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Key Considerations for the Automation of Physical Work in Organizations: the Effect of Stakeholders

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Abstract

In organizations, the adoption of automation is a crucial yet understudied phenomenon that surrounds the provision of successful human-automation teamwork in physical work settings. Automation adoption is an entangled process, where the social and technical aspects of organizations mutually shape each other. In this paper, we specifically focus on the stakeholders that affect automation adoption, to expose how their dynamics and practices to conceptualize, develop, and deploy automation could influence the facilitation of successful human-automation teams. First, we present our research in a specific organization, Amsterdam Airport Schiphol. Second, based on our insights, we discuss the key role of practitioners, technology suppliers, workers, and ecosystem actors regarding automation adoption; we illustrate their perspectives and development pathways, to point at key aspects that could influence the design of successful human-automation teams. Finally, we derive takeaways concerning the design of human-automation teams, that aim to inform future HCI research.

Keywords

Automation Adoption, Human-automation Teams, Organizations, Stakeholders

1. Introduction

In recent years, the automation of physical work has gained significant attention in organizational contexts. Organizations expect to, for instance, improve the efficiency of their operations and teams [1, 2, 3], ameliorate employees' working conditions by eliminating current undesirable tasks [4, 5, 6], address shortages of highly demanded professionals [7, 8, 9, 10], or reduce human errors [11]. However, despite those envisioned benefits, facilitating and supporting successful human-automation teams is often a challenge for organizations [12, 13, 14, 15, 10, 16].

In this paper, we argue that the adoption of automation is a crucial phenomenon surrounding the provision of human-automation teamwork in organizations [17, 16]. For instance, prior research highlights challenges related to the integration of automated solutions into existing workflows [14, 18] and governance structures [19], and argues that organizational procedures need to be established to favor these integrations [17, 20]. Yet, automation adoption is usually not considered when designing human-automation teaming guidelines, approaches, or best practices. Therefore, we propose to take a step back to further study the organizational dynamics and processes that are currently followed in physical workplace settings to conceptualize, develop, and deploy automation, and explore how human-automation teaming might be influenced by these organizational dynamics and processes.

Automation adoption is an entangled process [21, 22, 23]. As supported by sociomaterial theories, material artifacts and human actions co-constitute each other, meaning that, in organizations, the technical and social aspects are not only inseparable but are also mutually shaped [24, 23, 25, 26]. Studying this phenomenon is especially relevant in the case of emerging technologies, which can fundamentally transform all aspects of organizations [27].

In this paper, we further emphasize these ideas by focusing on the stakeholders that affect automation adoption in organizations, arguing that their dynamics and practice affect the facilitation of successful

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human-automation teams. First, we present research that we have conducted in a specific organization, Amsterdam Airport Schiphol, to illustrate the magnitude of the problem we are addressing as well as to base our insights on it. Second, we specifically discuss the key role of practitioners, technology suppliers, workers, and relevant actors within an organizations' ecosystem regarding automation adoption; we illustrate their perspectives and development pathways, to point at key aspects that affect the design of successful human-automation teams. We aim to offer a starting point for discussions regarding how these aspects could be incorporated into the design of hybrid human-automation teams, as well as the role of HCI research in facilitating that integration.

1.1. Background

The context of our research is Amsterdam Airport Schiphol, a Western European airport that is currently immersed in a 25-year automation program that involves its airside and terminal processes. The airside is the security-restricted area located outside an airport, where aircraft operations and supporting ground operations (e.g., baggage transport, aircraft fueling) take place [28]. The terminal refers to the airport building where passengers wait to be boarded before their trip; as such, several processes take place in relation to security, mobility, and catering to passengers. While the airport is currently involved in the development of several automation projects, most of them are still not mature, integrated, or stable enough to be utilizable within the airport's day-to-day operations. Besides, automation adoption issues also affect the creation of successful human-automation teams, sometimes leading to undesired work or low worker acceptance of automation technologies.

It is important to mention that airports function according to specific stakeholder structures and dynamics. The airport is the owner of the infrastructure and the main responsible for the facilitation of air travel. Nevertheless, third-party companies are the ones that execute the operations, namely, baggage handlers, airlines, maintenance companies, or bus driving companies. Finally, several authorities such as air traffic authorities or border control authorities are responsible for ensuring safe operations. In the development of automation projects, the perspectives of all these different stakeholders influence crucial aspects such as timing, the goals that are followed, or the conceptualizations of the automation solutions.

To date, we have studied the perspectives of practitioners regarding the main five automation projects currently taking place in the organization; specifically, we studied the automation of grass mowing operations, snow removal, passenger boarding bridge movements, passenger transportation on the airside, and baggage handling processes. Note that every project is in a different development stage, with some in their initial conceptualization stage (i.e., autonomous snow removal), others in the testing phase (i.e., autonomous lawnmower, baggage lifting robots, and autonomous bus), and some in further deployment and roll out stages (i.e., passenger boarding bridge). Through a study involving 16 practitioners with prior experience in one or multiple of those automation projects, we investigated 1) the challenges of automation adoption at the airport [17]; and 2) the imaginaries of automation shared by practitioners [16]. Afterwards, we conducted a second case study within the autonomous bus project to study the effects of automation on workers. Overall, our research serves to illustrate the intricate relationship between the multiple stakeholders involved in automation projects, as well as the effects of their decisions and development pathways in later work quality.

2. Stakeholders that should be Considered in the Automation of Physical Work within Organizations

In the following lines, we describe four stakeholder groups that affect automation adoption and, therefore, could be influential in the creation of successful human-automation teams. We describe their roles in automation projects and point at issues in their conceptualizations; afterward, we propose certain considerations for future HCI research that could help bridge those problems identified.

Note that we derive these aspects from the conducted research in Amsterdam Airport Schiphol.

There might be more stakeholder categories affecting automation adoption beyond the ones we describe here, such as higher management, society, worker unions, and legislative bodies. Still, our aim is to illustrate the influence of these groups rather than to provide an exhaustive list, and we consider that our categories and descriptions can already serve as inspiration for other organizational contexts.

2.1. Practitioners

With 'practitioners' we refer to the professionals that are in charge of implementing automation solutions within an organization. These can be external or internal innovation consultants, product owners, or area managers, meaning that their main expertise is the context, where they aim to innovate through the implementation of new technology. The knowledge of this stakeholder group regarding automation technology is limited, and as such, they closely collaborate with technology suppliers to translate the specifications of the context into technology requirements. Besides, they are also responsible for advocating for new innovations within their organization; they conceptualize future visions, create development roadmaps and project portfolios, and engage different parties in the approval and testing processes of automaton projects.

Practitioners affect automation adoption greatly since they are the ones that set long-term visions of what automation projects should look like as well as how they should be integrated into their organization. As highlighted by Breuer et al. [29], technology is developed according to specific views of the world and the context of use of those who shape it. Following this rationale, in Gomez-Beldarrain et al. [16] we studied the social imaginaries of automation of 16 practitioners of Amsterdam Airport Schiphol. Our results indicated that practitioners ground the need for automation in the problems the airport is currently facing (e.g., capacity issues, worker scarcity), and that automation is seen as a strong, *"deus ex machina"* solution [30] for those issues. This can be linked to notions of *technological-solutionism*, highlighted in prior literature [6, 31]. As previously noted in the works of Bradshaw et al. [32], this solutionist approach might be linked to *myths of automation*, which are societally widespread misconceptions around automation; these also affect the views of practitioners in thinking, for instance, that full automation will be error-free and will not require human operators. As a consequence, the human aspect of automation is often overlooked, and human roles are an afterthought rather than something that is designed upfront, as widely claimed by HCI scholars [33, 34, 15, 35].

2.1.1. Takeaway regarding the design of human-automation teams

Taking into account that practitioners are a crucial stakeholder in the design of successful human-automation teams, we claim that HCI research could study their innovation pathways further, to propose tools devoted to overcoming automation myths or promoting the inclusion of worker voices early enough in design pathways. Worker-centric HCI methods [36] are already considering the inclusion of workers in the design of new technology, but we consider that further tailoring this methods to practitioners' needs might be necessary to promote the creation of meaningful jobs and human-automation interactions [37, 38].

2.2. Technology Suppliers

The suppliers of automated solutions are in charge of developing the technology into concrete equipment, such as robots, autonomous vehicles, or supporting components. The expertise of this stakeholder group is the technology itself (e.g., its limitations, development timelines, maturity) which they later try to accommodate to specific contexts and organizational requirements.

Suppliers are pressed to sell their solutions, what can sometimes lead to over-promises of what their automated equipment is able to do. As highlighted by Baur and Iles [6], suppliers often reinforce myths around automation; they depict futures of flexible and empowered labor, yet workers increasingly become dependent on supplier services once automation is implemented. Besides, translating products from the lab to real-life contexts is not straightforward or "*plug-and-play*" [17]. In the airport context that we study, for instance, autonomous equipment needs to be tested and adapted to the context's

specific requirements before it works, which takes long development timelines and extensive efforts from the organization to enable this adaptation [16, 17]. We see that, while some equipment might work in isolated and clean environments (e.g., a warehouse), the complex, dirty, and unexpected situations that surround airport operations challenge existing equipment.

2.2.1. Takeaway regarding the design of human-automation teams

Future HCI research could investigate and rethink the translation of autonomous technologies from lab to organizational settings, to promote realistic and efficient pathways of technological adaptation; in that regard, it might be beneficial to unpack the adequacy of technologies for certain contexts, as well as to provide practitioners with tools to identify suitable suppliers and communicate technology requirements.

2.3. Workforce

Workers are the end users of automation technology. They usually receive technological innovations from their managers and are trained in new work configurations. Trust and technology acceptance play a crucial role in the adoption of automation by workers; in that regard, previous scholars highlight that top-down technology implementations often lead to new burdens for workers (in the form of *patchwork* [15] or *ghostwork* [35]), as technology developers and practitioners can overlook certain relevant aspects of worker tasks.

Workers are experts in their own work settings, responsibilities, and tasks. As mentioned in prior literature, including worker voices in the design, development, and validation of automation is beneficial not only to leverage their knowledge but also to ensure that meaningful work is created [15, 10, 36, 34, 37, 39, 38]. Nevertheless, while prior works have suggested following worker-centered HCI approaches in the development and deployment of automation [36], existing studies only focus on single worker groups [10, 34, 40, 41, 42]. By studying our context, we realized that this approach could be narrow-focused; in airports, multiple worker groups work together and interact in the same process. For instance, an autonomous bus deployment not only affects drivers but also airline crews, bus coordinators, bus directors, and traffic authorities. Therefore, studying how automation affects the work and interactions of a wider set of workers might be needed for human-automation teams to succeed.

2.3.1. Takeaway regarding the design of human-automation teams

We argue that worker-centered HCI methods would benefit from systemic approaches that not only include single worker groups in the design, development, and deployment of automation, but also consider the wider worker system where autonomous solutions will be embedded. Workforce-centric automation should be further explored. The work of Kim et al. [43] serves as an example of how anticipating the impact of technology on a wider set of actors can be insightful.

2.4. Ecosystem Actors

Some organizations are multi-stakeholder ecosystems, meaning that several actors work together in the provision of the processes and differ in goals or authoritative power. This is the case of ports or airports. For instance, while the airport organization is the infrastructure owner, the airside equipment and movements fall under the authority of air traffic control. As such, the agreement and approval of different actors is needed for automation projects to be tested or implemented on-site. This not only requires practitioners to follow specific administration procedures, but also causes delays in automation projects where disagreements might occur [17]. As discussed in our study [16], the different priorities of the actors as well as the late inclusion of some crucial parties might lead to failed automation adoption.

2.4.1. Takeaway regarding the design of human-automation teams

Future HCI research could help expose, negotiate, and bridge the different interests and fears of actors affected by automation innovation. In addition, it would be beneficial to identify when in innovation pathways those negotiations should take place, to ensure that stakeholders are included and informed in a timely manner.

3. Conclusion

In organizations, the adoption of automation is a crucial yet understudied phenomenon that should inform the provision of human-automation teamwork in physical work settings. This paper illustrates that automation adoption is an entangled process, by describing the roles and dynamics of four stakeholder categories that affect automation adoption as a consequence of their priorities, expertise, and practice. By offering examples from Amsterdam Airport Schiphol (The Netherlands), an airport that is currently embedded in an ambitious automation program, we describe the dynamics between practitioners, technology suppliers, workforce, and ecosystem actors in the conceptualization, development, and deployment of automation. We identify issues in current innovation dynamics and offer research directions for future HCI research, aimed at facilitating automation adoption toward meaningful human-automation teams. Ultimately, we consider that failing to consider these stakeholder dynamics might lead to non-actionable or detached human-automation interaction guidelines. Therefore, we urge researchers in human-automation teaming to embed their findings and propositions in the wider organizational considerations that we present here.

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Generative AI Use Declaration

The authors declare the use of generative AI tools in the preparation of this work, limited to a single task: assisting with sentence refinement (i.e., grammar and spelling corrections, and the condensing of lengthy sentences) during the manuscript's writing phase.

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