Engaging Automation at Work – A Literature Review

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Abstract. Automation pervades workplaces in an increasing pace and its effects on work practices and roles are far-reaching. Work tasks are typically automated with efficiency, effectiveness and safety in mind, but less attention is paid on the user experience aspects. As the amount of direct human control over technology is often decreased with automation, the human aspect of those systems might seem less essential and thus human-system interaction designers may not be consulted when automation is designed. Yet, fully autonomous and unmanned systems are rare, as humans often still have to monitor, intervene, maintain and control the automated environments – be it on-site or remotely. This paper discusses the need for better interaction design of automated systems with a focus on engaging user experiences in work environments. Results of a systematic literature on engaging user experience design in automation solutions used at work revealed that experiential human-automation interaction design is a neglected research topic. Therefore, we call for more research on automation design that improves not only efficiency, i.e., the pragmatic aspects of user experience, but also employee engagement and other emotional aspects of user experience. It is time for a turn to the experiential to take place also in the work automation context.

Keywords: Work Automation, Interaction Design, User Experience, Engagement, Human-Computer Interaction, Human Factors, Literature Review

1 Introduction

The amount of research on the human aspects of automation is increasing rapidly. These human aspects include, for example, topics such as human-automation interaction (e.g., [1]), the ethical aspects of automation (e.g., [2] and acceptance issues [3]. However, the user experience (UX) factors with automation especially in complex work environments has gained little scholarly attention [4].

Bainbridge [6] was among the first to briefly discuss some engagement issues of automation, such as boredom, reduced feeling of achievement, and lower job satisfaction. User experience research is mostly focused on consumer products, e.g., Hassenzahl et al. [5] raised the question of the experiential cost of automation using a coffee machine as an example. Both lines of research agree that the automated process may become meaningless to the users, and what might have previously been engaging tasks for the users may be degraded to, for example, waiting time [6, 5]. Following these lines of thought, this paper discusses the relevance of designing for engaging automation, especially at work environments where the users of technical systems can seldom decide on the level of automation they want. The specific focus on work here means that we study employees as expert users of automation. In addition, the work context serves as a specific environment for studying engagement, since long-term engagement with the tools at work may often rise from professional, rather than entertainment aspects.

We see engagement as a consequence of successful user experience design, which has gone beyond removing problems and frustration to providing motivating, exciting or pleasurable experiences. The design of engaging user interactions with automation is an important, but largely neglected area of research. Interaction designers may see automation as a threat to their jobs, because the common thinking is that with higher levels of automation, no user interface or human interaction is required. However, workplace automation progresses in stages, and on different levels of automation (LoA, see e.g. [7]), the human operator has a different role. While there are several models of LoAs, it is typical in all of them that the amount of human control decreases with the increasing automation level.

From the human perspective, automation refers to a device or a system that accomplishes (partially or fully) a function that was previously, or conceivably could be, carried out (partially or fully) by a human operator [8]. By engaging automation design for work, we refer to design that changes the related work processes less human-dependent, but with the goal of making the work more interesting for the employees instead of making the work more monotonous and boring, which can often happen [9].

Engagement has been interpreted in many ways, as it can mean different things depending on the context. This paper tackles the question of *what is known about engagement in relation to using automated systems at work.* Our approach to answer the question is a systematic literature review. Specific research questions regarding the literature review are as follows:

RQ1: How much is published about designing experiential automation systems for work contexts?

RQ2: Where this topic is being researched?

RQ3: What are the limitations of the current research?

2 Related research

Before going into the literature review, it is important to clarify the key concepts of this paper, namely, engagement and automation.

2.1 Engagement with Technology

To better understand the concept of engagement in the specific case of using interactive technical systems at work, we approach the concept from two neighboring research areas: work engagement and engagement with interactive tools. Work engagement can be defined as "a positive, fulfilling work-related state of mind that is characterized by vigor, dedication, and absorption" [10], see Table 1 for details.

Table 1. Work engagement factors by [10].

Factor	Definition
Vigor	High levels of energy and mental resilience while working, the willingness to invest effort in one's work, and persistence even in the face of difficulties
Dedication	Being strongly involved in one's work and experiencing a sense of significance, enthusiasm, inspiration, pride, and challenge
Absorption	Being fully concentrated and happily engrossed in one's work, whereby time passes quickly and one has difficulties with detaching oneself from work

Specifically, we are interested in the role of interactive work tools in the formation of work engagement, and in how to maintain work engagement as the level of automation increases. Therefore, our focus in this paper is on the research of engagement with technology and with interactive work systems.

The definitions of technology engagement are context-specific, and only a few publications in the field of interactive systems provide a definition for engagement. Publications on student engagement in e-learning and beyond provide perhaps the most developed view to the concept of engagement. In this field, [11] identified that the key problem in engagement literature is mixing the state of engagement, factors that influence student engagement, and the immediate and longer-term consequences of engagement, and provides a framework making this distinction in higher education setting. While the context in [11] is not work-related and many of the factors and consequences are not applicable in the domain of interactive tools used at work, we utilize the state of engagement, the factors affecting engagement, and the consequences of engagement as one conceptual framework that we will use in the literature review analysis.

Turner [12] sees engagement with technology as being positive and exploratory. The exploration aspect creates a "space" in which engagement occurs, and this space includes affordances of the technical artefact, which people subsequently exploit. According to [12], people engage with something and continue to do so basically because they enjoy doing that activity. Therefore, affect has an important role in engagement. In addition, people engage with technology, because it allows them to achieve their purposes and these purposes can be considered as a reciprocal expression of themselves (ibid.).

Sidner et al [19] defines engagement in human-robot interaction as "the process by which interactors start, maintain and end their perceived connection to each other during an interaction". This definition is also applicable with automated systems in which interaction between the human and the automated system is an active one, such as with service robots.

The publications discussing designing for engagement with automation are becoming more popular as the automation level of different environments increases. Automotive user interfaces seem to be the latest arena for engagement research, and in this context, engagement means the focus of attention. For instance, in cars, if drivers are disengaged from driving, it takes around 40 seconds to resume adequate and stable control of driving [23]. It is clear that in emergency situations, disengaged drivers are not able to react quickly enough. Instead of requiring drivers or users simply to keep their attention in the system, we should ask how to motivate the users to keep their attention on the system. Engagement to us means not only the focus of attention, but also motivation and enjoyment.

As we can see already from the literature above, there are many varying definitions for the term engagement. Since it is hard to follow a single definition, in this paper we build on [10] and discuss engagement in a continuum of short- vs. long-term engagement, from absorption (full concentration in work activities) to vigor (energy and mental resilience) and dedication (e.g., significance, enthusiasm, pride). This helps us to analyse the existing definitions and position them. For example, the definition of Sidner's human-robot interaction [21] engagement is on the short-term side, i.e., during an interaction episode, while work engagement is typically long-term.

2.2 Automation of Work Tools and Relationship with Usability

The strive for more automation in the workplace has been driven by a set of considerations that proved useful before the computer age, but must be reconsidered nowadays. One of the first considerations was the one proposed in the MABA-MABA (Machine Are Better At - Man Are Better At) by Paul Fitts [26] which was considering the best player, according to abstract tasks, between a human and a (steam) machinery (see Fig. 1).

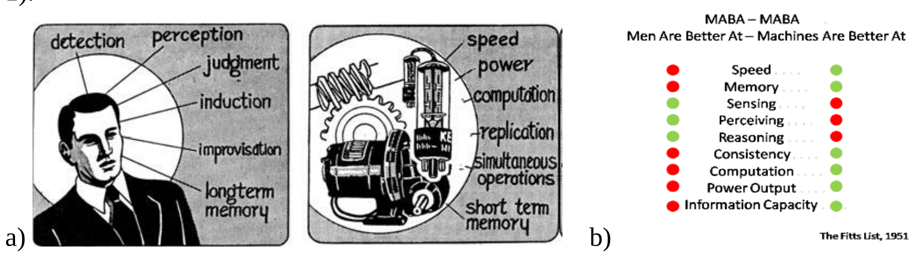

Fig. 1. a) Illustrations of the Fitts list ([26], pp. 7–8) – b) MABA-MABA list from Fitts [26]

From this figure it is interesting to note that only in number of functions, machines were better than human (3 positive scores for human and 6 for machines). Carver and Turoff [25] extended this notion of best player, replacing the steam machinery with computer systems (see Fig. 2).

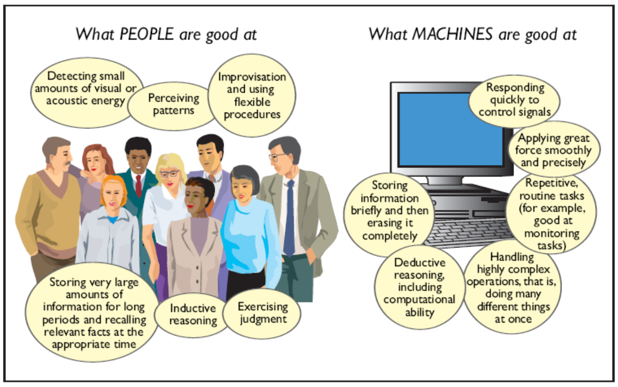

Fig. 2. Best player between human and computer from Carver and Turoff [25]

These two classifications (and especially the first one) have been extensively used both as a design driver and as a mean of assessing the adequateness of function allocation between humans and machines/computers. However, in research, it has been clearly identified that actual work requires the involvement of both machines and humans ("In modern defence systems, the majority of functions need both humans and machines to undertake complementary tasks" ([27], p. 53), cited in [28]).

Another major consideration pushing towards more automation in the workplace, came from studies on human error. Indeed, while some HCI contributions such as the Human Processor Model [29] were describing human behaviour as "flawless", other work (e.g. [30]) was highlighting that (within this human processor model) there was room for error within each processor (perceptive, cognitive and motor). While computer technologies were not getting more reliable (due to the fact that the computing field is evolving at high speed), the human error was always seen more prominent due to the impression that systems failures can always be fixed and fixing human errors is (due to the human nature) unfeasible. It was only much later that work from the dependable computing field was providing a more comprehensive view on failures, errors and faults integrating both human and systems errors in a single conceptual framework [31]. This kind of work highlights the fact that having more automation does not mean less errors as automation will fail, at least as much as other parts of the system will fail.

The fact that human and partly-autonomous systems are jointly involved when work has to be performed requires preventing as much as possible errors from both sides keeping in mind that allocation of function between the two is not a "zero sum" game: "automating a function does not necessarily result in a reduction in workload equivalent to the human work necessary for that function" [42]. This means that human work and the technical system with which the working human is cooperating have to be carefully designed. It also means that considering that the human will be able to take over when automation fails is not acceptable [43], especially when automation has been designed to replace the human operator.

An example of careful design can be taken from aeronautics where the accident rate is so low (less than one in ten million flights for the new generation of large civil aircrafts) that the underlying processes can be seen as exemplary.

Landing an aircraft may be perceived as an activity requiring very highly skilled operators and being safety critical, as an error might have catastrophic consequences. However, since the early 40s work has been carried out by the aircraft industry to provide pilots with an Autoland function. It was only on December 28th 1968 that the first civil aircraft (Airbus Caravelle) was qualified to use the Autoland function with a focus on reliability of the system offering segregation, diversity and redundancy mechanisms. Landing activities require performing flare (the nose of the plane is raised), managing thrust (reducing the value gradually), managing the roll (rotation of the aircraft along the axis running from nose to tail) and managing the alignment with the runway. Developing the Autoland function was done gradually performing first AutoFlare only, then adding AutoThrottle servos to handle thrust, and finally utilizing the autonomous management of roll leading to a fully autonomous landing system. While this system replaces humans very efficiently when visibility is low (including levels of zero visibility) its use is also extremely limited depending on other weather conditions, such as wind. For example, for a Boeing 747-400 the limitations are a maximum headwind of 25 kts, a maximum tailwind of 10 kts, a maximum crosswind component of 25 kts, and a maximum crosswind with one engine inoperative of five knots. This demonstrates the fact that careful design and deployment of automation in the workplace might increase feasibility of operations and the overall performance of a system. However, while work (and working conditions) and automation are considered, nothing is said about user experience and engagement of operators in such contexts even though the Hedonist magazine has a dedicated column called “on wings” dedicated to flying aircrafts[1].

In other domains such as walk up and use systems, automation is added mainly to reduce required labor and thus to reduce the cost of workforce. This usually comes along with a reduction of the number of tasks covered, more sequential tasks, more cumbersome and less enjoyable. Cash machines are a widely used example demonstrating this when comparing with getting cash at the cashier. At the cashier, one can request a 100 Euros note because it is green and the person wants to make a green gift to a kid. In the user’s own branch, it is often not necessary to prove identity as the cashier would know personally most of the clients. At the cashier, a PIN number and a card are not required, etc. Beyond cost of workforce reduction automations increases ubiquity and availability of service throughout the day. 2.3 Designing Interactive Systems for Engagement

Designing for engagement shares much of its history with user experience (UX) design. UX has been a research topic, since the 3rd wave of human-computer interaction started to pay more attention to the emotional, and not only the pragmatic aspects of technology use [13]. Since user experience design in practice often equals to user interface design and simply improving usability, we chose to focus on engagement, which requires more than problem-free use of interactive systems.

Ramsay, Barbesi and Preece [14[] were among the first ones to raise engagement as one of the web site design goals, and since then, the means for designing for engagement has been studied, for example, in the contexts of e-learning [15, 16, 17, 18], games [19] , and interactive public displays [20]. In automation contexts, designing for engagement has been mostly studied in human-robot interaction (e.g., Sidner et al.[21];

Rich et al. [44]), especially with service robots. Robots are one way to replace human work with automation, but at workplaces, automation often comes in other forms.

3 Method

The main method used in this work, a systematic literature review, aims to find all scientific literature in a specific topic. According to APA [45] p.10, literature reviews can help to

- define and clarify the problem;
- summarize previous investigations to inform the reader of the state of research;
- identify relations, contradictions, gaps, and inconsistencies in the literature; and
- suggest the next step or steps in solving the problem.

In this chapter, we report the literature review method used in this research, including the suitable parts of the structure recommended by Kitcheman et al. [24]. The publications filtering process was similar to the one used in [22].

3.1 Search Process

First, we tested three databases of scientific publications to investigate their coverage of relevant publications in the area of engagement with automation. Scopus database was selected, as the search with keywords 'engagement' and 'automation' yielded the highest number of publications. The final search was executed in October 2018.

The search process was done in 4 phases. In phase 1, one of the researchers executed the Scopus search and extracted the results to a table with publication information, including the title, keywords and abstract. In phase 2, the researcher checked the keywords and title to estimate the potential relevance of the publication. The same continued in the phase 3, where the researcher evaluated the abstract. In the last, 4th phase, the full text was studied to determine relevance of the remaining publications. In this last phase, the selection of potentially relevant publications was distributed to three researchers, so that each publication was examined by one researcher.

3.2 Inclusion and Exclusion Criteria

During the 4 phases of filtering, we included publications that focused on the engagement while interacting with automated systems at work. We did not set any criteria for the quality of the publication venue or publication. In phase one, the search keywords were selected based on our focus on *engagement in relation to using automated systems at work*: 'automation', 'work', 'interaction', and 'engagement'. Based on the initial search results, which were very limited, we expanded the search criteria to cover not only 'engagement' but also any emotional user experience, and not only 'automation' but also 'cyber-physical' as we expected cyber-physical systems to be used in industry. Conference reviews (cr) and other reviews (re) were excluded from the search criteria. The final search phrase for Scopus was:

TITLE-ABS-KEY ((automation OR cyber-physical) AND work AND interaction AND ("user experience" OR engagement OR emotional)) AND (EXCLUDE (DOCTYPE , "cr") OR EXCLUDE (DOCTYPE , "re"))

In phases 2 and 3, evidence on emotional aspects in work automation were searched from the keywords, title, and abstract. Publications that were clearly out of scope were excluded, others were kept in for a more careful study. The most typical reason for exclusion was that ‘work’ did not refer to a work context, but ‘work’ appeared in phrases referring to the research reported in the publication, such as ‘this work’ or ‘future work’.

In phase 4, a more thorough evaluation of the full publication was done to see if the publication was reporting some emotional aspects of interacting with automation systems at work. The most typical reason for rejection in this phase was, still, that ‘work’ did not refer to work context. In addition, papers that did not investigate human-automation interaction were excluded at this point of the filtering process.

4 Results

4.1 Search Results

The total number of publications found in phase 1 with the Scopus search phrase was 56. In phase 2, 19 publications were excluded based on keywords and abstract. Out of 37 publications entering phase 3, 26 were excluded based on the abstract. Out of these, 22 were excluded because they were not addressing work context, but smart home or city, or e-services for elderly or young people. One publication was excluded because term ‘automation’ was appearing only in the copyright statement that Scopus appends to the abstract (International Journal of Automation and Smart Technology). This paper was not about automation but smart technology and thus, did not fulfil the search criteria. Another publication was an extended abstract of a keynote talk, which did not go into the required level of detail to be analysed. Two other publications were excluded in this phase due to lack of automation or human-automation interaction focus.

Only 11 publications made it to phase 4, the full text study. Out of these, one was excluded due to lack of work context and one because it discussed human-automation interaction only as a motivation behind to the reported risk management study. The remaining nine publications are discussed in the next section.

4.2 Relevant Publications

The nine relevant publications were analyzed by the three main characteristics of relevant applications: Automation, Engagement/User experience, and Work context. A short description of each publication follows with analysis on the engagement.

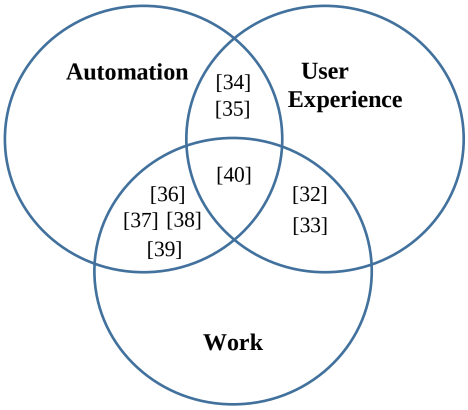

Fig. 3. Positioning of the literature with respect to the three relevant aspects; User Experience/Engagement, Automation, and Work.

[32] presents a prototype that exploits gesture-based interaction technique in the domain of flexible manufacturing systems (partly-autonomous loading stations controlled by operators). The objective of the paper is to assess the impact of novel interaction techniques (more precisely gesture-based ones) on user experience. While the loading stations are party autonomous, the paper focusses on UX (especially emotional UX, frustration and competence) and the work of the operators in terms of tasks. In that paper, automation is not part of the design space and is only considered as a behavioral aspect of the loading stations. For this reason, the paper appears in Fig. 3 at the intersection between Work and User Experience.

[33] looks at the UX elements in machinery automation from interaction design perspective. In addition, the authors describe the design implications of these elements and the benefits and challenges of applying UX to this domain. However, in the paper, machinery automation is used as the name for big machines in mining and forestry. Therefore, it is not related to automation beyond the actual device. Based on this, taking into account the sections in Fig. 3, the paper recognizes very well the aspects of work and UX, but not automation and thus appear in at the intersection of Work and UX.

[34] present a prototype called intelligent interaction and emotion that offers to a user a standard WIMP (Windows Icons Menus and Pointing devices [46]) user interface to control an air-cleaning device. The command and control system embeds contextual information affecting its behavior and good user experience is triggered by the possibility of breathing air of good quality produced by the device. For this reason, the system (device + command and control system) is autonomous and automation is distributed between these two components of the system. As this device belongs to the category of home appliances, it does not contribute to the work to be carried out by the user. This paper thus appears at the intersection between UX and Automation in Fig. 3.

[35] presents a theoretical study about how current emotional status of persons influence their reliance on automation. The case study is taken from security scanning

systems (for instance at airports) and the use of an Automated Weapon Detection system. The experiment has only been performed with students and does not relate to any work practice, hence its positioning at the intersection of automation and UX in Fig. 3. However, the paper concludes that positive emotional status increases reliance (i.e. likelihood to follow recommendations from an autonomous system) on automation.

[36] is a theoretically oriented paper examining how to combine the two traditions of activity theory and semiotics. In specific, the interest in [36] lays in analyzing technology-mediated work both from activity theory and semiotics perspective. The paper discusses various automation examples from ship control and wastewater treatment domains. The emphasis is on understanding the work activity and automated tools used in work. However, the UX or engagement aspects of these automated tools are not considered in the article, so this publication is placed in the intersection between work and automation in Fig. 3.

[37] is a practical paper describing the technical solution for the use of smart glasses as part of a cloud computing system in factory context. [37] aims to improve employee experience by freeing their hands to the actual work with wearable glasses, and by making communication more fluent with real-time video coming from the glasses to, e.g., the helpdesk operator. This makes communication between the back office and the shop floor more effortless, therefore we categorize this work as a work automation case. Beyond the general recommendation of using wearable technology, the paper does not discuss emotional aspects of automation. Therefore, it is placed at the intersection between work and automation.

[38] is very similar to [37] in its approach to provide good experiences in context of industrial fieldwork via wearable technology. The user experience goal is to provide employees "the right information to the right user at the right time and place". In addition to this pragmatic user experience, the emotional experiences of workflow automation are not discussed. The paper lists workflow automation as one of the keywords, and we categorized it as such a case: it is about automation and work but not about engagement.

[39] focuses on training for operators in the domain of manufacturing systems. The paper presents a tutoring system exploiting augmented reality interaction techniques integrating motion detection and force feedback. When manufacturing systems are getting more complex and embed more automation, classical on-the-job training is more difficult to perform. The paper is thus centered on work and how automation influences the acquisition of needed skills to perform that work. The user experience aspect is only touched in the paper through the notion of emotional knowledge (i.e. trainees and trainers being able to share information together with the emotions they were feeling), which was facilitated by the new technology made available at training time. The publication was placed between Automation and Work.

[40] investigates conducting experience design research in industrial work context based on UX goals. The particular focus is on a science-fiction prototyping method: how to utilize futuristic interaction videos as means of UX-goal driven design. The system featured is an automation system utilized in a production environment. Therefore, all the three elements of UX, automation and work are featured in this paper and the paper is placed in the middle of Fig. 3.

5 Discussion

The overarching research question that motivated this study was *what is known about engagement in relation to using automated systems at work?* The answer is simple: very little. This paper reported a systematic literature review in the intersection of automation, work, and user experience/engagement, and identified only one publication covering all three. Due to this limitation, eight closest works were included in the analysis as well. With this set of publications, we were able to answer our four specific research questions:

RQ1: How much is published about designing experiential automation systems for work contexts?

The literature review revealed a clear lack of research in the area of engaging work automation. Even after expanding the scope from engagement to user experience and emotional aspects in using automated systems, only one publication was identified to cover automation, work, and engagement or user experience.

RQ2: Where this topic is being researched?

It was interesting that 4 out of the 9 publications closest to the scope of this research originated from the Nordic countries. These countries are the ones that developed the participatory design approach to take the employees' perspective into account when designing work tools. This is known as the Scandinavian Tradition of democratic design. It is thus not surprising that the first publications introducing human-centred, experiential design of automation at work come from Scandinavia, especially Finland [32, 33, 35,].

RQ3: What are the limitations of the current research?

Automation is a vast field of research. Thousands of scholars are studying automation from technical, business, societal, human factors, etc. perspectives. Similarly, the research on work expands to various topics with a huge volume of scientific publications. Also user experience research has exploded during the previous years, as businesses have realized its importance to long-term business success. Given the volume of research done in these three fields, it is surprising that only a handful of scholars have investigated user experience of automation in work context. The answer to question of the limitations in the current research is simple: there is still a very limited number of publications tackling this recently born research topic.

5.1 Limitations of this study

A literature review is always dependent on its defined scope. We used only one literature database, Scopus, for this literature review, so the set of literature might be wider if other databases would have been covered. This literature review required the search keywords to appear in the title, keywords, or abstract of the publication. While we consider this search criteria adequate to find the key publications focused in the specific scope of ours, more examples of engaging work automation could be found in publications whose main focus is not on this topic. Finally, the selection of search keywords limits the scope of literature reviews, and the review could be expanded by adding new keywords.

6 Conclusions

We have discussed the concepts of engagement and automation, reviewing their definitions and providing examples. We found that these concepts are highly context-sensitive, and there is little research on them in the work context.

Automation design requires a multitude of skills and cross-disciplinary research, as automated systems should be reliable, dependable, resilient, secure, usable, accessible, and provide good user experience. Much attention has been placed on the first aspects, but on designing for user experience in automation where users' role is to monitor, intervene and control automated processes is still in its infancy. As working with automation is an increasing part of our life, the experiential aspects, such as engagement, become more important.

For safety-critical environments, increasing engagement via playfulness or gamifying the work might not be a good approach as these types of activities can draw too much attention and compromise safety in some situations. Especially, engagement to secondary tasks on the cost of the primary task would not be beneficial in work environments.

The concept of user experience is not well defined, therefore, it is hard for automation researchers to start working on this area and publish their research. Also the definition of engagement is highly context specific, and there are different interpretations of it even within the field of automation. In the case of car driving, engagement refers to the driver's focus of attention (e.g. in [23]), while in human-robot interaction, engagement refers to the perceived connection between the human and the robot during their interaction ([21]). The analysis of engagement literature, reported in chapter 2, we found it useful to analyze the definitions of engagement on the continuum from short-term to long-term. As the focus of this research is on work context, we are promoting engagement with automation as an emotional, motivational concept, in line with Schaufeli et al. 's definition [10] of the concept of work engagement.

This paper reported a systematic literature review to tackle question *what is known about engagement in relation to using automated systems at work*. The nearly empty intersection of automation, work, and user experience research in Fig. 3 may be due to the following reasons. Bringing automation to work context is motivated by increased efficiency and workforce savings, and the role of employees is seen disappearing as automation proceeds to levels where human operation is not required any more. Therefore, the human aspects in automation are considered of minor importance, while full attention is placed on the internal functionality of the automation system.

We hope this research opens the discussion on the need for further investigation of the experiential aspects of automation systems. A natural next step in future research is to broaden the literature review to automation engagement outside work context, and then test if the means of engagement in other contexts are applicable in the work domain. Since this literature review pointed us to an unexplored territory of research at the intersection of engaging user experiences, automation, and work, the list of relevant research questions for this area is long. Some of the interesting questions include:

- What does good user experience mean in case of work automation?
- How does engagement with automation differ at work and in leisure contexts?
- What does appropriate level of engagement mean in case of work automation?
- How can automation systems contribute to improving work engagement?
- Is design for engagement possible before acceptance and trust are there?
- What are the engaging interaction techniques and data visualizations for work automation?

The fundamental idea behind this work is that automated systems do not entirely eliminate the interaction between humans and the system, but there are different levels of human control. Humans must be able to intervene automated processes when needed. Instead of dismissing user experience design for automated systems, we need to rethink the interaction style ([40]). The need for good user experiences does not disappear with automation.

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