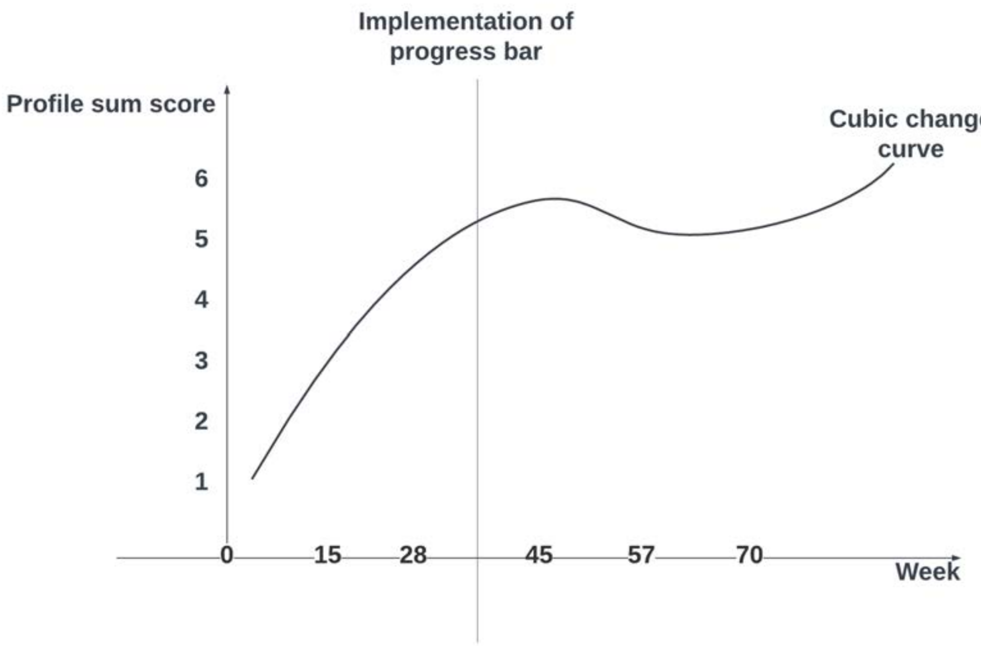


Figure 4. The cubic change curve of the extent of users' profile completion over time.

Discussion and Limitations

The current study started with the observation that enterprise collaboration platforms often lack individual activities. One solution to this problem is implementing motivating design features, such as gamification elements. We analyzed data from a platform that implemented one such feature, a progress bar of users' profile completions. This is of interest because activities on a platform depend on the availability of other users with knowledge, skills, interests, backgrounds, etc., which should also be visible to other platform members. With enterprises investing a tremendous budget in implementing such collaboration platforms, the results of this study are crucial to increase potential user participation and ultimately foster knowledge exchange to help improve the company's competitiveness. We found that implementing a gamification element of the progress bar could motivate users to fill in more information in their profiles. More specifically, the results of our study reveal a nonlinear curve of change in profile completion behavior over time, showing an initial increase in completion rates after implementing a new feature (progress bar), followed by a subsequent decrease, and ending in a second rise, see details in Figure 4. This shows that

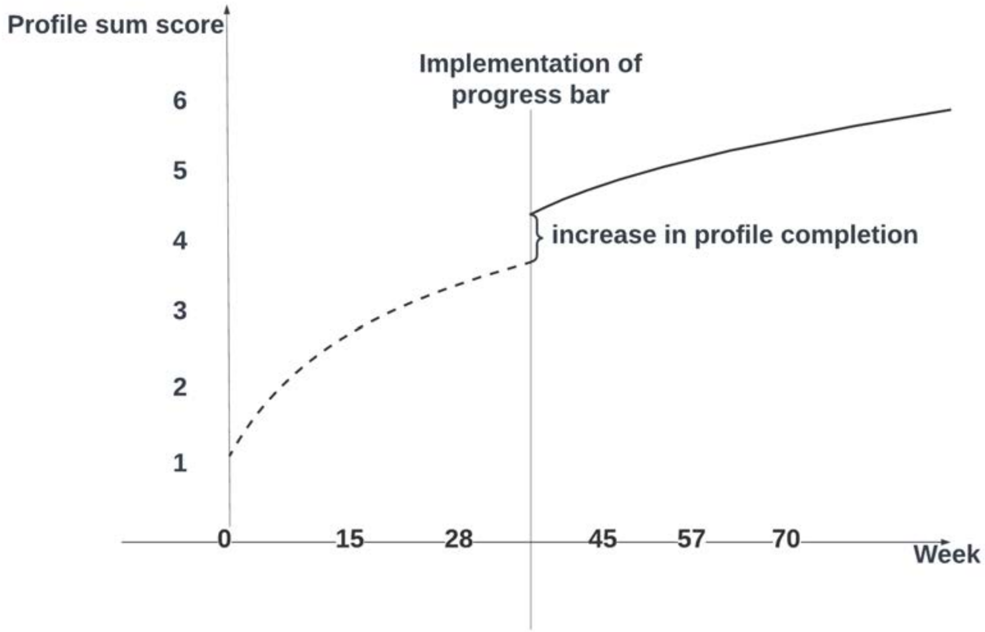


Figure 5. The effect of a progress bar on users' profile completion. The dotted line illustrates the timeline without a progress bar. The straight line illustrates the timeline with a progress bar. The difference between these two lines illustrates the increase in profile completion after implementation of a progress bar.

implementing a progress bar considerably impacts profile completion rates. It resulted in an immediate increase, leading to some fluctuations over time. The observed phenomenon of the initial increase, after introducing a new feature, and a subsequent decrease describes the novelty effect, which is essential to consider for evaluating new features (Koch et al., 2018). Nevertheless, the progress bar plays an essential role in motivating users to complete their profiles within the collaboration platforms, as demonstrated by the steeper increase in completion rates after implementing a progress bar (Figure 5).

According to earlier research, various gamification elements could intrinsically motivate users to perform their tasks (Xi and Hamari, 2019; Ryan et al., 2006). The progress bar provides a simple, understandable visual indication expressing an individual's sense of achievement. It gives users a concrete indicator of how far they've come and how much more they still need to do. This ease of usage could lead to a positive user experience. Furthermore, the progress bar is a good option for profile completion in the platform context of our study. Considering previous research insights, the *performance* of profile completion has also been positively affected by using this gamification feature, which further substantiates the findings of Mekler et al. (2017) and Mazarakis and Bräuer (2020).

Our study also highlights practical implications for organizations. They could think of including a progress bar on similar platforms. By doing so, organizations may improve user engagement and increase task completion. Platform designers in organizations should carefully choose gamification elements based on the platform's specificity. One of our findings indicates the fluctuations in users' profile completion over time, which signals to organizations that they should not only implement gamification elements but also examine their long-term influence. Quasi-experimental designs with repeated measures can show that such changes have an evidence-based foundation.

Some limitations within our study show potential for future research. Our data only contained boolean values that represented whether or not the respective profile components had been filled out. The quality of the profiles, e.g., how much information has been shared within the "about" field, has not been investigated within this study. In our study, we did not differentiate or weigh the importance of the profile components. A closer look at this might show us more information about the effectiveness of a progress bar relating to specific components. In addition, we considered all user profiles on the platform without considering individual differences. One example might be users' general activity levels. There might have been users who were not interested in becoming active participants on the platform but only used it to complete one mandatory task, e.g., data privacy training, and afterward never logged in again. Thus, it would be interesting to see how individual differences are related to the effects of comparable interventions on digital collaboration platforms.

Conclusions

Our investigation of users' profile completion rates on the collaboration platform of a large public sector organization revealed valuable findings. This study indicates that a progress bar effectively enhanced users' profile completion rates in enterprise collaboration platforms. Moreover, there was an interplay between users' profile completion, time, and implementation of the progress bar. In detail, users' profile completion rates show a steeper increase after the implementation of a progress bar compared to users' profile completion rates without a progress bar, proving this gamification element successfully motivated users to add information to the platform.

In addition to this clear result about the effectiveness of progress bars, we see a contribution of this paper in proposing and using a linear mixed-effect model-based approach to conduct the analysis. We have briefly discussed why this approach is superior to simply comparing access counts, as often done in evaluating new features.

While this study has shown positive effects of the gamification element "progress bar" on collaboration platforms over time, it is crucial to recognize the limitations that point to potential directions for further research in this area. Our study is a basis for further research into gamification on enterprise collaboration platforms. As proven, such simple gamification elements could help improve long-term success in platforms and foster knowledge exchange within organizations by connecting employees. Digital tools like these have great potential to shape the way we will work in the future. Further research projects could build on the insights of this work and explore additional intriguing questions, such as examining the correlation between profile completion and actual participation or user types on enterprise collaboration platforms (Schwade and Schubert, 2019) or further investigating the profile completion patterns of deleted profiles.

Acknowledgments

This research was partly supported by funding from the Bavarian Research Institute for Digital Transformation (bidt).

References

Chin, P. Y., Evans, N., Liu, C. Z., & Choo, K. K. R. (2020). Understanding Factors Influencing Employees' Consumptive and Contributive Use of Enterprise Social Networks. *Information Systems Frontiers*, *22*(6), 1357–1376, https://doi.org/10.1007/S10796-019-09939-5/TABLES/7.

Daniels, R. A., Pemble, S. D., Allen, D., Lain, G., & Miller, L. A. (2021). LinkedIn Blunders: A Mixed Method Study of College Students' Profiles. *Community College Journal of Research and Practice*, *47*(2), 90–105, https://doi.org/10.1080/10668926.2021.1944932.

De Reuver, M., Sørensen, C., & Basole, R. C. (2018). The digital platform: a research agenda. *Journal of Information Technology*, *33*(2), 124–135.

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining gamification. In *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, MindTrek 2011*, volume 11 (pp. 9–15).

Foster, R. N. (1986). *Innovation: The Attacker's Advantage*. Summit Books.

Gewehr, B., Gebel-Sauer, B., & Schubert, P. (2017). Social network of business objects (sonbo): An innovative concept for information integration in enterprise systems. *Procedia computer science*, *121*, 904–912.

Greeven, C. & Williams, S. (2017). Enterprise collaboration systems: addressing adoption challenges and the shaping of sociotechnical systems. *International Journal of Information Systems and Project Management*, *5*(1), https://aisel.aisnet.org/ijispm/vol5/iss1/2.

Hacker, J., Bernsmann, R., & Riemer, K. (2017). Dimensions of User Behavior in Enterprise Social Networks. *Knowledge Management and Organizational Learning*, *3*, 125–146, https://doi.org/10.1007/978-3-319-45133-6_7.

Haghir Chehreghani, M. (2017). Feature-oriented analysis of user profile completion problem. In J. M. Jose, C. Hauff, I. S. Altıngovde, D. Song, D. Albakour, S. Watt, & J. Tait (Eds.), *Advances in Information Retrieval* (pp. 304–316). Cham: Springer International Publishing.

Handley, M. A., Lyles, C. R., McCulloch, C., & Cattamanchi, A. (2018). Selecting and improving quasi-experimental designs in effectiveness and implementation research. *Annual review of public health*, *39*, 5–25.

Hazimeh, H., Mugellini, E., & Khaled, O. A. (2019). Reliable user profile analytics and discovery on social networks. In *Proceedings of the 2019 8th International Conference on Software and Computer Applications*, ICSCA '19 (pp. 496–500). New York, NY, USA: Association for Computing Machinery.

Herzog, C. & Richter, A. (2016). Use cases as a means to support the appropriation of enterprise social software. In *2016 49th Hawaii International Conference on System Sciences (HICSS)* (pp. 4072–4081).: IEEE.

Herzog, C. & Steinhuser, M. (2016). The impacts of enterprise social software on the innovation process. In *2016 IEEE 20th International Enterprise Distributed Object Computing Conference (EDOC)* (pp. 1–10).: IEEE.

Koch, M., von Luck, K., Schwarzer, J., & Draheim, S. (2018). The Novelty Effect in Large Display Deployments – Experiences and Lessons-Learned for Evaluating Prototypes. In *Proc. 16th European Conference on Computer-Supported Cooperative Work*: European Society for Socially Embedded Technologies (EUSSET).

Laitinen, K. & Sivunen, A. (2021). Enablers of and constraints on employees' information sharing on enterprise social media. *Information Technology and People*, *34*(2), 642–665, https://doi.org/10.1108/ITP-04-2019-0186.

Leonardi, P. M., Huysman, M., & Steinfield, C. (2013). Enterprise Social Media: Definition, History, and Prospects for the Study of Social Technologies in Organizations. *Journal of Computer-Mediated Communication*, *19*(1), 1–19, https://doi.org/10.1111/jcc4.12029.

Long, J. D. (2012). *Longitudinal data analysis for the behavioral sciences using R*. Sage.

Mazarakis, A. & Bräuer, P. (2020). Gamification of an open access quiz with badges and progress bars: An experimental study with scientists. In *GamiFIN* (pp. 62–71).

Mazarakis, A. & Bräuer, P. (2023). Gamification is Working, but Which One Exactly? Results from an Experiment with Four Game Design Elements. *International Journal of Human–Computer Interaction*, *39*(3), 612–627, https://doi.org/10.1080/10447318.2022.2041909.

Mekler, E. D., Brühlmann, F., Tuch, A. N., & Opwis, K. (2017). Towards understanding the effects of individual gamification elements on intrinsic motivation and performance. *Computers in Human Behavior*, *71*, 525–534, https://doi.org/10.1016/J.CHB.2015.08.048.

Meske, C., Brockmann, T., Wilms, K., & Stieglitz, S. (2016). Gamify employee collaboration - A critical review of gamification elements in social software. *CoRR*, *abs/1606.01351*, https://doi.org/10.48550/arXiv.1606.01351.

Meske, C., Brockmann, T., Wilms, K., & Stieglitz, S. (2017). Social Collaboration and Gamification. In S. Stieglitz, C. Lattemann, S. Robra-Bissantz, R. Zarnekow, & T. Brockmann (Eds.), *Gamification: Using Game Elements in Serious Contexts* (pp. 93–109). Cham: Springer International Publishing.

Meske, C., Junglas, I., & Stieglitz, S. (2019). Explaining the emergence of hedonic motivations in enterprise social networks and their impact on sustainable user engagement. *Journal of Enterprise Information Management*, *32*(3), 436–456, https://doi.org/10.1108/JEIM-08-2018-0177.

Nielsen, P. & Razmerita, L. (2014). Motivation and knowledge sharing through social media within danish organizations. In *Creating Value for All Through IT: IFIP WG 8.6 International Conference on Transfer and Diffusion of IT, TDIT 2014, Aalborg, Denmark, June 2-4, 2014. Proceedings* (pp. 197–213).: Springer.

Nikula, U., Jurvanen, C., Gotel, O., & Gause, D. C. (2010). Empirical validation of the classic change curve on a software technology change project. *Information and Software Technology*, *52*(6), 680–696.

Nitschke, C. S. (2021). *Monitoring Enterprise Collaboration Platform Change and the Building of Digital Transformation Capabilities: An Information Infrastructure Perspective (doctoral dissertation)*. Dissertation, Universität Koblenz-Landau, https://kola.opus.hbz-nrw.de/opus45-kola/frontdoor/index/index/docId/2229.

Nonaka, I. & Takeuchi, H. (1995). *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*. Oxford University Press.

Nonaka, l., Takeuchi, H., & Umemoto, K. (1996). A theory of organizational knowledge creation. *International Journal of Technology Management*, *11*(7-8), 833–845, https://doi.org/10.1504/IJTM.1996.025472.

Reeves, B. & Read, L. (2009). *Total Engagement: Using Games and Virtual Worlds to Change the Way People Work and Businesses Compete*. Harvard Business Press.

Reichardt, C. S. (2009). Quasi-experimental design. In *The Sage handbook of quantitative methods in psychology.* (pp. 46–71). Thousand Oaks, CA: Sage Publications Ltd.

Ryan, R. M., Rigby, C. S., & Przybylski, A. (2006). The motivational pull of video games: A self-determination theory approach. *Motivation and emotion*, *30*, 344–360.

Sailer, M., Hense, J., Mandl, H., & Klevers, M. (2013). Psychological perspectives on motivation through gamification. *Interaction Design and Architecture(s) Journal*, *19*, 18–37, https://doi.org/10.55612/s-5002-019-002.

Schiller, C. & Meiren, T. (2018). Enterprise Social Networks for Internal Communication and Collaboration. In *2018 IEEE International Conference on Engineering, Technology and Innovation, ICE/ITMC 2018 - Proceedings*: Institute of Electrical and Electronics Engineers Inc.

Schneider, D. M. & Goldwasser, C. (1998). Be a model leader of change. *Management Review*, *87*(3), 41.

Schubert, P. & Glitsch, J. (2016). Use cases and collaboration scenarios: how employees use socially-enabled enterprise collaboration systems (ecs). *International Journal of Information Systems and Project Management*, *4*, https://doi.org/10.12821/ijispm040203.

Schubert, P., Hager, J., & Paulsen, L. (2014). Auswirkungen von Gamification in Enterprise Collaboration Systems. In *Mensch & Computer 2014 - Tagungsband* (pp. 3–14). Berlin: De Gruyter Oldenbourg.

Schubert, P. & Williams, S. (2013). The Concept of Social Business: Oxymoron or Sign of a Changing Work Culture? In *BLED 2013 Proceedings*, https://aisel.aisnet.org/bled2013/26.

Schubert, P. & Williams, S. P. (2022). Enterprise collaboration platforms: An empirical study of technology support for collaborative work. *Procedia Computer Science*, *196*, 305–313.

Schwade, F. & Schubert, P. (2017). Social Collaboration Analytics for Enterprise Collaboration Systems: Providing Business Intelligence on Collaboration Activities. In *Hawaii International Conference on System Sciences 2017 (HICSS-50)*, https://aisel.aisnet.org/hicss-50/cl/data_science_for_collaboration/4.

Schwade, F. & Schubert, P. (2019). Developing a user typology for the analysis of participation in enterprise collaboration systems. In *Proceedings of the Annual Hawaii International Conference on System Sciences* (pp. 460–469).

Singer, J. D. & Willett, J. B. (2003). *Applied longitudinal data analysis: Modeling change and event occurrence*. Oxford University Press.

Suh, A. & Wagner, C. (2017). How gamification of an enterprise collaboration system increases knowledge contribution: an affordance approach. *Journal of Knowledge Management*, *21*(2), 416–431, https://doi.org/10.1108/JKM-10-2016-0429.

Trier, M., Fung, M., & Hansen, A. (2017). Uncertainties as barriers for knowledge sharing with enterprise social media. In *25th European Conference on Information Systems (ECIS)* (pp. 1619–1630). Guimarães, Portugal, http://aisel.aisnet.org/ecis2017_rp/104.

van Dijck, J. (2013). 'you have one identity': performing the self on facebook and linkedin. *Media, Culture & Society*, *35*(2), 199–215, https://doi.org/10.1177/0163443712468605.

Van Osch, W., Steinfield, C. W., & Balogh, B. A. (2015). Enterprise social media: Challenges and opportunities for organizational communication and collaboration. In *48th Hawaii International Conference on System Sciences* (pp. 763–772).: IEEE.

Werbach, K. & Hunter, D. (2012). *For the Win: How Game Thinking can Revolutionize your Business*. Wharton Digital Press.

Williams, S. P., Mosen, J., & Schubert, P. (2020). The structure of social documents. In *Proceedings of the Annual Hawaii International Conference on System Sciences*, volume 2020-Janua (pp. 2825–2834).

Williams, S. P. & Schubert, P. (2018). Designs for the digital workplace. *Procedia computer science*, *138*, 478–485.

Xi, N. & Hamari, J. (2019). Does gamification satisfy needs? a study on the relationship between gamification features and intrinsic need satisfaction. *International Journal of Information Management*, *46*, 210–221.

Yousaf, S., Imran Rasheed, M., Kaur, P., Islam, N., & Dhir, A. (2022). The dark side of phubbing in the workplace: Investigating the role of intrinsic motivation and the use of enterprise social media (ESM) in a cross-cultural setting. *Journal of Business Research*, *143*, 81–93, https://doi.org/10.1016/J.JBUSRES.2022.01.043.

Gabriela Marcu and Jina Huh-Yoo (2024): Social Connectedness as a Focus for Designing Technologies in Support of Mental Health. In: Proceedings of the 22nd European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centered Computing on the Design of Cooperation Technologies - Notes, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591), DOI: 10.48340/ecscw2024_n09

Social Connectedness as a Focus for Designing Technologies in Support of Mental Health

Gabriela Marcu and Jina Huh-Yoo
University of Michigan, Drexel University
gmarcu@umich.edu, jh3767@drexel.edu

Abstract. Technologies designed for mental health often target an individual user's behavior change, social support, or clinical treatment. However, there are limits to the impact of interventions focused on the individual when mental health challenges are intertwined with broader, systemic issues. This paper describes a complementary approach for digital mental health: designing for the critical ties between individual and collective wellbeing, by understanding the subjective experience of social connectedness. We report an interview study focused on youth mentors in the city of Philadelphia, which was initiated by their desire to incorporate digital technology in reaching and supporting youth in their community. We analyzed youth programs as a form of promoting social connectedness to address mental health in response to the traumatic effects of community gun violence and socioeconomic distress. We identified five interrelated layers of social connectedness: intrapersonal, interpersonal, small group, large group, and cultural.

Introduction

In 2023, the U.S. Surgeon General released two advisories on social connectedness as a pressing public health issue due to an “epidemic of loneliness and isolation” (2023a). A core pillar of the national strategy outlined for advancing social connectedness was to reform digital environments: “We must critically evaluate our relationship with technology and ensure that how we interact digitally does not detract from meaningful and healing connection with others” (2023a). The Surgeon General particularly urged more research into how young people’s social connectedness and isolation are impacted by digital social interactions such as those on social media (2023b), echoing the Centers for Disease Control and Prevention’s alert of a national mental health crisis among youth (CDC, 2023).

Despite this urgency, social connectedness is understudied in the design of technologies for mental health. Technology design tends to reduce mental health to behavior and states that can be objectively tracked, detected, and analyzed – even more so as we increasingly integrate artificial intelligence into these technologies. Yet social connectedness is an aspect of our health and wellbeing that is distinctly human, subjectively experienced, and not possible to automate. Technology design also frequently centers the diagnosis and treatment of mental illness, but mental health is more than just preventing or treating illness, it also includes well-being and thriving. For instance, we note how the World Health Organization defines mental health without a focus on illness:

> “Mental health is a state of mental well-being that enables people to cope with the stresses of life, realize their abilities, learn well and work well, and contribute to their community. It is an integral component of health and well-being that underpins our individual and collective abilities to make decisions, build relationships and shape the world we live in.” (WHO, 2022)

This definition also highlights the strong interdependency between individual mental health and collective wellbeing. The better our individual abilities to connect with others, develop relationships, and work together, the better we each are at contributing to healthier communities and an equitable social world, which in return provide environments that nurture the mental health of each individual. Digital technologies have long been touted for their promise to connect people as a part of this interdependency, and yet Americans are feeling more disconnected, isolated, and lonely (Office of the Surgeon General, 2023a).

We report on interviews with youth advocates concerned about the mental health of young people in Philadelphia neighborhoods affected by gun violence. These youth advocates had extensive experience creating youth programs (e.g., after-school activities, mentoring, clubs) to counter violence and community disintegration with social connectedness. Based on their own experiences growing up, living, and working in the same socioeconomically distressed neighborhoods, they worked to fill gaps in the community and meet the social connectedness needs of youth. The interviews we conducted were part of a larger project initiated by the youth advocates to incorporate digital technology (e.g., a mobile app) into these efforts. Our analysis aimed to learn from how interviewees designed youth programs in their communities, to inform how we might approach designing technologies that can similarly promote social connectedness in support of mental health.

Related Work

Digital Mental Health

Among scholars focused on how digital technologies can be designed to promote mental health, there is concern that the dominant medical model, which centers on diagnosing and treating mental illness, can overlook the efforts needed to prevent illness and promote different types of healing. Thieme et al. (2015) characterized an emergent holistic focus on mental health through four general areas for technology design: pleasure; a positive, strong sense of self; mental balance or mindfulness; and social wellbeing. Nunes et al. (2015) argued for a shift from clinically-oriented technologies to those that support everyday life experiences, such as daily decisions for self-care. Medicalization of mental health can also uphold inequities and fail to meet the needs of those whose mental health has been undermined systemically, even by those institutions meant to support them. Pendse et al. (2022) urged a shift from treatment to healing due to the colonial history of how mental illnesses are classified and diagnosed, calling for designers to consider lived experience, power relationships, and structural factors. Similarly, Bosley et al. (2022) discussed the importance of joy, self-advocacy, and healing to address systemic traumas experienced individually and collectively in Black communities.

This focus on healing through positive, everyday social connectedness for mental health is still nascent in the human-computer interaction scholarship, and there is limited guidance for designers about what alternatives there are to the dominant quantified, objective, and medicalized approaches in mental health – or how to put them into practice during design. Additionally, the role of social connectedness within everyday community contexts is often missing from existing approaches to designing digital technologies. Some relational aspects of mental health have been addressed in human-computer interaction (HCI) and computer-supported cooperative work (CSCW), through research focused on designing technologies for social support and collaboration around mental health – e.g., Burgess et al. (2022); Meyerhoff et al. (2022); Park (2018). But less is known about how social connectedness is experienced through and with digital technology, and how we can design for the subjective experience of social connectedness, which is different from social support (e.g., sharing information, providing diagnosis-specific emotional support), or group collaboration (e.g., online community formation, data aggregation, crowdsourcing).

Defining Social Connectedness

In recent years, social connectedness has been highlighted as a critical public health issue linked to physical health, mental health, emotional well-being, as well as living longer (Holt-Lunstad, 2022; Martino et al., 2017; CDC, nd). The absence of social connectedness is social isolation and loneliness (Holt-Lunstad and Steptoe, 2022; Office of the Surgeon General, 2023a). Psychologically, social connectedness can be understood as a perception existing cognitively within the self, regarding oneself in relation to others and the social world as a whole (Lee et al., 2001). A person's low sense of social connectedness has been linked to interpersonal problems such as avoiding social situations, being aggressive or controlling, and being either distrustful or too trusting of others — which in turn lead to psychological distress (Lee et al., 2001).

At the population level, CDC defines social connectedness as "the degree to which people have and perceive a desired number, quality, and diversity of relationships that create a sense of belonging, and being cared for, valued, and supported" (CDC, nd). Public health scholarship has only recently conceptualized social connectedness as a "unifying umbrella term" that explains how social relationships, through an interrelated set of factors, bring both risks and protections for health (Holt-Lunstad, 2022):

- **Structural:** A quantitative component that measures the size of a person's social network, the diversity of group memberships and roles, the frequency of interactions, and whether they live alone.
- **Functional:** The extent to which a person's individual needs (emotional, physical, tangible, informational, belonging) are met by the functions of social relationships, based on how they perceive and receive support.
- **Quality:** The positive and negative qualities of relationships, such as satisfaction, cohesion, intimacy, closeness, strain, conflict, inclusion, and exclusion.

Social Connectedness Compared to Social Support

Social connectedness differs from social support, which has been studied extensively in the HCI and CSCW literature. Social support is one of multiple related factors, and therefore does not provide as comprehensive of a framework for understanding how social relationships affect health and wellbeing. Public health scholarship and policy have shifted to the umbrella concept of social connectedness because it accounts for social support alongside other factors (e.g., social interaction, living arrangements, sense of loneliness), and also accounts for social support along a continuum (e.g., from meeting needs to not meeting needs, from emotional support to conflict, from belonging to exclusion) (Holt-Lunstad, 2022; CDC, nd).

Further, social connectedness links the health of individuals to the health, safety, and resilience of their communities (e.g., school, workplace, neighborhood) (CDC, nd). That is, the higher each individual's sense of social connectedness, the more they provide support to those around them, form a variety of relationships, and contribute to an inclusive community. Conversely, the lower each individual's sense of social connectedness, the more they avoid social interaction, experience conflict with others, and contribute to violence and the deterioration of cohesion in their community.

Within HCI and CSCW, a significant body of work has focused on online social support and online communities. When the term social connectedness appears in this literature, it refers to online interaction (Wang et al., 2022; Hirsch et al., 2023; Deighan et al., 2023), providing a sense of co-presence for those living alone (Davis et al., 2016; Jeong et al., 2018), or otherwise maintaining relationships at a distance (Mills et al., 2023; Xing et al., 2023; Biemans et al., 2009). We note that all of these studies used different measures of social connectedness (e.g., intimacy, cultural integration, co-presence, awareness), and to our knowledge the present study is the first within HCI/CSCW to apply the umbrella conceptualization of social connectedness (which encompasses structural, functional, and quality factors).

Due to the above focus on how we socialize online and at a distance, the sense of social connectedness within local communities has been understudied, especially in support of mental health. A notable exception is studies of people with refugee backgrounds, which have focused on how this population uses mobile phone applications to help them integrate and feel socially connected in their host country (Vuningoma et al., 2021), and have identified design implications such as focusing on community organizations and other collective local experiences, including technology use and non-use, rather than centering individuals or technologies (Ayobi et al., 2022). We build on this nascent literature by studying how youth programs are designed to give young people a sense of social connectedness in socioeconomically distressed neighborhoods, to draw insights for designing mental health technologies that promote social connectedness.

Methods

In this study, we used the public health concept of social connectedness – defined as structural, functional, and quality factors of social relationships – to ask the following research questions:

- RQ1: How are youth programs designed to **structurally** promote social connectedness within one's local community?
- RQ2: How are youth programs designed to promote the **functions** and **quality** of social relationships within one's local community?

To answer these questions, we conducted a secondary analysis of data from an existing interview study (Marcu and Huh-Yoo, 2023). In the original study, we had recruited eleven community leaders of Philadelphia's youth advocacy using the following criteria: (1) aged 18 and older, (2) have experience with programs supporting youth, (3) speak English, and (4) live in Philadelphia. The larger project is co-led by community collaborators, who provided a list of interviewees to contact, and we sent a questionnaire that consisted of the informed consent form and the screening questionnaire. The recruitment and the interviews were conducted after receiving approval from Drexel University's IRB #2010108219A001.

Interviews were conducted over Zoom, lasting 60 minutes, with the last three participants together as a focus group. Interviews were recorded, transcribed in full, then deidentified. The second author imported the deidentified transcripts to NVivo for secondary analysis.

The first author performed open coding focused on various types of social relationships within the community, and their positive and negative impacts on youth. This was followed by axial coding, during which the layers of connection were identified, originally as a set of four (intrapersonal, interpersonal, small group, large group). The first author then presented the codes to the second author, regularly discussing interpretations of the data, and iterating on the coding process until all transcripts were coded. At this point, the concept of the layers was selected as a key finding from among other themes — some of which were reported in a previous publication (Marcu and Huh-Yoo, 2023). The first author separated all of the data related to the layers and led a process of affinity diagramming to ensure a fit between the codes and data, with the second author providing feedback as the affinity diagram developed into the final set of five layers (adding cultural).

Finally, the authors returned to the literature to compare this analysis to relevant theory on social connectedness, identifying the definition and the structural, functional, and quality factors described by Holt-Lunstad (2022) as the best fit for explaining our empirical findings. As we wrote and interpreted our findings, we therefore used this definition, referring to the layers as structural layers, and explaining the factors we found within and across each structural layer as the functional and quality aspects of social relationships.

Table I shows the reported gender, ethnicity, age, and occupation(s) of recruited participants. The participants were part of youth programs that supported various aspects of mental and physical health and well-being as well as education. Some examples include volunteer organizations supporting teens' extracurricular activities after school, such as basketball, music, and tutoring. Others included health outreach organizations that educate teens on sexual health, protective sex, and public health (e.g., HIV). Others regularly invited adults who grew up in the neighborhood and are now famous celebrities, such as basketball players or successful business owners, to share tips for career development.

Findings

Our analysis identified **five structural layers** (RQ1) across which youth programs were designed to address young people's needs for social connectedness: (1) intrapersonal, (2) interpersonal, (3) small group, (4) large group, and (5) cultural.

Table I. Participant information.

P#	Gender	Ethnicity	Age	Occupation(s)
P1	F	Black	70s	Retired teacher, school director
P2	F	Black	40s	Principal (grades 5-12)
P3	F	White	60s	Director of a health organization
P4	F	Black	50s	Police staff inspector
P5	M	Black	N/A	Director of a non-profit organization
P6	F	Black	40s	Principal (grades K-5)
P7	F	Black	N/A	Principal (grades K-8)
P8	F	Black	80s	Reverend, community advocate
P9	F	Black	40s	Social entrepreneur
P10	M	Black	40s	Construction field worker, Community educator
P11	M	Black	40s	Sales manager, Community educator

We describe each of these layers below, to illustrate how social connectedness is enacted in different aspects of social life, enabling a range of influences that one's local community can have on an individual, and conversely the influences that an individual can have on their local community.

Within each structural layer, we describe examples of the **function and quality of social relationships** (RQ2) that influenced youth mental health and well-being within their community context. In particular, we highlight how these factors exist on a continuum from positive to negative effects. As a result, these influences are often in tension with one another, such as when a young person experiences violence in their neighborhood, and feels written off by their school, but feels cared for and supported by a basketball coach. The youth advocates we interviewed demonstrated how such tension between influences can present opportunities for an individual to learn new ways of being and connecting with others. We suggest that understanding these opportunities and accounting for tensions across layers can open up design opportunities for technologies that promote social connectedness.

Intrapersonal

To design for social connectedness, we first need to consider that connecting with others begins internally with one's sense of self-worth, willingness to trust people, and capacity for developing relationships (Marcu and Huh-Yoo, 2023). Interviewees explained the range of traumatic experiences to which youth are exposed, and the fight-or-flight response that they develop as a result — a well-established phenomenon in trauma theory (van der Kolk, 2015).

Interviews revealed how youths' past experiences may not only have lacked critical positive functions and qualities of social relationships, but also continue to impede their ability to connect with others. P6 described how she had observed these challenges within the school context as a principal:

> "Students, in their community, have had several traumas – between loss of income with parents and having to move, you know, transients, being at multiple schools, sometimes in the same school year, single parent households. Sometimes students have been abused themselves or they witness abuse at the hands of a parent, we have some students who have witnessed homicides. So just a lot of **factors that contribute to students not being able to fully engage**, you know, with learning. One of the biggest challenges is just on positive social interactions. Students not having their fight-or-flight type mentality. Inside of a school, when you know you have a student who drops the pencil when it gets too close to this other student or reaching to pick it up and that other **student who has been exposed to trauma, who has an issue with personal space, is now agitated and that could turn into a conflict**. So you know, knowing what students have been through and having people in the building that can work with students around trauma is just really important." (P6)

The traumas that P6 describes in Philadelphia are largely caused by socioeconomic distress. As interviewees explained, young people's behaviors and attitudes are a natural response to their environment. Their aim, through social connectedness, was to help youth cope with that response. For example, P8 described mentoring activities such as workshops to create vision boards, which are designed to address the hopelessness and lack of possibilities that youth internalize:

> "And when they do vision boards, they do a intense workshop, just to give them an opportunity to share the vision for their lives... careers... hope for the future. And these are impoverished youth that live in low socioeconomic communities and so sometimes their dreams and abilities are not believable. And so **we have to help them believe that they can achieve, and that there are possibilities to utilize their gifts and talents to become what they want**. And one of the young males, I'm going to never forget that he wanted to be an archaeologist and other youth never even knew what an archaeologist was. And so to find out that some of them have great artistic, professional dreams, and some of them don't even believe that they can achieve... because they feel hopeless. And because they look at all of these videos and they see other people achieving and they are frustrated. It is my belief that poverty breeds violence and depression and so, **my burden right now is how many youth are shooting each other and killing each other... because they feel hopeless**. That's a lot, but that, that's kind of just where we are." (P8)

Interpersonal

At the interpersonal layer of social connectedness, individuals develop one-on-one relationships with people who play different roles in their lives — parents, elders, teachers, employers, colleagues, peers, friends, romantic partners, etc. As discussed above, such relationships are dependent on the intrapersonal layer because the individual must have the social and emotional skills to build relationships.

In our study, interviewees viewed their role within the ecosystem of various other relationships that youth should ideally be able to rely on. For example, they built youth programs that not only enabled young people to form relationships with caring adults, but also to form relationships with their peers and mentor one another:

> “I think the peer mentors work really well. I do. Because they listen to one another. **They respect the opinion of one another.** So, you have, you know– **if you’re going through something, you have the option** of talking to your peer, or you have the option of talking to maybe your mom, or your dad, or an older adult.” (P4)

Interviewees emphasized that interpersonal relationships best develop organically, without necessarily assigning mentors. Therefore, youth programs organized activities that allowed youth the time and space to get to know a variety of people within small group contexts. We discuss this layer of social connectedness next.

Small group

Youth programs represent a small group context that allows for members to get to know one another interpersonally. Other examples of small groups include households, classrooms, and offices. At this layer, an important aspect of social connectedness is the sense of being welcome and included in the group. Interviewees explained that they addressed the need for continuity in a young person’s life by providing it in part through the small group (e.g., program, sports team, chess club), so that even if one mentor in their lives got busy, the collective would still be there to provide continuous connectedness. In this way, mentoring was provided across the interpersonal and small group layers:

> “All of our people, **whether they’re adults or children, we’re all considered mentors** and you may not necessarily be matched with with any individual. It just maybe according to, you know, what you enjoy so you may end up having a basketball mentor because you’re in the basketball program. But you may also end up, if you’re in a chess club, that means you also have whoever’s running the chess program becomes your mentor also. So it’s not a one-on-one mentorship, it’s more an extended family, and **we all play a part in that mentorship**.” (P5)

One of the reasons that small group connections were powerful forms of providing mentorship was that they took place within the geographic context of specific Philadelphia neighborhoods, in which residents had the same lived experiences. This broader neighborhood context is in the large group layer, which we will explain next.

Large group

At the large group layer of social connectedness, individuals may not get to know each other personally. Instead, they connect to what is unique about everyday life within a social group as large as a city, neighborhood, or school. Interviewees explained how the context of their Philadelphia neighborhoods, especially the prevalence of community gun violence, was having adverse effects on the wellbeing of local youth. Their own lived experience within these neighborhoods enabled them to connect with youth through understanding and compassion. In contrast, they noticed that teachers who lived farther away struggled to connect with local youth because they did not have that connection to the geographic community:

> "The majority of the teachers live nowhere near here. Then **they have no connection or understanding of what's really taking place in the city**, except what they see on the news. So without that connection... no matter what they do they're kind of, there's like this pull and tug, 'what do I do? what don't I do?' and that ends up making a person say 'forget it' and **they throw their hands up in disgust**." (P2)

The "disgust" felt toward large group challenges such as gun violence can therefore transfer onto interpersonal relationships like those with students. When teachers have an external perspective of the large group, it is easier to turn away from their challenges. Whereas interviewees lived alongside youth in the same neighborhoods, and having faced the same challenges, were better equipped to help young people cope. For instance, P8 drew on the large group context to explain how youth seem to approach planning for their careers:

> "It's amazing, some of them really wanted businesses. These young people are more oriented towards owning their own businesses as opposed to college degrees. And having a limo service, or touring service, or even real estate development, or some tangible possible vocation... that, we find, is more inviting and encouraging to them as opposed to eight to ten years in school to become a doctor or a lawyer. And they could be, could have the potential to do that. But they look at... vocations that are hands on as opposed to educational careers, unfortunately, because of the environment. And **I truly think that they don't think they're gonna live long.** I mean if you're involved in a neighborhood where people are getting killed, five and six a day, and people are shooting into neighborhoods. If you're having a 4th of July outing and somebody just ran, come and shoot. That's kind of depressing and discouraging that **they think that 'Oh, I could die any day' so I think that that deters their longevity of planning**, in terms of a career." (P8)

Expanding beyond a large group that is connected through place or geography, the next and final layer of social connectedness that we will discuss is cultural.

Cultural

Finally, individuals can feel connected to a culture, which can give them a general sense of belonging while also influencing how they connect to people through the other layers. For example, connecting to basketball culture can lead an individual to passionately follow games and wear jerseys (intrapersonal), make friends who share this hobby (interpersonal), play on a team (small group), and attend games to cheer on the local professional team (large group). The interviewees discussed how they tap into the popularity of sports culture in how they organize events and programs to engage youth.

We therefore define the cultural layer as a sense of belonging based on interest or identity that allows an individual to connect broadly with people with whom they may never interact. Specific to our context of youth programs, cultural relevance has for example been described as an important approach to supporting urban African American girls (Lindsay-Dennis et al., 2011). Social connectedness that draws from shared experiences of oppression—such as those faced by Black women and girls at the intersection of race, gender, and class—"can create opportunities to understand personal and community advocacy as well as constructive techniques to navigate problems within social and educational settings" (Logwood, 2020). Much of the shared understanding and collective advocacy that stems from this kind of social connectedness can extend beyond present and local circumstances, because experiences such as racism can reach far back across past generations and ancestors, or serve as a lived experience that is shared around the world — which is why the Black Lives Matter movement began from local protests over the police murder of George Floyd in Minneapolis, but spread globally within weeks (Gaines, 2022; Shahin et al., 2021).

Interviewees also referenced young people's generational culture, at times comparing it to the culture in which they themselves grew up, and highlighting the unique experience of being a young person today:

> "I grew up under the understanding that only a fool hates reproof... no one loves to be rebuked or reproofed at all, however, when it's done in a loving way, when someone is teaching you and guiding you, I definitely think that mentorship would be amazing. **Especially at the time we're in right now, children are angry**. They're angry because they're stuck in their houses [during the pandemic], they're angry because of social justice issues... there's environmental issues, there's so much. I think having someone to help steer them in the right direction, or a better direction, will be helpful." (P2)

P2 notes the function of relationships with adults to help young people channel their anger into productive paths, while P5 describes how peers can serve a different function due to their ability to connect around their shared generational culture, including an interest in video games and engagement with social media:

> "It's a tutoring program, which doesn't sound like much of a mentorship program because it's academic, but we have our peers tutoring other peers. And **it's much more effective in some senses, some instances, than it is with the adults**. Because they can go over academic work, but then they may be talking about gaming, for example. **So their conversations can go in different areas or they can use social media examples that I might not be able to use**. So the peer-to-peer mentorship, as well as long as we're training our mentors on how to be an effective mentor as well because we want to make sure that our mentors understand that you are partly responsible for your mentee, and so you have to be mindful of what you do, you say, and in how you represent yourself as well." (P5)

Discussion

We have used the umbrella concept of social connectedness to describe the structural, functional, and quality factors of social relationships that impact the well-being of individuals as well as communities. We articulated five distinct but interrelated structural layers across which interviewees had designed youth programs to address the social connectedness needs of local youth: intrapersonal, interpersonal, small group, large group, and cultural. We also explained, within and across these layers, how the functions and qualities of social relationships were affecting the mental health and well-being of young people in socioeconomically distressed communities. Peer and inter-generational mentoring were examples of how relationships could serve different functions across various structural layers. Meanwhile, qualities of youths' social relationships enabled them to feel a sense of belonging, co-develop their shared interests and identity, and connect around common lived experiences.

In this section, we discuss how social connectedness provides a novel approach to designing technology in support of mental health and well-being. We highlight two design implications: design across structural layers of social connectedness; and foster community advocacy to build both individual and collective resilience.

Design across structural layers of social connectedness

When designing technologies to support mental health, we recommend looking across the structural layers of social connectedness to identify community assets, sources of social support or belonging, and the potential influence of various types of relationships.

We initially entered this project with a more simple relational view, expecting that youth programs were facilitating primarily one-on-one mentoring relationships. We therefore anticipated we might ultimately design technologies for facilitating one-to-one mentoring matches or communication between a young person and their assigned mentor.

However, our analysis of how these programs were addressing the traumas experienced by youth revealed a more complex and layered approach to facilitating social connectedness. Understanding the tensions between these layers helped us gain a better understanding of what challenges youth were experiencing, and the role of social relationships in helping them face these challenges. In other words, we improved our problem definition before beginning to design a technological solution to address it. For example, youth did not always have the *intrapersonal* skills to avoid conflict and connect with others, but had opportunities to work on these skills through *interpersonal* relationships with peer mentors and adult mentors, who were available to give them guidance in the absence of positive influences among *large group* connectednesss within their neighborhoods, where they were often exposed to violence. A *small group* activity such as a basketball team enabled youth to connect with each other through close and repeated interactions, as much as through a shared *culture*, whether related to the sport or their common generation with peers.

The way we have conceptualized layers of social connectedness bears some similarity to what Park (2018) called a "mosaic of social support." In her study of college students, she found that their mental wellbeing was supported by a mosaic made up of three groups: close friends, parents, and acquaintances or anonymous online connections:

> "These social groups were somewhat structured, but also adaptable, meeting the different needs of each individual at different times. This flexible but tightly intertwined form of social support was crucial in maintaining the students' mental wellness." (Park, 2018)

We noted a similar ebb and flow to different sources of social connectedness, such as mentors' willingness to step in and provide guidance to a young person when they could see that the parents, teachers, or other adults in their lives were not able to meet these needs. However, our structural layers of social connectedness differ from the concept of the mosaic in that they represent how individual and collective well-being influence one another. Rather than a mosaic of multiple groups that surround an individual at its center, the individual is a part of the collective, and their subjective perception of how they connect to others across various layers is what contributes to their sense of self and their mental well-being. In turn, their sense of connectedness to others is what enables them to contribute to the wellbeing of their community and of those around them.

Unlike the direct social interactions making up the mosaic, the layers of social connectedness can also involve a sense of connectedness to one's ancestors, or to people across the world with whom one may never directly interact. Yet this sense of connectedness can have real tangible benefits to an individual's motivation and sense of self, and to a collective sense of identity and power. Here, our findings also relate to Burgess et al.'s (2019) concept of diffuse sociality, which they define as being proximate to others but focusing on one's own activities without directly interacting – such as studying at a coffee shop full of strangers, or playing an online game while seated next to a friend who is engaged in a different activity. In their study of self-managing depression, Burgess et al. found that diffuse sociality was useful when individuals felt they were not able to handle direct social interaction but could still benefit from feeling connected to or in community with others. Designing across the structural layers of social connectedness can help to identify opportunities for enabling diffuse sociality. For instance, technologies could help individuals realize how many other people around them share a certain interest, whether or not they directly interact with those people online or offline. Technologies could also help to organize or amplify community events, so that those who engage with them can feel a part of something bigger than themselves, regardless of how much they interact directly with others at the event.

Target factors where individual and collective well-being are intertwined

When designing technologies to support mental health, we recommend understanding how the individual and the collective influence each other's well-being, to identify opportunities for supporting both.

The public health concept of social connectedness is also novel and informative for design because it explains how the well-being of individuals is intertwined with the well-being of their communities. Many of our interviewees grew up in the same socioeconomically distressed neighborhoods where they were now creating programs to support the next generation of young people. From their lived experience and earned wisdom, we learned how these neighborhoods were (a) causing harm to youth, for example through the prevalence of gun violence and lack of opportunities, but also (b) providing an important source of relationships with people who can relate to them, care about them, and guide them. Having witnessed a rise in gun violence especially among youth, the interviewees described how they were aiming to disrupt these cycles by shaping young people's belief in themselves, how they socialize with one another, and how they view themselves as part of a larger community. In our approach to technology design, we were influenced significantly by understanding these efforts to support the mental health of youth, both individually and collectively, via promoting social connectedness.

For HCI and CSCW, social connectedness thus provides an evidence-based set of interrelated factors (structural, functional, quality) for understanding how social relationships across an entire community influence health. Social connectedness is a more comprehensive approach than social support, which is commonly discussed in the literature, yet without any agreed-upon definition or factors. We also build on the smaller number of studies that name social connectedness as their goal, but use various metrics such as intimacy, cultural integration, co-presence, or awareness – e.g., Biemans et al. (2009); Davis et al. (2016); Deighan et al. (2023); Jeong et al. (2018); Mills et al. (2023); Xing et al. (2023). We provide a unifying definition and set of factors to guide future work and enable our field to build evidence for how technologies can be designed to promote social connectedness. For example, designing for people who live alone Davis et al. (2016); Jeong et al. (2018) addresses one of the structural factors of social connectedness.

The design of technologies for mental health often focuses on the individual, and takes a clinical approach to treating or managing their symptoms or diagnosed illness. In contrast, the concept of social connectedness extends beyond the individual to situate their subjective experience in relation to the community around them. As such, our contribution with this approach aligns with increasing calls in the HCI and CSCW community to design for mental health more holistically, preventatively, and relationally (Bosley et al., 2022; Marcu, 2022; Nunes et al., 2015; Pendse et al., 2022; Thieme et al., 2015). Given also the challenges of engaging individuals directly about their mental health (Marcu and Huh-Yoo, 2023), designing for social connectedness can be a way to frame technology around a less stigmatized topic, which is no less important for one's mental health. For example, our findings demonstrated how youth programs and group activities were designed to address trauma and mental health. Although individual mentors must maintain continuity to have an impact on a young person's life, group activities such as sports or consistent events and locations can provide continuity at the programmatic level. Over time, the combination of the group context and one-on-one interactions work together to give a young person a sense of belonging that contributes to their belief in their self-worth. Youth advocates were also interested in guiding youth toward contributing to their community to help them feel a sense of purpose. Supporting these important social interactions requires technologies that strategically leverage local geographic information to bring users back to connecting locally.

Finally, in these findings, we saw strong similarities to Parker and colleagues' work with healthy eating among low-income African American communities, where they identified the value of collectivism for designing technologies for health (Parker et al., 2012; Parker and Grinter, 2014). They describe collectivistic systems as digital health interventions that focus on: the value of collectivism as a sense of communal responsibility, sensitivity to cultural uniqueness and local expertise, and collective action for the pursuit of systemic change (Parker et al., 2012; Parker and Grinter, 2014). Using social connectedness can help designers to design these types of systems for any type of health, by focusing on the structures that enable relationships to form, the functions that relationships serve, and the qualities that make relationships so transformative for mental health, physical health, and longevity.

Conclusion

In summary, the five layers of social connectedness expand our focus beyond social support — or lack thereof, including mistreatment and harm — that explain how people either feel a sense of belonging and worth in relation to others, or feel demoralized, isolated, and hopeless. Importantly, this type of social support concerns a person's subjective experience of connectedness to others, regardless of how tangible or quantifiable connectedness to others may be from an external, objective perspective. This kind of social support also has less to do with problem-solving (e.g., information seeking, symptom monitoring) than it does with a fundamental sense of human connection that enables building relationships and contributing to one's community. The layers of social connectedness also demonstrate how individual and collective well-being are intertwined. The absence of social connectedness leads not only to an individual's adverse mental and physical health outcomes (Office of the Surgeon General, 2023a), but also to antisocial behavior, violence, and the disintegration of neighborhoods — as reported by our youth advocate interviewees, who observed how local youth were being drawn into gun violence due to cycles of trauma and neglect.

Acknowledgments

We thank our community partners and interviewees for making this work possible. This material is based upon work supported by the National Science Foundation under Grant Nos. IIS 1816319 and 2144880.

References

Anderson, K. A. (2007): 'Mentoring and Standardized Achievement of African American Males in the Elementary and Middle Grades.'. *Middle Grades Research Journal*, vol. 2, no. 1.

Ayobi, A., R. Eardley, E. Soubutts, R. Gooberman-Hill, I. Craddock, and A. A. O'Kane (2022): 'Digital mental health and social connectedness: experiences of women from refugee backgrounds'. *Proceedings of the ACM on Human-Computer Interaction*, vol. 6, no. CSCW2, pp. 1–27.

Biemans, M., B. van Dijk, P. Dadlani, and A. van Halteren (2009): 'Let's stay in touch: sharing photos for restoring social connectedness between rehabilitants, friends and family'. In: *Proceedings of the 11th international ACM SIGACCESS conference on Computers and accessibility*. pp. 179–186.

Bosley, B., C. N. Harrington, S. M. Morris, and C. A. Le Dantec (2022): 'Healing Justice: A Framework for Collective Healing and Well-Being from Systemic Traumas'. In: *Designing Interactive Systems Conference*. pp. 471–484.

Bowers, J. M. (1991): 'The Janus Faces of Design: Some Critical Questions for CSCW'. In: J. M. Bowers and S. D. Benford (eds.): *Studies in Computer Supported Cooperative Work: Theory, Practice and Design*. Amsterdam, etc., pp. 333–350, North-Holland.

Burgess, E. R., M. C. Reddy, and D. C. Mohr (2022): '"I Just Can't Help But Smile Sometimes": Collaborative Self-Management of Depression'. *Proceedings of the ACM on Human-Computer Interaction*, vol. 6, no. CSCW1, pp. 1–32.

Burgess, E. R., K. E. Ringland, J. Nicholas, A. A. Knapp, J. Eschler, D. C. Mohr, and M. C. Reddy (2019): '"I think people are powerful" The Sociality of Individuals Managing Depression'. *Proceedings of the ACM on Human-Computer Interaction*, vol. 3, no. CSCW, pp. 1–29.

CDC (2019): 'Preventing adverse childhood experiences: Leveraging the best available evidence'. *Atlanta, GA: National Center for Injury Prevention and Control, Centers for Disease Control and Prevention*.

CDC (2023): 'Youth risk behavior survey: Data summary trends report 2011-2021'. *Atlanta, GA: National Center for HIV, Viral Hepatitis, STD, and TB Prevention*.

CDC (n.d.): 'How Does Social Connectedness Affect Health?'. https://www.cdc.gov/emotional-wellbeing/social-connectedness/affect-health.htm. Accessed: Feb 24, 2024.

Clark, L. F., K. S. Miller, S. S. Nagy, J. Avery, D. L. Roth, N. Liddon, and S. Mukherjee (2005): 'Adult identity mentoring: Reducing sexual risk for African-American seventh grade students'. *Journal of Adolescent Health*, vol. 37, no. 4, pp. 337–e1.

Coulton, C. J., J. E. Korbin, M. Su, and J. Chow (1995): 'Community level factors and child maltreatment rates'. *Child development*, vol. 66, no. 5, pp. 1262–1276.

Culyba, A. J., K. R. Ginsburg, J. A. Fein, C. C. Branas, T. S. Richmond, and D. J. Wiebe (2016): 'Protective effects of adolescent–adult connection on male youth in urban environments'. *Journal of Adolescent Health*, vol. 58, no. 2, pp. 237–240.

Cutrona, C. E. and J. A. Suhr (1992): 'Controllability of stressful events and satisfaction with spouse support behaviors'. *Communication Research*, vol. 19, no. 2, pp. 154–174.

Davis, K., E. Owusu, J. Hu, L. Marcenaro, C. Regazzoni, and L. Feijs (2016): 'Promoting social connectedness through human activity-based ambient displays'. In: *Proceedings of the international symposium on interactive technology and ageing populations*. pp. 64–76.

Deighan, M. T., A. Ayobi, and A. A. O'Kane (2023): 'Social Virtual Reality as a Mental Health Tool: How People Use VRChat to Support Social Connectedness and Wellbeing'. In: *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*. pp. 1–13.

Dillahunt, T. R., A. J. Lu, A. Israni, R. Lodha, S. Brewer, T. S. Robinson, A. B. Wilson, and E. Wheeler (2022): 'The Village: Infrastructuring Community-based Mentoring to Support Adults Experiencing Poverty'. pp. 1–17.

DiSalvo, C., F. Gemperle, J. Forlizzi, and E. Montgomery (2003): 'The hug: an exploration of robotic form for intimate communication'. In: *The 12th IEEE International Workshop on Robot and Human Interactive Communication, 2003. Proceedings. ROMAN 2003.* pp. 403–408.

Finkelhor, D. (2009): *Children's exposure to violence: A comprehensive national survey*. Diane Publishing.

Finkelhor, D., H. Turner, A. Shattuck, S. Hamby, and K. Kracke (2015): *Children's exposure to violence, crime, and abuse: An update*. US Department of Justice, Office of Justice Programs, Office of Juvenile ....

Forkan, A. R. M., P. Branch, P. P. Jayaraman, and A. Ferretto (2019): 'An Internet-of-Things solution to assist independent living and social connectedness in elderly'. *ACM Transactions on Social Computing*, vol. 2, no. 4, pp. 1–24.

Gaines, K. K. (2022): 'Global Black Lives Matter'. *American Quarterly*, vol. 74, no. 3, pp. 626–634.

Gerson, E. M. and S. L. Star (1986): 'Analyzing due process in the workplace'. *ACM Transactions on Office Information Systems*, vol. 4, no. 3, pp. 257–270.

Hanlon, T. E., B. D. Simon, K. E. O'Grady, S. B. Carswell, and J. M. Callaman (2009): 'The effectiveness of an after-school program targeting urban African American youth'. *Education and Urban Society*, vol. 42, no. 1, pp. 96–118.

Hardy, K. V. (2013): 'Healing the hidden wounds of racial trauma'. *Reclaiming Children and Youth*, vol. 22, no. 1, pp. 24.

Hirsch, L., F. Müller, F. Chiossi, T. Benga, and A. M. Butz (2023): 'My Heart Will Go On: Implicitly Increasing Social Connectedness by Visualizing Asynchronous Players' Heartbeats in VR Games'. *Proceedings of the ACM on Human-Computer Interaction*, vol. 7, no. CHI PLAY, pp. 976–1001.

Holt-Lunstad, J. (2022): 'Social connection as a public health issue: The evidence and a systemic framework for prioritizing the "social" in social determinants of health'. *Annual Review of Public Health*, vol. 43, pp. 193–213.

Holt-Lunstad, J. and A. Steptoe (2022): 'Social isolation: An underappreciated determinant of physical health'. *Current Opinion in Psychology*, vol. 43, pp. 232–237.

Hurd, N. M. and R. M. Sellers (2013): 'Black adolescents' relationships with natural mentors: associations with academic engagement via social and emotional development.'. *Cultural Diversity and Ethnic Minority Psychology*, vol. 19, no. 1, pp. 76.

Jeong, K., J. Sung, H.-S. Lee, A. Kim, H. Kim, C. Park, Y. Jeong, J. Lee, and J. Kim (2018): 'Fribo: A social networking robot for increasing social connectedness through sharing daily home activities from living noise data'. In: *Proceedings of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*. pp. 114–122.

Johansen, R. (1988): *Groupware. Computer Support for Business Teams*. New York and London: The Free Press.

Kaziunas, E., M. S. Klinkman, and M. S. Ackerman (2019): 'Precarious interventions: Designing for ecologies of care'. *Proceedings of the ACM on Human-Computer Interaction*, vol. 3, no. CSCW, pp. 1–27.

Keller, T. E. (2005): 'A systemic model of the youth mentoring intervention'. *Journal of Primary Prevention*, vol. 26, no. 2, pp. 169–188.

Kogan, S. M., G. H. Brody, and Y.-f. Chen (2011): 'Natural mentoring processes deter externalizing problems among rural African American emerging adults: A prospective analysis'. *American Journal of Community Psychology*, vol. 48, no. 3, pp. 272–283.

Lee, R. M., M. Draper, and S. Lee (2001): 'Social connectedness, dysfunctional interpersonal behaviors, and psychological distress: Testing a mediator model.'. *Journal of Counseling Psychology*, vol. 48, no. 3, pp. 310.

Lerner, R. M., J. V. Lerner, V. M. Murry, E. P. Smith, E. P. Bowers, G. J. Geldhof, and M. H. Buckingham (2021): 'Positive youth development in 2020: Theory, research, programs, and the promotion of social justice'. *Journal of Research on Adolescence*, vol. 31, no. 4, pp. 1114–1134.

Lindsay-Dennis, L., L. Cummings, and S. C. McClendon (2011): 'Mentors' reflections on developing a culturally responsive mentoring initiative for urban African American girls'. *Black Women, Gender+ Families*, vol. 5, no. 2, pp. 66–92.

Logwood, D. C. (2020): 'Critical Black feminist mentorship: A review of a middle school and university-sponsored program for adolescent Black girls'. Ph.D. thesis, Eastern Michigan University.

Marcu, G. (2022): 'Toward Trauma-Informed Design of Behavioral Interventions: A Case Study on Classroom Management'. In: *Proceedings of 20th European Conference on Computer-Supported Cooperative Work*.

Marcu, G. and J. Huh-Yoo (2023): 'Attachment-Informed Design: Digital Interventions That Build Self-Worth, Relationships, and Community in Support of Mental Health'. In: *Proceedings of the 2023 ACM Designing Interactive Systems Conference*. New York, NY, USA, p. 2453–2468, Association for Computing Machinery.

Martino, J., J. Pegg, and E. P. Frates (2017): 'The connection prescription: using the power of social interactions and the deep desire for connectedness to empower health and wellness'. *American Journal of Lifestyle Medicine*, vol. 11, no. 6, pp. 466–475.

Meyerhoff, J., R. Kornfield, D. C. Mohr, and M. Reddy (2022): 'Meeting Young Adults' Social Support Needs across the Health Behavior Change Journey: Implications for Digital Mental Health Tools'. *Proceedings of the ACM on Human-Computer Interaction*, vol. 6, no. CSCW2, pp. 1–33.

Michalski, C. A., L. M. Diemert, J. F. Helliwell, V. Goel, and L. C. Rosella (2020): 'Relationship between sense of community belonging and self-rated health across life stages'. *SSM-population health*, vol. 12, pp. 100676.

Mills, C., D. Y. Geiskkovitch, C. Neustaedter, W. Odom, and B. Axtell (2023): 'Remote Wavelength: Design and Evaluation of a System for Social Connectedness Through Distributed Tabletop Gameplay'. In: *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*. pp. 1–19.

Nunes, F., N. Verdezoto, G. Fitzpatrick, M. Kyng, E. Grönvall, and C. Storni (2015): 'Self-care technologies in HCI: Trends, tensions, and opportunities'. *ACM Transactions on Computer-Human Interaction (TOCHI)*, vol. 22, no. 6, pp. 1–45.

Office of the Surgeon General (2023a): 'Our Epidemic of Loneliness and Isolation: The U.S. Surgeon General's Advisory on the Healing Effects of Social Connection and Community'. *U.S. Department of Health and Human Services*.

Office of the Surgeon General (2023b): 'U.S. Surgeon General's Advisory on Social Media and Youth Mental Health'. *U.S. Department of Health and Human Services*.

Park, S. Y. (2018): 'Social support mosaic: Understanding mental health management practice on college campus'. In: *Proceedings of the 2018 Designing Interactive Systems Conference*. pp. 121–133.

Parker, A., V. Kantroo, H. R. Lee, M. Osornio, M. Sharma, and R. Grinter (2012): 'Health promotion as activism: building community capacity to effect social change'. In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. pp. 99–108.

Parker, A. G. and R. E. Grinter (2014): 'Collectivistic health promotion tools: Accounting for the relationship between culture, food and nutrition'. *International Journal of Human-Computer Studies*, vol. 72, no. 2, pp. 185–206.

Pendse, S. R., D. Nkemelu, N. J. Bidwell, S. Jadhav, S. Pathare, M. De Choudhury, and N. Kumar (2022): 'From treatment to healing: Envisioning a decolonial digital mental health'. In: *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*. pp. 1–23.

Richards, O. K., G. Marcu, and R. N. Brewer (2021): 'Hugs, bible study, and speakeasies: designing for older adults' multimodal connectedness'. In: *Designing Interactive Systems Conference 2021*. pp. 815–831.

Ringland, K. E., J. Nicholas, R. Kornfield, E. G. Lattie, D. C. Mohr, and M. Reddy (2019): 'Understanding mental ill-health as psychosocial disability: Implications for assistive technology'. In: *Proceedings of the 21st International ACM SIGACCESS Conference on Computers and Accessibility*. pp. 156–170.

Rogers, C. (1951): *Client-centered therapy: Its current practice, implications and theory*. London: Constable.

Shahin, S., J. Nakahara, and M. Sánchez (2021): 'Black Lives Matter goes global: Connective action meets cultural hybridity in Brazil, India, and Japan'. *new media & society*, pp. 14614448211057106.

Spencer, M. B. (1995): 'Old issues and new theorizing about African American youth: A phenomenological variant of ecological systems theory'. *Black youth: Perspectives on their status in the United States*, pp. 37–70.

Stoff, D. M. and V. A. Cargill (2016): 'Future HIV mentoring programs to enhance diversity'. *AIDS and Behavior*, vol. 20, no. 2, pp. 318–325.

Thieme, A., J. Wallace, T. D. Meyer, and P. Olivier (2015): 'Designing for mental wellbeing: towards a more holistic approach in the treatment and prevention of mental illness'. In: *Proceedings of the 2015 British HCI Conference*. pp. 1–10.

Valentino, S. and M. Wheeler (2013): 'Big brothers big sisters report to America: Positive outcomes for a positive future. 2013 Youth Outcomes Report'. *Retrieved online from http://www. bbbs-gc. org/Websites/bbbsgallatincounty/images/20130425_BBBSA_YOS2013. pdf.*

van der Kolk, B. A. (2015): *The body keeps the score: Brain, mind, and body in the healing of trauma*. Penguin Books.

Vuningoma, S., M. R. Lorini, and W. Chigona (2021): 'How refugees in South Africa use mobile phones for social connectedness'. In: *Proceedings of the 10th International Conference on Communities & Technologies-Wicked Problems in the Age of Tech*. pp. 128–137.

Walsh, D., G. McCartney, M. Smith, and G. Armour (2019): 'Relationship between childhood socioeconomic position and adverse childhood experiences (ACEs): a systematic review'. *J Epidemiol Community Health*, vol. 73, no. 12, pp. 1087–1093.

Wang, Q., S. Jing, and A. K. Goel (2022): 'Co-Designing AI Agents to Support Social Connectedness Among Online Learners: Functionalities, Social Characteristics, and Ethical Challenges'. In: *Designing Interactive Systems Conference*. pp. 541–556.

World Health Organization (WHO) (1946): *Constitution of the World Health Organization*. Basic Documents, Geneva: World Health Organization.

World Health Organization (WHO) (2022): *Mental Health [Fact Sheet]*.

Wyatt, S. (2009): 'The brotherhood: Empowering adolescent African-American males toward excellence'. *Professional School Counseling*, vol. 12, no. 6, pp. 2156759X0901200615.

Xing, Y., R. M. Kelly, M. J. Rogerson, and J. Waycott (2023): '" Keeping the Program Going": Technology Use by Community Organizations to Support the Social Connectedness of Older Adults During the COVID-19 Pandemic'. *Proceedings of the ACM on Human-Computer Interaction*, vol. 7, no. CSCW2, pp. 1–26.