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Workers united: Digitally enhancing social connectedness on the shop floor

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ABSTRACT

Organizations increasingly implement processes-oriented setups like value stream production. Whereas this transition may bring many advantages on an organizational level, related studies show that shop floor workers feel less able to maintain close contact with others and exchange awareness cues. Their diminished social connectedness has consequences on the personal (e.g., reduced satisfaction) and organizational (reduced efficiency) level. The current wave of digitization brings ample opportunities for companies to bring their employees closer together again. In order to identify such opportunities, we have studied the shop floor production practices of an automotive OEM (original equipment manufacturer) for nearly two years. Following a scenario-based action design science approach, we have developed problem and activity scenarios as well as a prototype that helps the workers to improve their social connectedness in three different scenarios. Eight weeks of use demonstrated the prototype's positive impact on the employees' social connectedness by allowing for social appraisal and by improving their sense of sharing and involvement. Our results show which information technology (IT) design elements can contribute to social connectedness on the shop floor.

1. Introduction

In recent years, many companies have changed their production from function-oriented to more processes-oriented setups (Hellman, Kastberg, & Siverbo, 2015; Tang, Pee, & Iijima, 2013), of which value stream production is a prominent example. Value stream production is the creation of a flow of activities oriented towards the seamless contribution of all these tasks to deliver the selected products and services without any waste. At the same time, function-orientation focusses on organizing functions efficiently without considering their connection to other functions in delivering products and services. Whereas value stream orientation has proven to be beneficial from an economic point of view (Kohlbacher & Reijers, 2013), first studies show that shop floor workers feel left out when such a transition takes place (Leyer, Stumpf-Wollersheim, & Kronsbein, 2017). Value stream orientation can help overcome formal organisational boundaries (Wanberg, Javernick-Will, Taylor, & Chinowsky, 2015), i.e., employees are generally in contact with more of their colleagues. However, they are less able to maintain close contact with others and exchange fewer awareness cues, which reduces their social connectedness. Social connectedness can be understood as a sense of sharing, involvement (including relationship salience, shared understandings and knowing each other's experiences) and social appraisals (defined by the connections' quantity and quality; Baumeister & Leary, 1995; Ijsselsteijn, van Baren, & van Lanen, 2003; Lam, 2013; Rettie, 2003; Smith & Mackie, 2007).

While its benefits are not in question, there are no detailed studies on how social connectedness on the shop floor can be improved to support employees (Yoon & Lee, 2010; Yoon, Hacker, Hewitt, Abrams, & Cleary, 2012). Overall, organisations need to increase social connectedness on the shop floor to support their employees and increase their efficiency (Poleacovschi, Javernick-Will, & Tong, 2017). Doing so requires adequate support to enable connectedness - which IT solutions have been enabling for many years (Rettie, 2003), but is not systematically applied in shop-floor environments.

Thus, our study poses the research question: How can employees' social connectedness on the shop floor be enhanced with information technology (IT) solutions?

We studied an automotive OEM (original equipment manufacturer) that had recently changed its employees' organisational grouping from shopfloor to value stream production. As a part of a larger project to revisit and improve the role of shop floor workers, we identified the manufacturing workers' need to connect with colleagues between their shifts to ensure communication, coordination, and knowledge retention. Based on empirical insights from interviews and observational

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data, and adopting an action design science research approach, we defined problem and activity scenarios and implemented a framework that helps employees be and remain connected. Our evaluation results show how the framework allowed the employees to connect cross-functionally and create a close social environment.

Our study contributions are threefold: firstly, we show the value of the concept of social connectedness as a theoretical basis to ensure efficient production in value-oriented designs with IT solutions. Secondly, we illustrate how to design IT solutions to support employees in connecting with each other in value stream-oriented designs. Thirdly, we highlight the importance of understanding how to support employees on the level of work routines in gaining positive outcomes in socially responsible work environments as highlighted by prior work on a company level (Chen, Feldmann, & Tang, 2015; Giannoccaro & Carbone, 2017).

From a practical perspective, decision making when striving for value orientation should consider implementing designs that make use of IT solutions that address social connectedness to ensure production efficiency. The identified IT design elements can guide manufacturing companies on how to design similar solutions for shop floor problems.

As Fig. 1 shows, we firstly present the social connectedness concept from a theoretical viewpoint and its application on the shop floor (in Section 2). Next, we describe our methodology, a scenario-based action design science research approach based on qualitative data collection and analysis in Section 3. Then, by describing the problem scenarios as a basis for the problem identification and analysing them in terms of social connectedness, we explore the as-is situation in the case company (Sections 4 and 5). The subsequent activity scenarios serve as a basis for the solution objective and demonstrate how the IT artefact connects employees (Section 6). We present our evidence with data gathered from the evaluation (Section 7) and discuss their implications (Section 8) before the paper concludes with a summary, the limitations, and an outlook on future research (Section 9).

2. Background

2.1. The academic roots of social connectedness

Research on social connectedness originates from the field of psychology, where the construct of belongingness was established as a major self-need that provides the structure and motivation for self-expression (Baumeister & Leary, 1995; Smith & Mackie, 2007). This self-need is described by self-psychology theory (Kohut, 1984), stating that the definition of oneself is also dependent on the reflection of the relationship with others and the inherent comparison with the others in these relationships. Kohut (1984), for example, demonstrated that human beings strive to be 'a part of' to avoid feelings of loneliness and alienation and found that three significant aspects constitute the concept of belongingness: companionship, affiliation, and connectedness. Whereas companionship and affiliation originate in childhood, a sense of connectedness begins to emerge during adolescence and extends throughout adult life (Lee & Robbins, 1995). Only then do people feel comfortable and confident within a broader social context than family or friends. This sense of connectedness allows people to maintain feelings of being 'human among humans' and to identify with those who may be perceived as different from themselves (Kohut, 1984).

The concept of social connectedness is related to those of awareness and social presence, but it is not equivalent to these (Rettie, 2003). Social connectedness is an emotional experience (evoked by, but independent of, another's presence), while social presence is a judgement of others' perception in a mediated communication (Biocca, Harms, & Burgoon, 2003). By contrast, a continuous sense of awareness allows people to learn about another person's daily routine, which in turn leads to an increased sense of social connectedness (Dey & de Guzman, 2006). As an example, instant messaging systems (IMS) help us illustrate the difference between awareness, social presence and social connectedness. The awareness that others are online in IMS conveys social connectedness even when there is no message exchange. Similarly, the exchange of text messages creates social connectedness, although there might be no spatial presence of employees (Lam, 2013; Rettie, 2003). Hence, although there may be no real life contact in IMS, the sense of connectedness, the feeling of being in touch, can be strong (Ijsselsteijn et al., 2003).

2.2. Social connectedness at the workplace

Social psychology recognises human beings' need to be connected as one of the primary motivational principles that underlie social behaviour (Smith & Mackie, 2007). Consequently, it has received considerable attention from research on workplace relationships. Employees' communication and collaboration patterns are highly intertwined with the social connectedness concept (e.g. Ijsselsteijn, van Baren, Markopoulos, Romero, & de Ruyter, 2009). Since we can argue that nobody knows everything, it seems reasonable for people to rely on others to gain the knowledge they lack (Larsson, 2007). However, social connectedness not only enables co-workers to share their knowledge (Mom, Van Den Bosch, & Volberda, 2009) and experiences (Dyer & Nobeoka, 2000), but it may also foster their trust and cooperation (Adler & Kwon, 2002). Furthermore, strong social relationships at the workplace can contribute to lower staff turnover rates (Riordan, Vandenberg, & Richardson, 2005) and improve individual work performance (Kuegler, Dittes, Smolnik, & Richter, 2015; Zhang & Venkatesh, 2013). The affective benefits of connectedness could be a stronger group attraction, a feeling of staying in touch, a sense of sharing, belonging, and intimacy (Ijsselsteijn et al., 2003). In contrast, people struggling to feel connected begin to feel different and distant from others. They may find it hard to accept social roles and responsibilities, making them even more isolated (Lee & Robbins, 1995).

When researching social connectedness at the workplace, it is often conceptualised objectively as the number of social ties employees have

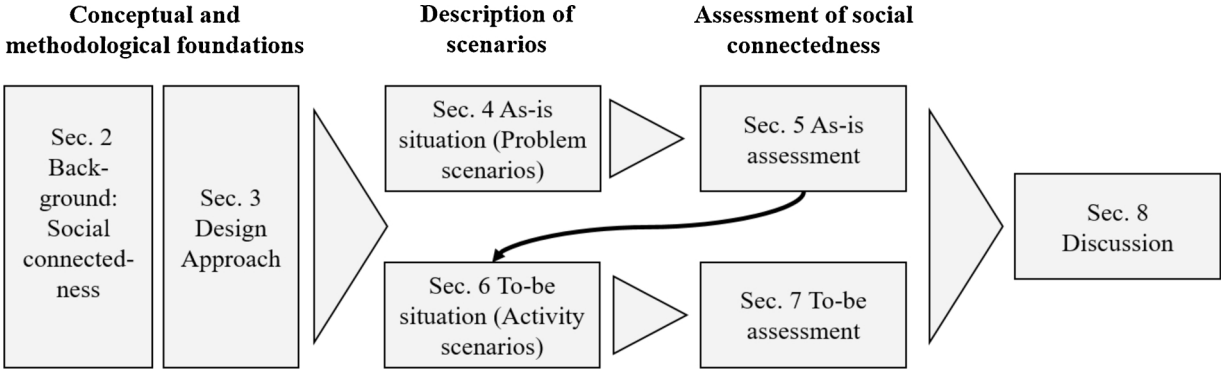

Fig. 1. Integration of scenario-based action design science research and theoretical lens.

(e.g. Bandiera, Barankay, & Rasul, 2008). However, in this paper, we follow the reasoning that social connectedness is as a subjective concept describing the degree to which employees perceive that they are enabled to improve the quality of the relationships with their co-workers and increase their quantity (Ijsselsteijn et al., 2009). Therefore, in line with the findings of van Bel, Smolders, Ijsselsteijn, and de Kort (2009), we conceptualise social connectedness according to two dimensions: 1. social appraisals (defined by the quantity and quality of the connections) and 2. a sense of sharing and involvement (which includes the relationship's salience, shared understandings and knowing each other's experiences). Being connected to co-workers (or feeling a belongingness in a specific context such as the workplace) is rarely addressed in prior work and the influence of organisational factors (such as IT-support in our case) should be analysed to understand how social connectedness at the workplace can be fostered (Jena & Pradhan, 2018).

2.3. IT-support for social connectedness at the workplace

A number of studies have investigated how interpersonal relationships can develop through information technology, therefore improving a firm's operational capabilities (Lam, Yeung, & Cheng, 2016; Schryen, 2013; Smith & McKeen, 2004; Vaidyanathan & Devaraj, 2008). Consequently, research on public social networks has investigated the role of social connectedness in recent years (e.g. Grieve, Indian, Witteveen, Anne, & Marrington, 2013; Jewell, Anthony, & Murphy, 2019; Ledbetter et al., 2011). For example, Köbler, Riedl, Vetter, Leimeister, and Krcmar (2010) find that the amount of information shared on a public social network increases users' social connectedness. In another investigation, Ellison et al. (2007) also find that the intensity of public social network use is positively related to the formation of social connectedness. Similarly, Riedl, Köbler, Goswami, and Krcmar (2013) find that a high use frequency of public social networks predicts users' level of social connectedness. It is, however, a note from the domain of older adults that humans need accessible and targeted communication systems that focus on the respective context, hence, going beyond standard social networks to increase social connectedness successfully (Barbosa Neves, Franz, Judges, Beermann, & Baecker, 2017).

On the level of information technology within companies, Cai, Huang, Liu, and Wang (2018) analyse the impact of disclosed enterprise social media on agility performance of employees via psychological constructs (psychological meaningfulness, psychological availability and psychological safety). The authors identify a positive relationship but suggest social connectedness as a relevant variable to be analysed due to low numbers for the explained variance in their analysis (Cai, Huang, Liu, & Wang, 2018). Moreover, standard tools such as video software together with webcams can be adopted by companies to increase the connectedness with customers. Yet research on how social connectedness between employees at the workplace (discussed at the example of social work) is expanding by using information technology is missing so far (Bullock & Colvin, 2015).

On the level of information technology designed to support work environments specifically, the digital transformation of the workplace requires social connectedness of employees especially when they work in different locations. In order to ensure social connection, it is important that employees have the technology available to connect more easily and share information (Dery, Sebastian, & van der Meulen, 2017). Hence, the emphasis of such technology is to provide and connect context-relevant information between employees for the execution of work tasks with the aim of increasing social connectedness beyond personal contacts. Such an organisation of work environments that allow for a close social connection is also an essential part of lean management (Mazzocato et al., 2012). Information and knowledge should be exchanged closely between employees by establishing cross-functional teams, for example (Larsson, 2007). The importance of synchronous communication between employees working together in teams is essential in this regard and solutions from static work stations already indicate a positive impact (Mazzocato et al., 2012). Moreover, related work in connecting employees socially can also be found in knowledge management systems supporting the execution of operations. Here, it is highlighted that connecting employees based on incorporating knowledge to processes is beneficial (Leyer, Schneider, & Claus, 2016). Such solutions must be close to the workplace and easily accessible (Damodaran & Olphert, 2000).

Summarizing prior work, it is found that information technology with the aim of increasing social connectedness is essential and should be aligned to the work context of employees. With the focus on co-workers in shared processes (hence not socially connecting employees in a company in general), the information exchange between employees is most important incorporating the availability and exchange of such information to increase social connections (in terms of social appraisals a sense of sharing and involvement between co-workers). Such approaches are however rarely analysed with regard to socially connecting co-workers in their work activities and should be embedded in their work environment.

3. Research method

3.1. A scenario-based design action science research approach

Since it is our goal is to improve the situation of shop floor worker by supplying them with a new IT artefact that to supports their ability to socially connect, our study follows the design science research (DSR) paradigm (Hevner, March, Park, & Ram, 2004). Our approach is

conceptually based on the foundations of action design research (ADR), as we share the view that "IT artifacts are ensembles shaped by the organizational context during development and use" (Sein, Henfridsson, & Purao, 2011, p. 1). Therefore implementation, intervention and evaluation can be seen as integral activities[1] .

In order to formulate theory-based problem objectives and solution principles, we adopted a scenario-based design procedure (Rosson & Carroll, 2002). This allowed us to describe and discuss a future IT solution at an early stage in the development process and keep the interaction between designers and users high. Scenarios allow conveying important characteristics of users, typical tasks they engage in, tools they use, and their organizational context. Against this background, the scenarios made the theoretical elements "socially recognizable" (Orlikowski & Iacono, 2001, p. 121). This approach allowed us to include how potential users usually perform activities, thus ensuring alignment with work practices. In this context, a scenario is framed in a specific way that allows it to be evaluated, but also to remain broad enough to be easily adapted (Rosson & Carroll, 2009).

ADR postulates that created and evaluated artefacts should be informed by theories (Sein et al., 2011). In the context of solutions to support workers on the shop floor, adequate behavioural theories have to be selected and adapted to the work context so that the developed artefact is in line with typical human behaviour (Walker, Chicksand, Radnor, & Watson, 2015).

We used the earlier introduced theoretical foundation of social connectedness, to structure the problem (theory type IV), to identify solution possibilities (theory type IV), and to guide design (theory type V) (Sein et al., 2011) based on Gregor (2006). Gregor (2006) suggests a taxonomy that classifies information systems theories with respect to the manner in which four central goals are addressed: analysis, explanation, prediction, and prescription. The five different types of IS theory distinguished by Gregor (2006) are: (1) theory for analyzing, (2) theory for explaining, (3) theory for predicting, (4) theory for explaining and predicting (EP theory), and (5) theory for design and

[1] Section 3.3. (Data Collection) contains a detailed description of how the principles of ADR were considered.

action.

3.2. Case context

We examined SAC[2] - an automotive supplier with more than 82,000 employees and a worldwide network of manufacturing locations, research & development facilities and sales offices - to understand how organisations can provide shop floor workers with structures that support their social connectedness. The plant that we examined is located in the south of Germany and produces various engine components. It was selected because its workers face a new value-stream-oriented work environment that does not support their social connectedness. The plant has just recently changed its production from one separated by workshop areas to value-stream-based manufacturing. This change, inter alia, led to a redesign of the existing structures and processes. Our study focuses on the value stream of chain spanner production processes with the production being divided into several groups, each of which creates components for the final product and is part of the value stream.

When examining the consequences of this change for employees, we observed that the employees on the SAC shop floor were having problems with feeling connected. We, therefore, delved into this situation to gain deeper insights into social connectedness as observed in this particular group (Flyvbjerg, 2006) and to study this complex situation in its specific context (Gibbert, Ruigrok, & Wicki, 2008).

3.3. Data collection

This study practice-inspired research is a part of the international research project FACTS4WORKERS, whose goal is to create attractive and intelligent workplaces in a factory of the future (Leyer, Richter, & Steinhüser, 2019). In line with this goal, we initially studied how work practices on the shop floor can be supported through human-centric IT solutions. A deep understanding of workers' individual practices has been the basis from which we suggest sociotechnical solutions that support smarter work (Richter, Heinrich, Stocker, & Schwabe, 2018). Our empirical analysis is based on different collection techniques and data sources (Benbasat, Goldstein, & Mead, 1987) to achieve a rich and flexible research process (Dubé & Paré, 2003). We were aiming at gaining an understanding of how the employees complete their daily work, how they interact with one another and the tools that the company provides to support them. As part of the project, we had five visits between March 2015 and February 2017 which allowed us to observe the employees on the company site (see Fig. 2). In addition, we collected data from diverse internal documents, such as handbooks, work lists, and process descriptions. As part of the visit in April 2015, we conducted 17 semi-structured interviews (I_01-I_17) with an average length of 41 min, following the guidelines of Strauss and Corbin (1990) to gain an understanding of those employee perceptions which are difficult to capture on the shop floor level. Employees generally have no knowledge of theoretical ideas and practical concepts, but express these in their way, because they do have practical experience and knowledge. In-depth interviews are therefore, an adequate way of freely capturing their thoughts and opinions. Such interviews not only lower the barrier to articulation (compared to standardised questionnaires) but also allow their opinions to be translated into standardised theoretical dimensions (Hickey & Davis, 2003; Johnson, 2002).

Following a scenario-based approach (Rosson & Carroll, 2002), as described above (Section 3.1), we used these comprehensive data to illustrate the as-is situation in the form of problem scenarios that enable us to perform a structured analysis. For the analysis, we did not only compare the current situation with the expressed workers' needs, but we also contributed theoretical knowledge gained from prior research on social connectedness (the two dimensions of social appraisals as well as sharing and involvement as outlined in Section 2). Out of this, we designed activity scenarios that aim at describing a situation where the SAC employees feel more connected. To underpin our argumentation and to provide evidence, we included exemplary quotes from the interviews in the scenario descriptions (Dubé & Paré, 2003).

We evaluated the problem and activity scenarios with the workers in September 2015 in order to include their feedback on design ideas already at this early stage. This did not only enable an "authentic and concurrent evaluation" (Sein et al., 2011) but also allowed to consider both other related principles of ADR:

- "Reciprocal Shaping": the scenarios also illustrated to organisational context as important background for design decisions
- "Mutually Influential Roles": These feedback discussions included a mutual learning process about what is possible from an organisational (workers) and technical (designers) perspective

Based on these findings, we then developed a framework of an IT-supported design to address the problem of lacking social connectedness as identified in the problem scenarios. The first stage of implementing the framework was a mockup (click-dummy prototype). We presented it in April 2016 and evaluated it in feedback workshops with management and in 5 think-aloud interviews with workers. After several months of development and continuous communication with SAC, we finally installed a validator (a running software prototype) at the SAC site, and it was used for eight weeks between November 2016 and January 2017. As part of the evaluation, we conducted another 14 semi-structured interviews (E_01-E_19) with an average duration of 21 min between December and February 2017. The results of this evaluation also allowed for what Sein et al. (2011) call "guided emergence", i.e. we were now mostly interested in the implications of this "organizational use, perspectives, and participants" (Sein et al., 2011) for the further design iterations.

All the interviews were transcribed and encoded, and the qualitative content analysis method (Mayring, 2000) was employed on the text documents to obtain information from them. We adopted a coding approach to search for patterns following the social connectedness dimensions (1: Social appraisals; 2: Sense of sharing and belonging) as presented in Section 2.

4. As-is situation (problem scenarios)

In the following, we present the problem scenarios that we developed as part of the scenario-based design procedure. The problem scenarios serve us as the basis of the theory-building phase. As part of the problem scenarios, we use personas (Rosson & Carroll, 2002) in order to create a better understanding and empathy for the workers' situation.

4.1. Problem scenario 1: maintenance

The production at SAC continues 24 h per day in a three-shift operation. A typical shift begins and ends with the shift handover, which involves operators, tool setters and team leaders. These roles basically describe the task within a shift. Operators work directly on the machines and maintain the production process. Tool setters monitor the quantities and quality of the multiple machines, set up and retool the machines if necessary and support the operator when required. Team leaders coordinate the operators and the tool setters in each production area and report to the product managers.

After the shift handover, the setters and operators carry out the necessary maintenance procedures and document them. Maintenance work has to be done per month, per week, per day or even per shift. The individual tasks are described in paper-based maintenance instruction sheets. All employees have to sign the maintenance plan – a separate

[2] We use SAC as a pseudonym instead of the real company name due to privacy concerns of the company. SAC has no deeper meaning.

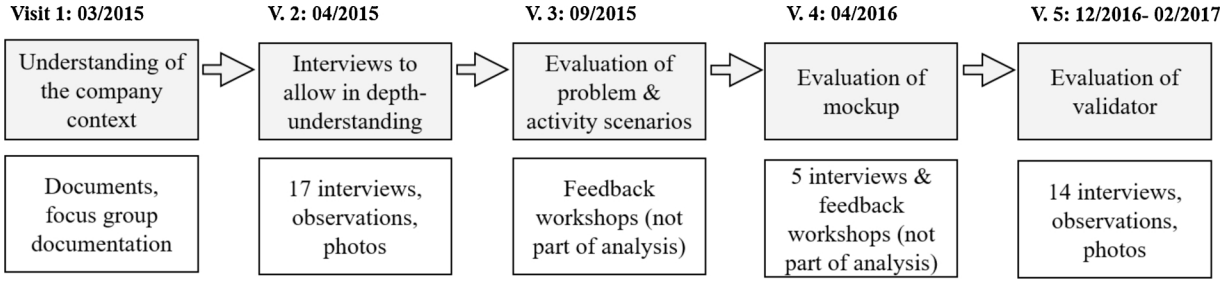

Fig. 2. Overview of data collection.

sheet – whenever they complete their maintenance work.

First, the operator, Josephine, has to check which tasks have to be done that day and executes them according to the instruction sheet. After finishing, she signs the plan. Additional information, for example, whether she had to replace a particular part, is not documented. The process is static, which means all tasks are executed within a fixed interval and cannot be adjusted dynamically. Martin, Josephine's team leader, is responsible for monitoring that maintenance work is done correctly. He can only do this by checking the signatures on the maintenance plans located at the machines. He cannot control whether individual tasks were executed properly and does not have detailed information about what exactly was done. Fig. 3's problem scenario shows Josephine doing maintenance work using the maintenance instruction sheet. The maintenance plan is attached to the machine. The background shows team leader Martin's place of work.

4.2. Problem scenario 2: retooling

The machines are calibrated and retooled to meet the requirements of the current orders. Tool setter Marc has to retool a machine for a new type of product, so he prepares the machine for the retooling procedure. Each step must be documented in a separate 'retooling preparation and follow-up processing' sheet, which has to be printed and signed. Since Marc is an employee with considerable experience, he deals with many machines and even more types of products. From his perspective, finding and printing the right papers in this first step is a time-consuming effort (Fig. 3). He comes across a problem with the calibration of a specific measurement part and remembers that the retooling procedure six months earlier had identified a similar problem. But what exactly was this problem, and is there any documentation on it? He cannot find anything in the standard 'retooling script', therefore he looks for the relevant entries in the handwritten shift book, but to no avail. This leads to time being wasted and leaves Marc disappointed. He has to look for a new solution for the problem and cannot take advantage of the knowledge that could have been available if there was a proper documentation.

Subsequently, the setters measure whether the parts currently being produced are within the value ranges specified beforehand. During the production, the operation of the machine is monitored continuously and, if necessary, materials are replenished. In addition, as part of a regular production monitoring, the operators regularly check each semi-manufactured product for the defined quality. If shortcomings are detected, the setters recalibrate the machine. The team leader records the product quantities several times a day and compares these with the nominal number of production orders. When the required product quantities have been reached, the machines must be retooled for the following order. At the end of the shift, the handover to the next shift takes place.

4.3. Problem scenario 3: shift handover

At the end of the shift, tool setter Marc documents important occurrences in the handwritten shift book. He has to fill in a shift-handover sheet, on which he documents key issues concerning the shift personnel, material, machines and further planning. Both processes are redundant since almost the same information is being documented. Consequently, Marc sometimes only makes short notes in the shift book. Owing to the lack of time at the end of the shift, he often forgets to document incidents that occurred some hours previously and which might be important. Furthermore, the shift book is a simple paper notebook, which means he cannot attach additional information, such as special documents or photos, although these could be useful to document defective parts. That can be a problem if he wants to look up similar incidents a few weeks later. The chance of finding a well-documented incident and learning from it is relatively low.

5. As-is assessment - social connectedness in the as-is situation

As shown in the problem scenarios, the large number of documents and their decentralised storage are a major challenge - especially across

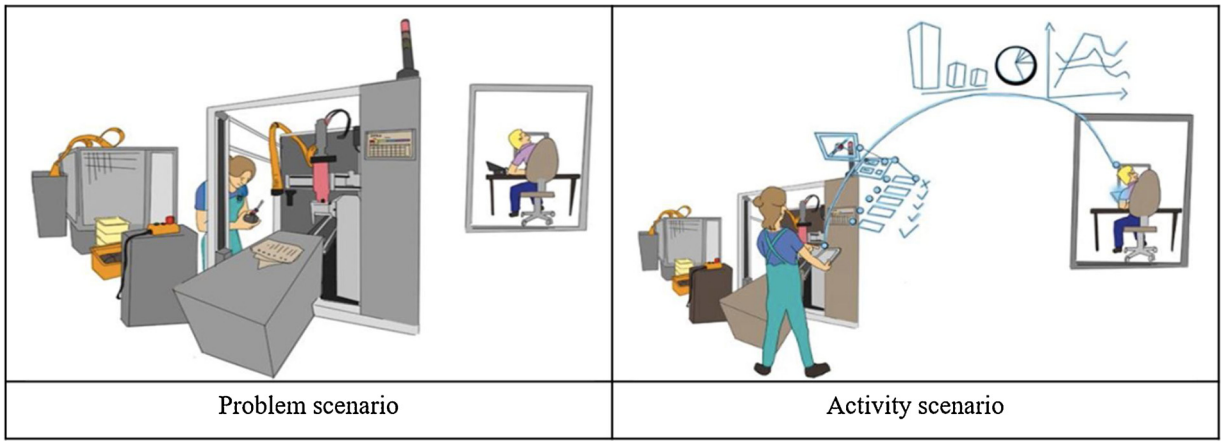

Fig. 3. From paper-based maintenance work to integrated workflow control.

multiple shifts or over more extended time periods. In addition, the documentation processes have not been digitised and are partially inefficient. The exchange of information between employees mostly occurs orally and is not well structured, which means the sharing and traceability of critical information over longer periods cannot be guaranteed. It is not possible to access relevant information centrally and efficiently. Furthermore, our data show that redesigning the organisational grouping along its value streams has left the employees feeling disconnected. In the following, we structure the analysis along social connectedness's two dimensions.

5.1. Social appraisal

Social appraisals involve satisfaction with one's social situation in terms of the quantity and quality. In our case, the specific conditions at SAC strongly shape *the number of social connections*. Most connections are established within individual value streams, parallel shifts, at specific workstations or between similar positions. I_14 mentioned:

"When I walk through the shop floor, I literally see individual islands. In the next step, these islands need to be interconnected. We probably did not enforce this strongly enough to date." Especially the operators, but also the tool setters are bound to their individual workstations. Accordingly, most of their communication occurs on-site without the possibility of regular contacts with others elsewhere. Furthermore, the employees have hardly any chance of communicating directly across hierarchies. Most connections beyond the own value stream, shift, hierarchy level and workstation are via the team leader:

> *"[The team leader] is always there for me. He is the carer. He makes sure that everything runs smoothly. He has the contacts, he organises the people." (I_04)*

The value-stream-based redesign of the organisation has meant many changes for the SAC employees. A significant change with direct implications for the *quality of the connections* is that the positions have not only changed textually but regarding their actual location.

"In the past, employees of the turning shop, the galvanisation shop and the assembly were highly specialised people. They were a well-integrated team with members that complemented one another beyond the value streams. They shared their knowledge and helped one another when problems occurred. Each one had his key areas in which he was very well versed." (I_06) Although intense contact between the different maintenance groups is desired and intended, it has turned out to be quite tricky. After the reorganisation, the team leaders of each value stream moved with their offices to the ground floor, while the assembly team remained on the first floor:

> "*The team leader being on-site was definitely an advantage. He could be addressed directly when problems arose in order to solve them quicker*." (I_01).

Furthermore, the Quality Assurance (QA) team, which is supposed to be present on the shop floor, is actually not very often there. Instead, some of them even seem to *"fear being in the heat, in the turning or galvanisation shop"* (I_11). All these changes lead to a feeling of having less time for one another. Although the connection itself is still there, the people perceive it as deteriorating.

5.2. Sense of sharing and involvement

Our interviews reveal that people from different departments do not fully *share their understanding* of optimal working results. The primary goal of the QA team is to reveal and prevent faults, but the assembly team seeks to maximise the machine output. I_06 summarised this: *"As the QA [team], we are and must be far more sensitive about quality features. We are paid to do so. The assembly is more focused on performance in terms of quantities."* Furthermore, it is often difficult to establish a common ground for solving a specific problem. For example, I_17 stated that *"… sometimes failures are pretty barmy. It is hard to comprehensibly describe what is not functioning or what has changed."*

Because major parts of the work at SAC are bound to the various machines, getting to *know each others' experiences* is mostly restricted to on-site communication. As described above, most of this communication is face-to-face. However, handwritten documents at the specific work stations also play a significant role. For example, particular problems that occurred during the day have to be documented in a paper-based shift book. Nevertheless, this shift book is a less helpful tool than previously presumed: Some employees forget to write in it or just don't want to do so, while others' handwriting is challenging to decipher. (I_02: *"If you don't document a problem immediately in the shift book, even if it is just a trifle, you can easily forget it. The following shift will then not learn about it, and it just fizzles out."*) Consequently, much information is lost, because detecting and getting to know others' relevant previous experiences is not easy and often merely dependent on coincidence.

Finally, the *salience* of the *relationship* between employees has dwindled. Although a sense of being in touch is quite important for the interviewees, some mentioned that they miss the feeling of being together beyond personal contact. For example, I_05 said that his *"contact person for this kind of problem is simply not here. He is far away, not tangible, not approachable. And then, if you have a problem, you cannot work on it and solve it."*

6. To-be situation (Activity scenarios)

Building on the problem scenarios as described above and on the theoretical considerations of social connectedness, we created activity scenarios to demonstrate a digital solution's potential to support the

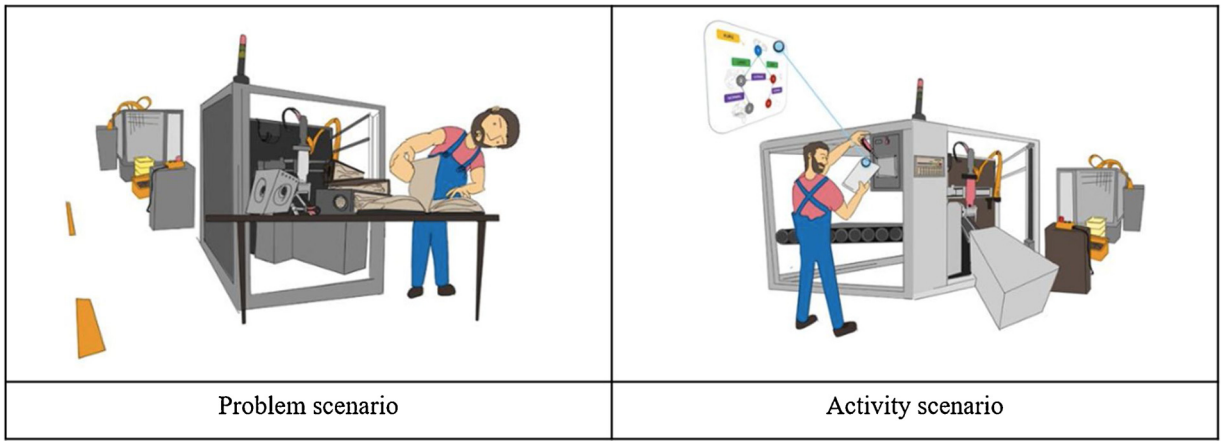

Fig. 4. From problems during the retooling to easy information access to retool a machine.

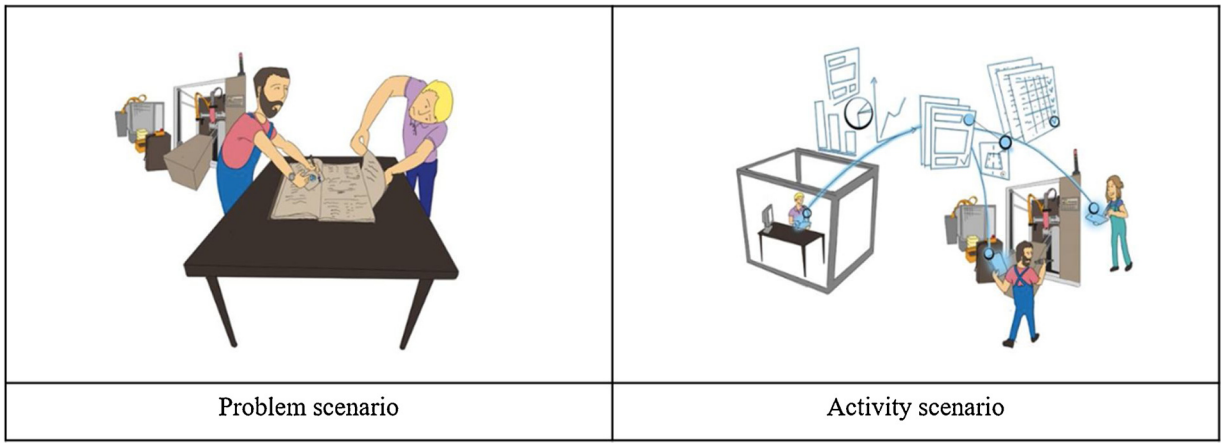

Fig. 5. From handwritten shift log to digital integrated shift log.

employees in their daily work. In all three Figs. (), each activity scenario is contrasted with the associated problem scenario to not only highlight the differences between the as-is situation and the post-intervention situation but also to illustrate our approach. As we intend to understand how IT solutions, in general, can affect social connectedness at the workplace, we depict the activity scenarios in detail along with the practices rather than describing the developed software and its features in detail.

6.1. Activity scenario 1: maintenance

When carrying out the shift-wise maintenance process, a tablet guides Josephine through the execution steps. As shown in Fig. 3, Martin has an opportunity to check the provided information via his tablet. The IT solution provides Josephine with precise information on each step, enriched by images that show her what to do. This makes maintaining all the machines, even the ones she maintains less frequently, far easier. She can provide precise information on her actions in each step without time-consuming documentation. For example, after having checked a special part, she simply confirms the task by tapping on 'Part OK' or 'Part exchanged'. The typical life cycle of a wear part is six months; nevertheless, Josephine has to check the that part's wear and tear every week, because she has no information on when it was last exchanged. Currently, the framework (termed SAC.me) allows dynamic adjustments of the maintenance plans, which means that whenever she or one of her colleagues exchange a special wear part, the task of checking this part's wear and tear will only be required in four months' time and not every week. By contrast, team leader Martin has a powerful and convenient way of not only checking whether the maintenance work has been done properly but also of using the additional information that the IT solution provides to detect and analyse particular incidents. For example, the readjustment of a special measuring device is usually done each month, but when Martin currently looks at the SAC.me, he may see that the device has had to be readjusted three times the past week. He might start wondering whether this has something to do with the recent high number of spoilt parts.

6.2. Activity scenario 2: retooling

Fig. 4 shows Marc retooling with the help of his new mobile application. By selecting the type of product to be retooled, the corresponding forms appear automatically without any tiresome searching and copying. He uses the digital template for 'retooling preparation and follow-up processing' and sets his digital signature by simply clicking on 'confirm'. The digital 'retooling script', which includes a pictorial supplement in addition to the text, guides him through the retooling procedure, while the template allows him to add notes and remarks. In other words, execution and documentation coincide and are integrated into the same form. Marc also remembers that there was a problem during the retooling six months before and he can now use the new application's 'information archive' to look up relevant information on the specific machine and type of product. Here he can choose between a daily and a monthly view, and, owing to filtering options, he has an optimal overview of which type of machine and product was processed, when this occurred and how long it took. He can see whether any problems occurred and prevent possible new problems while retooling. Additionally, he can see all the shift book entries and the added photos in a specific order. The retooling procedure can, therefore, be executed far quicker and more efficiently. Once Marc had provided all the information of the task's execution, a new entry is automatically generated in SAC.me. This allows him to easily share his experience with other colleagues who may want to make use of it in the future.

6.3. Activity scenario 3: shift handover

At the end of the shift, tool setter Marc and his colleague Josephine document important occurrences in SAC.me (as illustrated in Fig. 5). Martin can also look up the provided information on his device. The solution does contain not only Marc's manually entered information but also information that the IT solution generated during the execution of the tasks, for example, tasks like maintenance work or retooling. Moreover, the shift-handover sheet is integrated in such a way that it does not have to be filled in separately. A major advantage of the solution is that all the entries, notes and status of completed tasks are done in parallel with the task processing during the shift. Marc no longer needs extra time at the end of a task or the shift to fill in documents. Additionally, it allows Marc to link the documents and the photos, thus providing a coherent view that includes all activities and incidents at a particular machine. Aggregated information is stored centrally, and team leader Martin can access the data at any time. This makes troubleshooting and problem analysis far easier and more efficient.

7. To-be assessment - social connectedness after the intervention

After deploying the framework in November 2016, it was in use for more than eight weeks before we interviewed and observed the shop floor workers who used the implemented prototype according to the framework in their daily work. To cover the different perspectives, we also talked to managers (who perceived the use situation from a bird's eye view). Similar to the analysis of the as-is situation, we structure the following evaluation results according to the dimensions of social connectedness dimensions.

7.1. Social appraisal – breaking down silos

Our evaluation clarified that the employees use SAC.me to re-establish connections that they had previously been aware of, thereby increasing the *number of connections*. The solution helps them break down the silos that emerged after the reorganisation of the production as described in problem scenario analysis. The interviewees noted that connections were re-established across single value streams, parallel shifts and specific workstations. With SAC.me, they see how many contacts they actually have available on the shop floor and derive more satisfaction from their social contacts. This is highlighted explicitly by E_15, who described how the improvement in the *quality of the connections* is perceived:

> *'If multiple departments used it — the QA [team] is supposed to join, technologists, mechanics and others may also — we could all communicate with and coordinate each other. Previously, we had to call somewhere, the contact person might not be there or had little time; you had to search for hours.'*

Hence, the social connections are not only visible but also provide additional information regarding availability, which is perceived as very useful, especially on geographically dispersed shop floors.

7.2. Sense of sharing and involvement - merge different worlds and find common grounds

As our data shows, SAC.me can increase satisfaction with the employees' social situation by increasing their feelings of closeness, shared understandings, and the provision of information about one another's experiences.

SAC.me's picture and video functionalities have established a *shared understanding* of problems. In addition, the comment function serves to share ideas and bring people with similar ideas together. E_13 stated that 'the video functionalities are quite handy. You can make short movies about the process, send them around and explain what is going wrong. Others can have a close look at them and understand what happened.' This feature lowers the sharing barrier, as there is often not much time on the shop floor during production.

With regard to getting to *know one another's experiences*, the readability of all entries is a powerful SAC.me characteristic. People do not have to 'struggle with illegible handwriting and read and understand what others have done' (E_14). Furthermore, the dependence on being on-site to get to know others' experiences is dramatically reduced. Instead, SAC.me allows employees to experience benefits by keeping track of what the others do, regardless of the time and where they are. The starting page, for example, helps provide an overview that increases awareness. Furthermore, the keyword search and other browsing functionalities enable people 'to gain information about previous experiences that they would never have been able to access before' (E_19). A further SAC.me advantage is that people who previously refused to note their experiences in the handwritten shift book 'feel an urge to document their incidents in the digital solution' (E_13).

By representing or reminding people of their social connection to others, SAC.me also addresses the *salience of social relationships*. Even though it does not replace personal face-to-face meetings, it strengthens the feeling of being connected. Employees feel closer to their colleagues, even if they do not see them and have the feeling that they are always present. Such a feeling is expressed in being able to approach colleagues directly when experiencing a problem. For example, if a problem occurs, 'I instantly know whom to turn to. That was more difficult previously' (E_10). Hence, by providing the employees with information about where their co-workers are, what they are currently doing, and how to make contact, a sense of being in touch evolves. This argument is especially important because employees think that 'experience cannot always be expressed on paper' (E_6). Feeling close to relevant colleagues is therefore important to maintain personal relationships.

8. Discussion

The above-presented to-be assessment of social connectedness after the intervention (through SAC-me) showed that social connectedness is a valuable concept to understand changes towards a value stream organisation on manufacturing companies' shop floor – and to reconfigure if needed.

The implemented IT solution helped to re-establish the connections between employees that had dwindled after the company's reorganisation. Related studies showed that in such process-oriented environments, direct colleagues with whom employees work on the shop floor are usually more distant in a geographic sense (in either other machine shops or even production sites) (Leyer, Hirzel, & Moormann, 2015). We contribute to this discourse in showing how IT solutions can help bridge the often perceived social distance by designing them to foster the feeling of being in touch in the production context. As our analysis shows, a social connectedness design is beneficial in terms of the number and the quality of social connections, but also in terms of the sense of sharing and involvement. These two dimensions are in line with the process orientation concept underlying the change from shop floor to value stream designs. Whereas the generalization of the problem instance and the generalization of the solution instance were already illustrated in the scenarios, the following can be seen as the derivation of high-level design principles from the design research outcomes:

1 Process orientation captures employees' knowledge in terms of their connections to their colleagues. Moving to a value stream design requires established and sustainable social connectedness measures.
2 Process awareness is necessary to consider issues beyond the own workplace and is more likely when there are established social ties to colleagues and a sense of sharing between them.
3 Process coordination addresses the need to coordinate work activities, for example, in a shift book; constant and intense social relationships reflect these activities.

As such, the solution is in line with a supporting process orientation, which underlies the change from shop floor to value stream designs.

Compared to general social network software (e.g. social media, chat rooms) as presented in Section 2.3, the presented IT solution is embedded and workplace focussed. This is an important difference as the system structure is aligned with the daily work procedures and enables seeming less support and access for employees. Social connections occur with the co-workers along the value stream and not in general as with social network software. This provides a specific purpose for which social connections are fostered and hence overcomes the weakness of these general tools not providing adequate, goal-oriented support for a specific group of co-workers with a focus on value flows.

8.1. Theoretical implications

From a theoretical perspective, our study first contributes to the existing literature by introducing the concept of social connectedness as a valuable theoretical basis to ensure efficient production in value-oriented designs. Prior work has established positive outcomes of socially responsible work environments on a company level (Chen et al., 2015; Giannoccaro & Carbone, 2017), but has not focused on the specific theoretical nature of social interactions between employees.

Second, we contribute to understanding the mechanism of how social connectedness can be improved in value-oriented designs. In doing so, we provide insights on the level of employees by showing that social appraisal and sense of sharing and involvement are relevant in typical routines. Especially the link between problem and activity scenarios helps in this regard. As the to-be assessment shows, the results

can also be abstracted to the company level as processes run across several departments and serve in delivering products and services for customers. Hence, benefits in terms of efficiency and financial performance, both costs and profits, can be expected by an increase in social connectedness. In addition, we contribute to the alignment of human resources and manufacturing operations (González-Sánchez, González-Sánchez, & Gonzalez-Benito, 2018) by showing how the alignment can be improved by an IT artefact allowing for autonomous social connections of employees on the shop floor.

Third, our results show how IT can be designed in the context of social connectedness. As such, we contribute to the discussion of the design of IT artefacts being used in production. While prior work such as Meyer, Buijs, Szirbik, and Wortmann (2014), for example, highlight the analytical nature, we emphasise the alignment with human behaviour. Hence, we emphasize the importance of considering the individual when it comes to determining the effects of IT in the workplace. As such our results help to understand the role of IT as 'digital enhancer' of employees' social connectedness on the shop floor and show how adopting appropriate IT solutions can help to achieve a successful transformation towards a value stream organisation.

8.2. Practical implications

The practical implications of our study for manufacturing companies mean that, in times of reduced face-to-face contacts between employees on the shop floor due to value stream designs, the social component should not be forgotten. Companies should invest in designing digital solutions that follow the elements presented in this article. Such solutions increase employees' social connectedness so that they still have a feeling of being connected. If this is not done, the benefits of a value stream design could be lost, with employees feeling isolated and being less productive over time. Hence, the investment in perceiving the benefits of a process-oriented production design should be accompanied by such a solution in order to unfold their full potential.

When it comes to designing IT solutions to address specific social connectedness needs in the specific situation, the above-mentioned factors can be used as guiding principles. IT solutions can support both social appraisal and a sense of sharing and involvement by making it easy to exchange short messages that are visible to others to. One could say that our framework acts as an enterprise social network. As such, it is possible that background knowledge from studies that looked into building enterprise social networks in other companies could help, too as discussed in Section 2.3, when it comes to the implementation of social connectedness.

8.3. Limitations

Despite its contributions, our study has some limitations that need to be considered and which will guide our future research. Our analysis is limited to a single case study, which has the advantage of exploring the aspects under analysis in detail, but might be specific to the case, thus limiting their generalisability. Subjectivity plays a vital role in the cognitive processing of our data. Instead of claiming objectivity, we, therefore, rely on intersubjectivity (Dubé & Paré, 2003) by involving a team of researchers in the data collection and analysis. While single case studies do not usually allow for statistical generalisation, we expect 'analytical generalisation' (Gibbert et al., 2008) to theory, rather than relying on a population to justify our findings.

While we demonstrated the framework in a typical manufacturing environment, further research should include other cases to gather more empirical evidence. Furthermore, the presented framework has not been permanently implemented, but employees evaluated it in their immediate shop floor environment. While the employees know their shop floor environment very well and experienced the change towards a value stream design, the implementation might lead to different experiences and perceptions. Hence, observing experiences where the solution has been implemented could enrich the insights presented. Future work should also cover the inclusion of other upcoming digital elements on the shop floor, such as smart robots that support human employees.

9. Conclusion and outlook

The so-called 'digital age' is usually associated with significantly improved computing power, artificial intelligence and robotics (David, 2015), all of which result in higher productivity and replacing human labour with technology (e.g. Brettel, Friederrichsen, Keller, & Rosenberg, 2014). Whereas advances in technology lead to significant changes in traditional shop floor workplaces (Appelbaum, 2013), including a loss of social connections, our study demonstrates that using a digital solution can contribute to and strengthen workers' social connectedness on the shop floor. The results of our study provide important clues on how IT can help connect employees on the shop floor. We adopted a concept in which social appraisals, as well as a sense of sharing and involvement, defines the degree of social connectedness (van Bel et al., 2009). To achieve this, the developed solution not only addresses the quantity and quality of connections (e.g. Bandiera et al., 2008) but also considers the dimensions of their relationship's salience, the shared understandings and getting to know one another's experiences. These findings will help researchers gain a better understanding of the social connectedness phenomenon and help practitioners launch and manage IT projects on the shop floor.

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