The Consideration of Job Satisfaction in the Design of Assistance Systems in Production

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Abstract. Assistance systems designed to help workers in their jobs are increasingly used in industry. Technological progress makes these systems more powerful and extensive, but often nobody questions the extent to which they actually support the users and do not patronize them. For the development of such systems, we found the requirement analysis to be rather complex because human factors and social constraints are more difficult to determine than technical requirements. To counteract these difficulties, we pursue in our approach the involvement of people as knowledge carriers in the development of new technologies. In this paper we outline our framework how human factors aspects of acceptance and job satisfaction can be taken into account in the conception and design of assistance systems.

Keywords: Human-centered · Industry 4.0 · Job satisfaction · Evaluation · Assistance systems

1 Introduction and Motivation

The trend towards ever greater connectivity, higher speeds, and more complex products and production processes in industrial developments has led to an increasing use of cognitive and physical assistance systems in industrial enterprises. Such systems assist users in their actions and their extended use results in increased human-machine interaction, with machines gaining more automation and humans increasingly taking on a supervisory role (see [5] and [6]).

Two different directions of human-machine interaction can be distinguished. On the one hand, user assisting interactions of the assistance system are those that support the user. On the other hand, assistance system assisting interactions are those with which the user must prepare and discontinue the assistance system for support (Fig. 1). However, these preparation interactions are often difficult to visualize through planned investigations of workers under real workplace conditions but may be an additional burden.

In many cases, the users who do the preparatory work are not those who benefit from the system. Since not only the assistance system supports the workers

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but also vice versa, they need to be integrated into the overall process. Humans are seen as a central element in the production of the future (see [16]) and it is important to put them at the center of the development of these new technologies in order to focus on aspects of job satisfaction, stress and strain on employees, and to avoid negative effects of automation as much as possible.

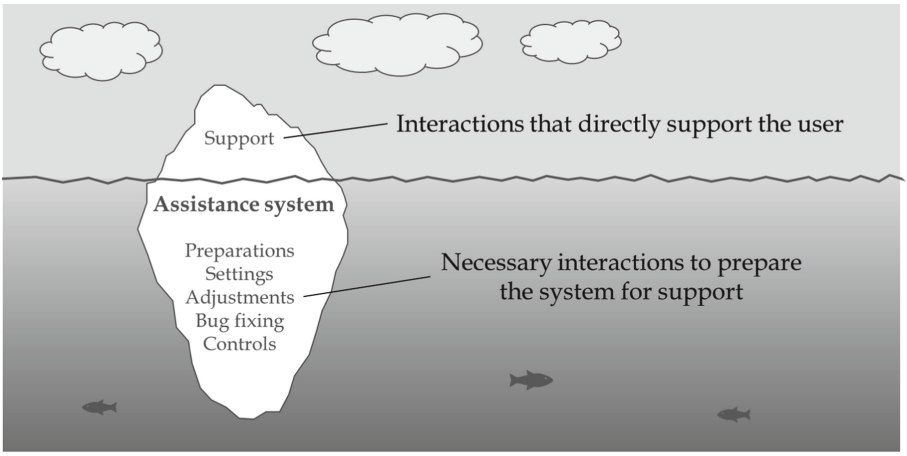

Fig. 1. Difference between user and assistant supportive interactions of assistance systems

Based on these insights we set the focus on figuring out the interdependencies between assistance systems, their acceptance and job satisfaction. When designing Software applications and services in manufacturing environments, workers needs and expectations in particular have to be considered in order to achieve smooth work flows.

The paper initially provides psychological literature on work-related theories in advance. Furthermore, design studies on the effects of assistance systems on aspects of job satisfaction are examined. After that we present the developed framework and its proper application, which deals with the integration of aspects of job satisfaction into the design of assistance systems. Finally, the summary concludes the findings.

2 Relationship Between Job Satisfaction, Acceptance and Assistance

Before we can think about the relationship between assistance and job satisfaction, we outline which factors, and to what extent, can influence job satisfaction, and what options are available to evaluate and assess that.

2.1 Concepts for the Design of Work

The design of the work has been a focus of work psychological research for decades. In particular, with the steady development of new automated systems, this area is becoming increasingly important. The literature shows that a variety of factors influence constructs such as job satisfaction or the overall well-being of employees. One of the basic theories for the beneficial design of work is the Job Characteristics Model (see [7]), which focuses on the core job dimensions of skill variety, task identity, task significance, autonomy and feedback. Over time, the central factors have been expanded and knowledge-based characteristics and physical aspects were also included (for an overview see [12] and [15]).

Another theory is the two-factor theory according to Herzberg et al. [11], which distinguishes between motivators and hygiene factors. Hacker [8] describes further key aspects for the design of beneficial work, whereby the completeness of the work is emphasized here. An activity is complete when the employee is involved in all phases (organizing, planning, executing and controlling), which Hacker also calls "sequentially complete" work. Another aspect, the "hierarchical completeness", describes task profiles, which include both complex and less complex activities. According to Hacker, central aspects to be considered when assessing a job are monotony, problem-solving ability, the ability to learn to work and the importance of control and autonomy. If the completeness of work is not given, the learning and development opportunities of the worker are limited, which in turn has a negative effect on motivation, well-being and personal development of the worker.

Karasek [13] describes the Job Demand & Control model, which deals with the relationship between job demands and job decision latitude in relation to the general experience of stress and strain in the work context. According to the model, job demands and job decision latitude can vary independently and, depending on the relation to each other, lead to the employee's stress or positive experience of the activity.

From the literature above, the central aspects of designing conducive work have been summarized for the MMAssist project (https://www.mmassist.at/). Based on the approach of the evaluation framework in the FACTS4WORKERS project (https://facts4workers.eu/, see [9]), which referred to the dimensions of autonomy, competence, variety, relatedness, protection, efficiency and quality, we presented the dimensions in a more differentiated manner, based on the work of Morgenson and Humphrey (see [12] and [15]). As a result, we have used for our framework the dimensions of **task level** (variety of tasks, autonomy in terms of decisions, temporal and content organization of the task, etc.), **knowledge level** (complexity of the task, problem-solving skills, variety of skills, information processing, etc.), **social level** (social support, interaction with colleagues) and **work context** (physical requirements, working environment) for the description of the work-related factors.

2.2 Effects of Assistance Systems on Aspects of Job Satisfaction

Previous work design studies describe a variety of factors to consider when (re)designing work, as is the case with the introduction of new technologies. The difference between assistance systems and high-automation systems is that the first support people at work, while the second need people as supporters. As this publication concentrates on assistance systems rather than high-automation systems, the human factor problems are not to be seen in the area of monitoring and transition problems, but rather in designing the assistance systems so that they can offer usable support. The approach to the development of assistance systems is therefore even more directly bounded to the human user and requires the understanding of what exactly should be supported.

Effects of automated systems on various outcome variables, such as employee job satisfaction, have been studied for decades (see [10]). Basic theoretical formulations were postulated by Wall et al. [17], who saw four major areas influenced by the introduction of automated systems: employee autonomy (temporal, methodical and task control), cognitive requirements (monitoring and problem-solving skills), Change of responsibilities and social interactions. The direction of the effects (positive or negative) depends mainly on the design of the automated system and the way it is connected.

Similarly, Cascio and Montealegre [4] describe the relationship between automated systems and employee demands. Reduced control and autonomy of the employee while at the same time perceived increased work demands threaten to bring negative effects to the introduction of automated systems. Likewise, Baethge-Kinsky and Tullius [2] highlight the change in the requirement structure, which relates in particular to analytical and problem-solving competence, but also requires additional knowledge of operational processes, social-communicative and self-organizational skills.

Based on the historical development of assistance systems, Mital and Pennathur [14] argue that technological developments tend to de-qualify workers rather than helping people achieve more self-determination and more fulfilling work. They therefore see the further development of the abilities of the employees as a central point, which must be considered when introducing new systems.

Experimental studies, such as Bala and Venkatesh [3], report negative effects of assistance systems on the experience of employees in terms of requirement and freedom of action - especially in the initial implementation phase of assistance systems - which in turn reflected reduced levels of employee job satisfaction. However, these effects were dependent on the system characteristics of the assistance system.

2.3 Introduction of an Assistance System and Interactions with the Users

Especially with the introduction of assistance systems, it requires the conversion and the support of the workers in order to prepare and adapt the system

accordingly. Such often quite flexible and adaptive activities are difficult to prescribe and more likely to emerge through experimentation and active recognition of customization options. These interactions require a positive, interested, and open attitude towards the system, so a high system acceptance. This makes it possible not to perceive change and restructuring as a threat, but to face it with confidence and participation.

Above all, the connection between the changing role of workers resulting from assistance and job satisfaction is essential. For example, a shift in roles may result from a shift in activity towards increased supervision activities of workers, which could be positively or negatively evaluated by them, thereby having an impact on overall job satisfaction. Another case could be that while workers prepare the assistance for other workers, they do not receive benefits themselves. The addition of such new activities without own benefits could have a slightly negative impact on workers acceptance and job satisfaction and should be considered (Fig. 2).

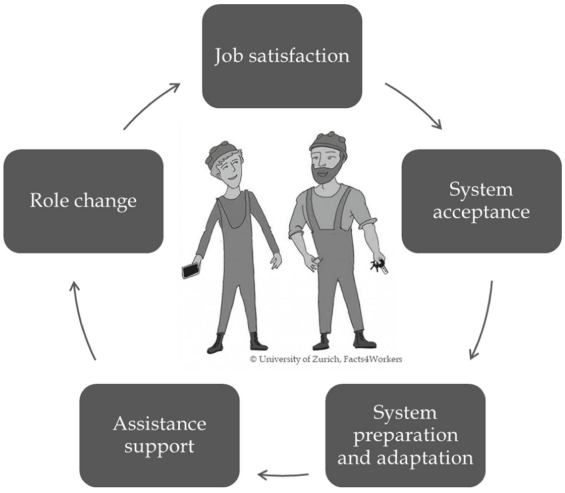

Fig. 2. Relationship between job satisfaction, acceptance and successful introduction of assistance

3 Framework for Considering Job Satisfaction in the Design of Assistance Systems

Based on the theoretical content described above and the previous EU projects FACTS4WORKERS and SCOTT (https://scottproject.eu/) we developed a job satisfaction framework to explain the sequential processes that will be used in the MMAssist II project to embed aspects of job satisfaction into the development process of assistance systems. At the beginning, the requirements for the specific assistance systems are surveyed by the respective industrial partners. The focus

here is on the specific problems that occur, the people who are going to use the system, the respective work activities and the nature of the environment and organization.

Aspects of job satisfaction are gradually being introduced in three phases (Fig. 3):

i At the beginning of the process, "Guidance Questions" are formulated for the assistance system development team, which provide initial recommendations for the consideration of job satisfaction aspects in the conceptual development of assistance systems. These questions serve as the first basic orientation and should help developers to consider these disciplinary considerations in development work. The questions relate to the four dimensions of task level, knowledge level, social level and work context, as described in Sect. 2.1, and serve to differentiate the respective aspects of job satisfaction.

ii After the assistance systems have been fundamentally specified in consultation with employees, industry partners and technical developers, and Guidance Questions have already been taken into account, the formulation of specific recommendations will be made in a second phase. These recommendations are addressed to developers.

For this purpose the persona-scenario-goal methodology is used, that combines goal orientation with the persona method to negotiate conflicting goals [1]. Operational scenarios with personas are formulated, which describe the assistance systems in the usage context in more detail. Subsequently, the anticipated effects of the recommended measures on the job satisfaction of the employees are estimated on the basis of an assessment matrix.

Finally, recommendations are formulated to consider aspects of job satisfaction, which are passed on to the development and industry partners. The content of the recommendations is based on the basic aspects of job satisfaction described above and the interaction between introduction of the system, role change, job satisfaction and acceptance.

iii In the third phase, the respective assistance systems are subjected to an iterative evaluation. For this purpose, baseline measurements are carried out with specially developed survey methods before the assistance systems are introduced.

Our approach pursues both a quantitative evaluation (using a questionnaire) and a qualitative evaluation (using interviews). Questionnaires have the advantage of being easily quantifiable and efficient. Interviews, on the other hand, provide valuable insight into the workers' view of the assistance systems. A combination of both methods is therefore preferable in order to obtain a differentiated picture. The questionnaire also relates to the four dimensions described in Sect. 2.1. During the project, repeated measurements are then carried out, which in turn inform the further development of the assistance systems in an iterative process.

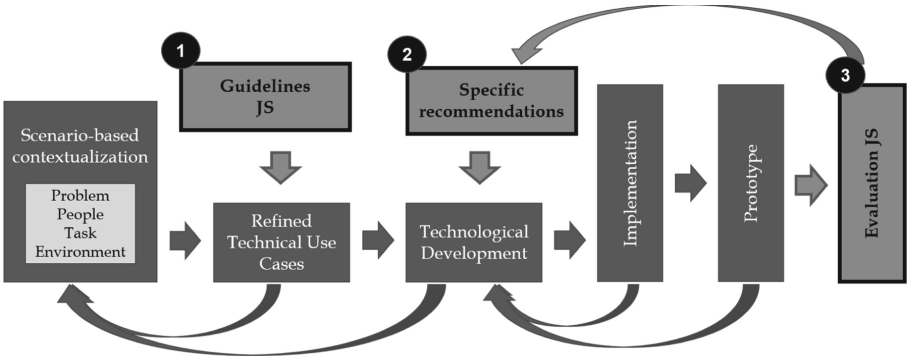

Fig. 3. Framework for integrating aspects of job satisfaction into the development of assistance systems (MMAssist II Framework)

4 Application of the Framework

As part of the requirement analysis, we issued a short questionnaire to the employees participating in the project in order to record the actual status in terms of job satisfaction and use it as a baseline. It became clear that the time required for the requirements analysis was already relatively high for the employees and therefore the issue of an additional questionnaire was often limited or even partially impossible.

In order to be able to adequately support the conception of assistance systems with regard to job satisfaction, we developed "Guidance Questions" and sent them to the development team in summer 2018. In addition, we participated in workshops to further define the assistance units to provide input on important aspects of job satisfaction, by using the assessment matrix. Finally, in April 2019, we conducted two initial evaluations at our industrial partner, where the survey instruments (questionnaire and interview) were used and tested. The focus here was on the assistance units "digital instructiois" ("EvoAssist" system), "documentation" ("Workheld" system) and "communication with experts" ("EvoCall" system). The systems address two different positions: engineer in the repair center and service technician.

The evaluation interviews show that positive effects can be expected through the introduction of the assistance systems, such as a reduction in complexity and an increase in the problem-solving abilities of employees. However, the already mentioned necessary preparatory activities, the potential effects on the roles of the employees and the associated organizational changes must be highlighted here. Specifically, when creating videos for the EvoAssist assistance system, it can be seen that the worker who has to create these instructional videos, on the one hand, needs time resources for this and, on the other hand, does not actually benefit from the system, or only indirectly and to a lesser extent (e.g. because there are fewer queries to answer by phone). This problem will now be tried to counteract, in the next steps.

At the end of the process we will again conduct a survey to determine the status of job satisfaction and compare it with the results from the first session, to make a statement about the overall impact of the assistance system on job satisfaction of the employees.

5 Summary and Conclusion

In this paper the conception of a work satisfaction framework is presented, which is used in the context of the development of cognitive and physical assistance systems in production. It is used in all phases of the project, whereby it is recommended to focus on the needs of the workers and to look at the overall system, especially during the requirements analysis. The results obtained so far and the experience gained from the previous projects FACTS4WORKERS and SCOTT confirm that the successful introduction of assistance systems must be accompanied by comprehensive considerations of the organizational and management framework.

Since workers often are not included in the development of the systems in advance, negative consequences such as lack of acceptance and the resulting non-use of the systems can be expected. This relationship clearly points to the importance of the human-centered design process, involving workers in the development process. The entire system (including the area "under the water" that cannot be seen by the developers) can only be visualized by a human-centered approach. The main contribution of this paper is to demonstrate a way how such human-centered approach can be realized in real-world developments of industrial assistant systems.

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