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Abstract
The current wave of digitalization has important implications for manufacturing companies. In this article, we suggest applying the theoretical lens of value co-creation as a comprehensive approach to explore the potential of digitalization trends. We use it to identify the potential of better integrating shop floor workers in the shaping of digital solutions and managerial actions. Insights from two case examples show how improved consideration of cognitive needs and the provision of opportunities for social connection to a community of workers makes them feel more valued, confident, empowered and integrated. This can balance other forms of frustrations and negative emotions, leading to a better perception of the overall relationship experience at the shop floor.

1 Introduction

Today's industrial companies are under increasing pressure to drive innovations and implement organisational changes that make them more competitive and sustainable. In order to transform the shop floor, the recent generation of information technology (IT) seems to be able to especially support two areas: on the one hand it can advance the automation of manufacturing processes (Armbruster, Erceg, Pandza, & Dreher, 2007; Brettel, Friederichsen, Keller, & Rosenberg, 2014; Chi, Kang, & Wang, 2013) and on the other hand it can put shop floor workers and their skills more in the focus (Campatelli, Richter, & Stocker, 2016; Steinhueser, Waizenegger, Vodanovich, & Richter, 2017). However, so far, there has been little work done on recognising and incorporating the needs and contributions of the shop floor worker into the design of these innovative digital solutions. To address this gap we suggest applying the widely-adopted concept of co-creation (Payne, Storbacka, & Frow, 2008; Prahalad & Ramaswamy, 2004) and extending it beyond customer relationships (Sarker, Sarker, Sahaym, & Bjørn-Andersen, 2012; Vargo & Lusch, 2008), as a theoretical lens for identifying and integrating the needs of the empowered shop floor worker in an *intra-organizational* digitalization context. Our research is guided by the following question: *How can shop floor workers be better involved in an intra-organizational value co-creation process?*

To answer this question, we first systematically revisits key digitalization trends in the context of manufacturing in order to elaborate the implications for the role of empowered shop floor workers in the evolving *intra-organizational* digitalization contexts. We then explore two case studies in digitalizing organizations to surface organizational practices that embrace proactive involvement and contributions of empowered shop floor workers in the digital factory.

The main resulting contributions of this paper are a conceptualization and an empirical illustration of the value co-creation process in the intra-organizational context of the digital factory. This addresses the current lack of theoretical understanding about how to make shop floor worker part the design of these innovative digital solutions. Moreover, we demonstrate practical examples that map to the conceptualised processes of the normative framework. As a practical implication, we demonstrate how this co-creation framework can be used as a comprehensive analytical tool to better consider the needs and contributions of empowered shop floor workers.

We start this paper by summarizing trends on the shop floor brought about by IT and impacting individuals and the organisation (Chapter 2). In order to study this impact systematically, we briefly introduce value co-creation and use a process-based framework for managing value co-creation (Chapter 3). In Chapter 4, we then explain how the close collaboration with industrial companies has allowed us to identify value co-creation opportunities in the manufacturing context. Based on these cases, we illustrate the process-based co-creation framework, thus creating an account of how value can be co-created with the shop floor workers as central actors in the manufacturing service system (Chapter 5). Based on this data, in Chapter 6 we discuss how the manufacturing industry can leverage challenges they are experiencing by focussing efforts on the value co-creation process as shop floor worker with central importance.

2 Domain: Digitization trends on the shop floor

In order to be able to present current sociotechnical manufacturing trends, we conducted an extensive review of the latest literature. Concerning scientific publications, we followed a structured approach (Webster & Watson, 2002) by searching leading journals, conferences and books using the keyword sieves that the online databases EBSCO and IEEE Xplore, the ACM Digital Library and Google Scholar offer. Our search covered but was not restricted to the terms manufacturing OR production OR industry AND digitalisation OR smart factory OR industry 4.0 AND trends. Forward and reverse searches provides us with additional relevant articles for our study. In the following, we present the results of this review. We found a large number of relevant trends that we categorized into (1) technology, which is the basis for this transformation and catalyses the other changes on (2) individual and organisational levels.

2.1 Technology as a Catalyzer

New technological developments can serve as drivers for change on organizational and individual levels (Köffer, 2015). As a first trend, the web-based linking of machines, sensors, computers, and also humans, is rapidly moving towards the idea of the connected factory (Silcher, Königsberger, Reimann, & Mitschang, 2013). The benefits of the so-called "Internet of Things" (IoT) technologies include reduced down time, increased quality and less waste as well as greater visibility of the manufacturing floor (Ashton, 2009). This connectivity enables companies to leverage the value of their plant floor

information and promises an increase in productivity, improved utilization of assets, and better decision-making. IoT technologies allow devices to communicate automatically and enable companies to monitor, collect, process, and analyse huge amounts of data, which may lead to more precision and the chance to get deep insights into manufacturing processes. Measuring and monitoring real-time data from across the factory leads to rapidly growing data sets that are increasingly gathered by affordable and numerous sources and often so large or complex that traditional data processing applications are inadequate to deal with (Lee, Lapira, Bagheri, & Kao, 2013). In this context, the term big data was coined. To capture business value and meet the demands of smart manufacturing, companies need to be able to manage these large data sets and extract meaning out of them. This large quantity of data leads to new questions and solutions concerning especially the analysis, search, sharing, updating, and visualization. Advanced analytics in the form of predictive analytics, user behaviour analytics, or certain other methods that extract value from data, are needed to cope with this great amount of data (Lee et al., 2013; Wamba, Akter, Edwards, Chopin, & Gnanzou, 2015). It offers possibilities to make extensive use of analytical tools often capable of providing diverse reporting on any device, anytime. Such detailed technical analytics is further implying the relevance of empowered employees who are engaging in value-adding sense-making processes by applying their expertise to interpret the data and contribute to an appropriate selection of information (data relevant in a context). They further need to facilitate the difficult process of aggregating of local detailed data to facilitate decisions with impact beyond individual functions and departments. In the next section, we discuss the resulting implications for the individuals in more detail.

2.2 Implications for the individual and the organisation

As with any new way of working, or even more general - of doing - individuals need to learn and adopt it, get used to it, and, in the best case, benefit from it. Thus, striving towards a smart factory impacts work practices on the shop floor. Employees face changed processes, they need to handle new technologies and accomplish different tasks. With the spreading and growing importance of technology in the manufacturing sector, the need to be able to acquire new skills to get the work done properly increases. Individuals are not only facing changes of technologies, but, as a consequence, also the increasing complexity. Providing workers with information where and when it is needed and, more generally speaking, supporting the employees in their daily work promises significant benefits (Mavrikios, Papakostas, Mourtzis, & Chryssolouris, 2013). As a consequence, shop floor workers are expected to solve occurring problems as fast as possible and to constantly improve their work-related knowledge and skills (Appelbaum, 2013; Ullrich, 2016).

People who were not born into the digital world have learnt to use different kinds of technology at some stage in their adult lives and are likely to experience some difficulties in accepting technology related changes at work (Wang, Myers, & Sundaram, 2013). Conversely, the “digital natives” have grown up with diverse IT (Vodanovich, Sundaram, & Myers, 2010). The way people process information fundamentally differs and depends from how and when they grew up (Ng, 2012; Wang et al., 2013). It could be shown, that this implies an ease with which digital natives learn to make use of unfamiliar technologies (Ng, 2012; Wang et al., 2013). They need, however, to be provided with the opportunity to use them for meaningful purposes (Huyler, Pierre, Ding, & Norelus, 2015). In order to remain competitive, companies need to take this into account.

Another perspective on the same phenomenon is that some employees may be faced with fears about whether digital natives and smart machines will soon take over their jobs (Brynjolfsson & McAfee, 2011). However, humans with the most diverse skills and competencies as well as with valuable experience have always added value to manufacturing processes and this is likely to continue (Gorecky, Schmitt, Loskyll, & Zühlke, 2014). There is a variety of possible ways in which people and machines will work alongside each other (Brynjolfsson & McAfee, 2014). When facing this challenge appropriately it is important to rethink and develop group specific learning arrangements and individual work place designs (Köffer, 2015). Organizations will need to examine knowledge-intensive processes and determine which tasks can best be performed by machines and which by humans (Gorecky et al., 2014). Thus, early training and supporting employees to prepare for a collaborative future with smart machines is essential. In sum, learning processes, the important role of developing diverse valuable human experiences and capabilities, the likely more exploratory new understanding of digital solutions, the importance of identifying individual purpose and motivation to facilitate adoption all call for, again, a better and empowered integration of opinions needs and contributions from shop floor workers, which is frequently attenuated and underdeveloped in organizational cultures.

When addressing a change in strategy, its success strongly depends on a firm’s ability to evolve its corporate culture. Thereby, companies are advised not only to take advantage of emerging technologies,

but also, critically, to embrace the new business strategies that those technologies drive. Enterprises must focus on enabling people to accomplish more with technology (Gorecky et al., 2014). They will have to create a new corporate culture that looks at technology as the way to enable people to constantly adapt and learn, continually create new solutions, drive relentless change, and disrupt the status quo. It is the task of managers to promote an organizational climate that supports decentralized and self-responsible use of information assets. Many leaders are required to develop new skills, resulting in training recommendations for supervisors, who have a prominent position in digital workflows (Köffer, 2015). The rise of the generation of digital natives, brings a new kind of employee not only with different attitudes towards technology but also with different outlooks, aspirations, and expectations regarding their employer, their workplaces, and about how work should be organized (Vodanovich et al., 2010). It appears that preferences are shifting towards aspects such as connectivity, information or entertainment (Hanelt, Piccinini, Gregory, Hildebrandt, & Kolbe, 2015).

We have illustrated above that as technology matures it becomes essential to consider the organisational context and to better embrace the needs and value contributions of shop floor worker in the evolving intra-organizational digitalization context. In order to explore the above mentioned digitization trends from the perspective of the shop floor worker, we take the theoretical lens of value co-creation.

3 Theoretical Lens: Value co-creation on the Shop floor

In existing literature there are a number of approaches that focus on the needs of the shop floor worker. For example, studies point out the relevance of better addressing the *emotional* dimension of employee's technology adoption (Stein, Newell, Wagner, & Galliers, 2015). However this strand of studies is mostly focused on the employees solely and so far not linked to the surrounding organizational aspects such as management objectives. Similarly, research on knowledge management is emphasizing employees' needs and contributions in the context of knowledge transfer (Wasko & Faraj, 2005), but does not theorize how the contributions *integrate vertically* with the interests and activities of managers and system implementers. While this gap is better addressed in theories on organizational learning processes from individuals to the organizational level and back (Crossan & Berdrow, 2003), individuals' experiences in their practices are not foregrounded. Finally, contributions on *strategizing* to better embrace strategic influences from employees (Henfridsson & Lind, 2014) are not systematically and theoretically focussing on the important encounters and convergences between the managerial and the employee perspectives.

To overcome the limitations of the narrow and partial views of existing research, we suggest to use value co-creation as an alternative broader vantage point for a more *integrated analysis* of the needs and contributions of shop floor workers and their integration with organizational objectives. This concept departs from the observation that "contemporary business organizations are increasingly turning their attention to *jointly creating value with a variety of stakeholders*" (Sarker et al., 2012p. 137 emphasis added). Thus, this concept is a useful way to shed light on the value-generating intra-organizational processes that involve shop floor workers. While the perspective of value co-creation (Payne et al., 2008; Prahalad & Ramaswamy, 2004; Vargo & Lusch, 2008) was initially mostly limited to studying customer relationships, Vargo and Lusch (2008) explicitly extend it beyond the firm/customer relation to include value configurations of economic and social actors within networks across various levels of aggregation.

Similar to the changing balance of company-consumer relationships in the context of a customer-driven value creation process (Prahalad & Ramaswamy, 2004), our context implies a changing balance of management-employee relationship in the process of organizational innovation and the appropriation of digital solutions. Employees are moving away from being recipients and target for the implementation of IT products to become a more active part of a transparent and interactive value exchange. In the context of IS research, only few studies go beyond the customer relationship scope and focus on business-to-business contexts (Grover & Kohli, 2012; Sarker et al., 2012), but to the best of our knowledge there is no attention yet to the intra-organizational setting and the shop floor workers as main stakeholders in the co-creation process.

The co-creation perspective grounds in a service-dominant (S-D) logic (Vargo & Lusch, 2008). S-D logic views service as the basis of all exchange and emphasizes the process, rather than the output, of value creation. Co-creation interaction is requiring on-demand access to resources with high transparency about trade-offs and risks, hence emphasizing joint problem solving and active dialogue between participants (Prahalad & Ramaswamy, 2004), e.g. in trustful communities. Payne et al. (2008) argue that such a work context provides for relationship experiences, which are part of the employees' practices, where they learn and (re-)link own behaviours to organizational contexts. This suggests an extended consideration of different dimensions of the employee's (relationship) experiences. We refer

to this as occurring in an intra-organizational context where we are shifting the traditional customer-supplier relationship (in service dominant logic) to an employee-organization relationship.

In the intra-organizational context, the co-creation view suggests that value is not about customising technology offerings for employees but rather giving them an opportunity to customize their own assortment of resources (Vargo & Akaka, 2012). This is especially important at the shop floor, where the focus is on providing an assortment of resources that can be bundled and rebundled in different ways according to what shop floor workers own view and value assessment (Vargo & Akaka, 2012). So that, the organisation can co-create value with the worker by enabling or empowering them to better carry out their job role (using a customisable IT solution for example). The organisations' interest in leveraging the latest technological trends for the benefit of the bottom line is thus pursued by increasing the productivity and efficiency of the worker. In turn, value for the worker lies in the ability to leverage their knowledge and skills in a manner that increases their autonomy and ability to complete their work in the best possible way.

In this paper, we adapt the general co-creation experience framework proposed by Payne et al. (2008) in order to embrace the contributions of empowered shop floor workers. This process-view recognizes the need for long-term, dynamic and interactive engagement and practices between the shop floor workers and the organisation. We suggest to adopt the framework with the following layers for: (1) Shop floor worker processes; (2) organisation processes; and (3) encounter processes (we will further discuss this later, cf. Fig.1). Shop floor worker learning takes place based on the experience that the worker has during the relationship with the organisation. This relationship experience has the elements (1) cognition—based on an information-processing approach, (2) emotion—attitudes and preferences and (3) behaviour—actions that result in experiences. The results of the workers learning process are manifested in changes within the worker's attitudes and preferences. The organisation's value-creation process is a series of activities that begins with understanding the shop floor worker value-creation processes. This learning, in turn, has an impact on how the worker will engage in future value co-creation activities with the organisation. Similarly, organizational learning takes places as the supplier learns more about the shop floor worker and leads to more opportunities becoming available for the organisation to further improve the design of the relationship experience and enhance co-creation with the workers (Payne et al., 2008).

The organisation's value-creation process is a series of activities that begins with understanding the shop floor worker value-creation processes. This involves: 1) a review of co-creation opportunities; 2) planning, testing and prototyping value co-creation opportunities with organisations; 3) implementing worker solutions and managing worker encounters; and 4) developing metrics to assess whether the enterprise is making appropriate value propositions. Learning more about worker requirements helps the organization to design its service offerings that can give the firm competitive advantage in the market. Encounter process is a series of two-way interactions and transactions occurring between the worker and the organisation linking the worker processes with the organisations processes. Three forms of encounter types are conceptualized to facilitate value co-creation between the stakeholders: communication, usage, and service encounters. We will now present results from cases that serve to illustrate main aspects of the co-creation framework with practical instances, which also is meant as a first research-based support for the framework.

4 Study Context

Our empirical illustration and assessment is based on a study that is a part of an international research project which aims to create attractive and intelligent work places in a factory of the future. Using a mix of participant observations and interviews, we initially studied how practices on the shop floor can be supported through human-centred IT solutions. A deep understanding of workers' individual practices has been our basis to deliver suggestions (in the form of requirements) for sociotechnical solutions that support smarter work. For this paper we select, analyse and illustrate two case companies out of altogether 6 companies. We plan to analyse more for our future work.

For this purpose, we designed a semi-structured interview guide which ensured that certain aspects were captured in a comparable way, while also allowing us to do "deep dive" into interesting topics that arose during the interviews. The coarse structure included (amongst others) questions on individual work practices, group work practices, the worker's perspectives on an envisioned situation and on the current situation's potentials. Another method applied in the data-collecting process was the contextual inquiry technique (Holtzblatt & Jones, 1993). With this technique, people are observed while carrying out their tasks in their normal work environment. For profiles of the companies referred to in this article and the corresponding details of data collection please see Table 1.

Company	Industry	Country	Observ.	Interv.
Hidria Rotomatika	Electrical steel laminations and die-cast rotors	Slovenia	yes, incl. videos	9
thyssenkrupp Steel Europe	Steel products	Germany	yes	11

Table 1: Overview of the case companies and their project contexts

In the next section we use case vignettes to illustrate how manufacturing organisations can leverage elements of the process based value co-creation framework to create worker-centric technological solutions that ultimately benefit the organisation as well. Shop floor workers' value creation processes begin with the series of activities that they need to carry out to achieve a particular goal. This very much depends on the level of information, knowledge, skills and other resources they can access and use. Relationship experience is based on the information processing abilities of the worker, the feelings and emotions they feel towards work practices and technologies for example and then how they behave depends on their experiences of having interacted with a particular technology or new work practice.

5 Illustrating the Framework with Case Vignettes

5.1 Shop floor Worker Processes

To start with, we observed operators of the machining departments, who deal with turning and milling machines at Hidria Rotomatika. A preliminary analysis of the workers needs highlighted how some operations could be time-consuming and require the acquisition of paper-based data or knowledge from an experienced colleague. These data are then processed manually in order to obtain a smooth process. Especially machine setup processes and measurements of each part can be very complex and time-consuming. While these aspects are not considered the core of the work practice they influence the workers' perceptions of the IT solution. The time consuming setup generates negative experiences that leads, in combination with ambitious work goals, to frustrations that shape attitudes and preferences. Thus, it is helpful for the workers to be better able to exploit the data that their machines protocol during the operations. The rigid setup was not considering previous decisions. In this way the setup process was not noting the perspective of the shop floor worker, leading to negative experiences and lost opportunities to recognize solutions and contributions from the employees. At the same time, addressing these related attitudes and preferences makes it more likely to produce IT solutions that are embraced by shop floor workers. In the new solution workers now automatically receive all relevant information in a digital format and are able to fix the problem directly at their current work station. Moreover, the operators acquire more autonomy due to the implementation of a trend analysis of the process, which usually means the degradation of some components or machines. In this case the operator becomes a leader of a proactive analysis phase for the machine maintenance that is actually carried out using a traditional reactive approach (repair actions when the process stops due to e.g. a broken part) by the maintenance team. This allows the operator to gain more autonomy and take charge of advanced tasks that are beneficial both for the process (higher availability of the plant) and its satisfaction (higher autonomy and possibility to be the responsible for the process well-being).

At thyssenkrupp Steel Europe (TKSE), we observed the practices of the mobile maintenance team in the areas of air-conditioning technology and electricity. The paper-based, asynchronous information exchange between the employees who are involved in the fault process often leads to delays or redundant work. Furthermore, at the site of the disruption, there is often a lack of knowledge that employees could deliver. In this case, the opportunities to directly communicate with other colleagues, e.g. to exchange pictures and documents, are missing. The frequent request to build more ways of knowledge exchange stresses the important cognitive dimension of the co-creation relationship. Information-processing is considered an important activity of the observed practices which influences the perceived relationship experience. Acknowledging the cognition-related preferences of the employees hence suggests an improved experience and invites more contributions that may lead to a better result. In this context, TKSE realised that it is important that the workers are provided with the necessary information in a bundled, contextual and mobile way. This could be realized through the implementation of a mobile employee-centred knowledge management system that places the maintenance staff at the centre of attention. Active knowledge sharing holds a great potential for the improvement of manufacturing work and worker satisfaction. More importantly, in providing a solution which once again takes into account regular shop floor worker frustration, the worker would feel more valued, more socially connected to the work community and better motivated to contribute in such a system. The improved consideration of cognitive needs and the provision of opportunities for social connection to a community of workers does not only consider cognitive aspects, but is also likely to improve the emotional dimension, as workers

feel more valued, confident, empowered and integrated. This can balance other forms of frustrations and negative emotions, leading to a better perception of the overall relationship experience at the shop floor. It can empower workers to share their contributions openly in a communally updated pool of knowledge. Full utilization of worker-generated content and peer sharing about best practices, problem solving and ideas fuels organizational learning and even worker-driven innovation. This can remove productivity bottlenecks and improve the pace and depth of on-the-job learning.

5.2 Organisation Processes

Conversely, organisational learning is based appropriating and understanding the knowledgeable contributions of the employees and the ability to leveraging such insights *across* similar manufacturing contexts (Payne et al., 2008). They can do this by leveraging co-creation opportunities (embracing technological breakthroughs, acknowledging changes in industry logic and familiarising themselves with shop floor worker preferences and needs), by planning, that is by listening to the shop floor workers and implementing those technologies that best support their work practices keeping in mind their specific needs, requirements and abilities. And finally implementing prototypes for example and measuring shop floor worker value gained through metrics. For example, the Hidria case company ensured they implemented an IT solution which illustrates the co-creation opportunities part of the framework. They understood that accessing knowledge and the ability to interact effectively was a key work practice for their shop floor workers. Therefore, they implemented natural interfaces enabled the workers to utilize big data analytics fuelled by automated electronic measurements to make decisions more effectively when calibrating production equipment. Better access to information and analytics would allow to cut production times while increasing product quality and reducing waste due to making better-informed decisions and detecting patterns and trends in product deviations. Whereby, enhancing shop floor workers regular work practices.

Another example of leveraging co-creation opportunities can be seen with the implementation of self-learning manufacturing systems at Hidria (an example of embracing technological breakthroughs in the manufacturing context). One of the proposed IT solutions of Hidria provided supporting tools for operators at the shop floor that shifted their workloads towards more predictive rather than reactive maintenance tasks. Moreover, the newly introduced IT artefact included a feature whereby the solutions to a specific problem can also be rated by the workers (collating metrics). This allows the organisation to gain regular feedback on value provided by IT solution. In addition, an employee can generate new solutions in forms of comments, videos or pictures. In doing so, Hidria is able to dynamically co-create existing solutions with its workers, so that they feel empowered to contribute more and in turn use the solutions.

5.3 Encounter Processes

In both case settings, the interactions between the shop floor workers and the management where mostly institutionalized via a long term project setting, in which we participated. The project members were, as boundary spanners, iteratively facilitating the dialogue with shop floor workers to surface their IT user needs and contributions. The projects also supported the workers when the solutions did not work for them. There were no other systematic encounters established that went beyond ad-hoc unidirectional complaints that were communicated upwards in the hierarchy. This may also be a case of implementation maturity, where the case companies are still in the process of implementing. Encounter processes can include communication (how new technologies are announced to workers), usage encounters (how new technologies are rolled out to workers) and support encounters (how workers are supported through training etc. for new technologies). We see this as a strategic opportunity to support the value co-creation process for manufacturing organisations.

6 Discussion

In our assessment of how digitalization trends affect the organizational context we note that as technology matures, the focus of IT development can shift from a largely technical perspective to a more holistic sociotechnical perspective. As we have shown in this paper, a number of sociotechnical trends lead manufacturing companies to change the way they work.

One of these changes includes designing people-centred workspaces that pay more attention to their employees and put them into the centre of their efforts (Campatelli et al., 2016; Steinhueser et al., 2017). These multi-facetted organizational implications call for a conceptual framework that is able to integrate various previously unconnected perspectives. Correspondingly, we illustrate how a process based co-creation framework can help to accentuate the relationship between the shop floor worker and the

organisation as a longitudinal, dynamic, interactive set of experiences and activities performed by both actors in the manufacturing service system.

Our adopted perspective also acknowledges that there is a strong need to develop a full understanding of where an organisation's offering fits within the empowered shop floor workers' overall activities and past experiences (i.e. Relationship Experience and Co-creation in Figure 1) (Payne et al., 2008).

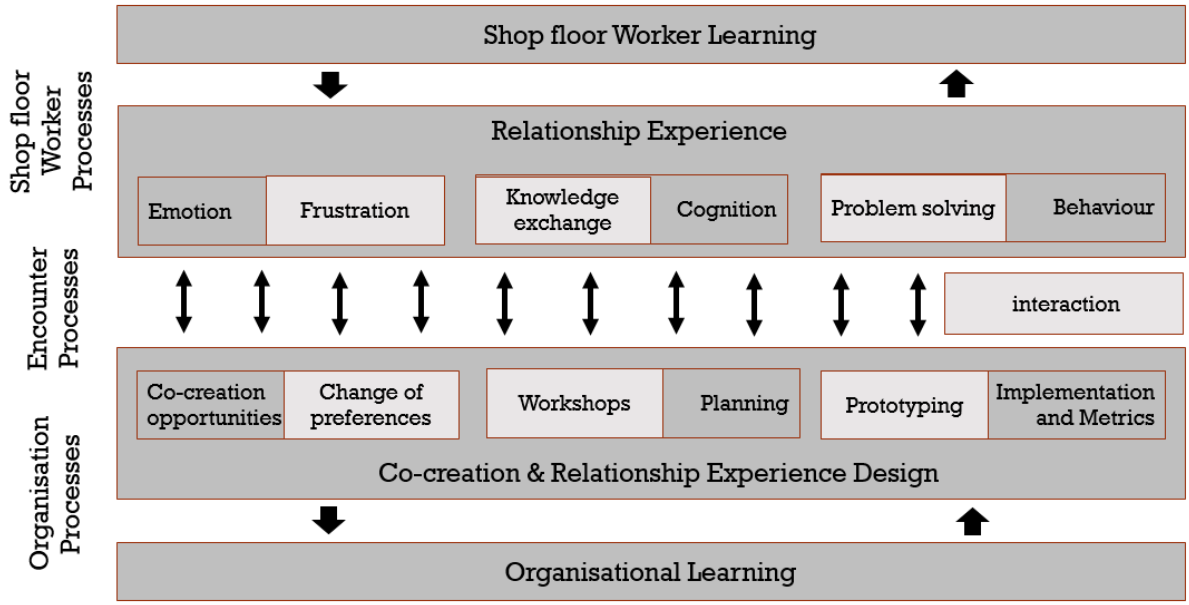

Figure 1: Co-creation Experience Framework for the intra-organizational Context

Our study addresses the identified contextual challenges of digitalization and aims at structuring and assessing how shop floor workers get involved in an intra-organizational value co-creation process. In order to provide a systematic account of this involvement, we adapt the co-creation experience framework to the intra-organizational context (Fig.1). Our analysis of a series of case examples suggests that applying this concept to the intra-organizational context can help to better consider shop floor workers and empower them. Our observations and interviews illustrate, how the shop floor workers' *relationship experience* and learning form a suitable starting point for co-creating organizational value in the context of a digitalizing factory. Recognizing how *cognition* and *emotions* of shop floor workers influence their *behaviours* helps to engage in useful interactions and encounters with the shop floor workers. The organization needs to embrace and understand these learning processes in order to generate *co-creation opportunities* such as important *changes of preferences* that better recognize the employees' perspective. In turn, organisational learning can take place in the form of *planning*, which could be more interaction-oriented, e.g. via workshops as well dynamically co-creating solutions through prototyping for example during the *implementation and measurement*. More generally, the encounters integrate individual learning by employees and organizational learning from management. An overview of this approach is given in Fig. 1.

In our analysis we noted that one key aspect of the shop floor workers' ability to contribute value to the service system is the amount of information, knowledge, skills and other operant resources that they can access and use (Normann, 2001). If an organisation wants to encourage maximum use of their proposed IT solution, they have to develop capacity to either add to the shop floor worker's total pool of resources in terms of competence and capabilities (skills they already possess), or to influence their process in such a way that the workers are able to utilize available resources more efficiently and effectively (to gain new skills/knowledge).

In noting that the human worker keeps a preferred role in future manufacturing systems through the ever-rising demand in complexity, knowledge work and decision making, the humanistic perspective might provide a sustainable point of view to design for basic human needs as autonomy, relatedness and competence (Gagné & Deci, 2005; Spreitzer, Kizilos, & Nason, 1997) as well as variety (Turner & Lawrence, 1965). To this end, the shop floor learning perspective especially becomes important. The shop floor worker's experience of the organisation and the latest IT offering to enhance their jobs is a culmination of their cognitions, emotions and behaviour. These elements are not mutually exclusive, they work together to portray the shop floor worker as thinker, feeler and doer (Payne et al., 2008). By taking into account these three aspects of learning, the organisation has an opportunity to shift the focus

from producing and implementing an IT solution to a more dialogical process with the shop floor worker. By doing so, organisations can rather co-create experiences that simultaneously leverage technological advancements in the manufacturing domain and take into account the shop floor worker's needs, preferences and capabilities.

Our case analysis also surfaced that the central layer that integrates the shop floor worker with the organization via interaction encounters is not yet comprehensively designed and implemented across the studied organizations. While interaction takes place through normal reporting processes and the mentioned project-based inquiry, we noted in our cases that transparent institutionalized means to facilitate ongoing dialogue as mostly absent. This may well be a case of implementation maturity, where the case companies are still in the process of implementing. Encounter processes can include communication (how new technologies are announced to workers), usage encounters (how new technologies are rolled out to workers) and support encounters (how workers are supported through training etc. for new technologies). We see this as a strategic opportunity to support the value co-creation process for manufacturing organisations.

Beyond noting the importance of organizational learning, knowledge exchange and understanding the worker's experiences, the co-creation framework hence also provides insights on existing gaps that are necessary to conclude a larger process. Similarly, while our cases document partial practices that taken together across the organizations support the gains of applying the co-creation perspective, we also note that no case example has a complete and explicit co-creation initiative. On the positive side, this suggests that the co-creation perspective is useful as an analytical approach with a strong potential to systematically design and understand how value in digitalization contexts can be created in a way that better recognizes the contributions of shop floor workers. The framework thus helps to integrate partial aspects of strategizing, knowledge transfer or organizational learning on the one end and IT implementation approaches on the other (e.g. prototyping). The viewpoint is for example surfacing in more detail how organizational learning is departing from interaction encounters and is oriented towards co-creating value. Co-creation thus offers an overarching frame of reference lending meaning and orientation to the involved partial aspects such as organizational learning or knowledge exchange, which are often enough only taking place horizontally across workers. With that, co-creation highlights the importance of vertically integrating the partial elements between shop floor workers and the organizational management. In this context, the co-creation framework further points to the importance of reconsidering of the interplay of formal and informal interactions. Informal practices like venting emotions, addressing individual problem solving practices or changing preferences need to be considered across hierarchies and brought into synergy with more formal planning and implementation processes in order to effectively accomplish the complex act of co-creating.

7 Conclusion

In this article, we find that the value co-creation framework proposed by Payne et al. (2008) can provide a comprehensive approach to address the shop floor workers' relationship experience and to guide the assessment of how the contributions of these valuable professionals can better be integrated in the digital solutions and managerial actions. The analysis of co-creation processes synthesizes existing analysis of partial aspects such as knowledge transfer, emotional aspects of IT adoption, or IT implementation practices into a bigger framework that can guide organizations that face digitalization challenges. The main contribution of this article is the mapping of shop floor worker and organisation processes to identify co-creation opportunities and to ground the framework empirically. We also identified the potential to establish encounter processes that are not yet clearly highlighted by our case vignettes. Our main ambition was to motivate a new perspective on the digitalizing organization.

To our knowledge, this article is the first of its kind to link this framework to the intra-organisational context and thus there were some limitations of our research that should be identified. For example, the shop floors referred to here is a specific example in a European context and one that may not be generalizable to all shop floor environments or to other countries. Companies could have different levels of maturity and this of course may impact their shop floor environment and their readiness to embrace aspects of this framework. Beyond our initial exploration of the co-creation framework in a manufacturing setting, future research could invest in highlighting selected aspects of this framework in more detail or compare the results more comprehensively against traditional approaches. A promising research objective is the investigation of existing encounter processes. Moreover, we have only focussed on one particular value co-creation framework in this paper. In the future, it may be useful to combine different aspects of other co-creation frameworks (Grönroos & Voima, 2013; Prahalad & Ramaswamy, 2004).

8 References

Appelbaum, E. (2013). The impact of new forms of work organization on workers. In G. Murray, J. Bélanger, A. Giles, & P. A. Lapointe (Eds.), *Work and Employment in the High Performance Workplace* (Vol. 120). London: Continuum.

Armbruster, H., Erceg, P. J., Pandza, K., & Dreher, C. (2007). Managing knowledge in manufacturing: results of a Delphi study in European manufacturing industry. *International Journal of Foresight and Innovation Policy, 3*(3), 256-276.

Ashton, K. (2009). That 'internet of things' thing. *RFiD Journal, 22*(7), 97-114.

Brettel, M., Friederichsen, N., Keller, M., & Rosenberg, M. (2014). How virtualization, decentralization and network building change the manufacturing landscape: An Industry 4.0 Perspective. *International Journal of Mechanical, Industrial Science and Engineering, 8*(1), 37-44.

Brynjolfsson, E., & McAfee, A. (2011). Race against the machine. *Digital Frontier, Lexington, MA*.

Brynjolfsson, E., & McAfee, A. (2014). *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*: WW Norton & Company.

Campatelli, G., Richter, A., & Stocker, A. (2016). Participative Knowledge Management to Empower Manufacturing Workers. *International Journal of Knowledge Management (IJKM), 12*(4), 37-50.

Chi, H.-L., Kang, S.-C., & Wang, X. (2013). Research trends and opportunities of augmented reality applications in architecture, engineering, and construction. *Automation in construction, 33*, 116-122.

Crossan, M. M., & Berdrow, I. (2003). Organizational learning and strategic renewal. *Strategic management journal, 24*(11), 1087-1105.

Gagné, M., & Deci, E. L. (2005). Self-determination Theory and Work Motivation. *Journal of Organizational behavior, 26*(4), 331-362.

Gorecky, D., Schmitt, M., Loskyll, M., & Zühlke, D. (2014). Human-machine-interaction in the Industry 4.0 era*IEEE*. Symposium conducted at the meeting of the International Conference on Industrial Informatics (INDIN), Porto Alegre, Brazil.

Grönroos, C., & Voima, P. (2013). Critical service logic: making sense of value creation and co-creation. *Journal of the academy of marketing science, 41*(2), 133-150.

Grover, V., & Kohli, R. (2012). Cocreating IT value: New capabilities and metrics for multifirm environments. *MIS Quarterly, 36*(1).

Hanelt, A., Piccinini, E., Gregory, R. W., Hildebrandt, B., & Kolbe, L. M. (2015). Digital Transformation of Primarily Physical Industries-Exploring the Impact of Digital Trends on Business Models of Automobile Manufacturers Symposium conducted at the meeting of the International Conference of Wirtschaftsinformatik, Osnabruck, Germany.

Henfridsson, O., & Lind, M. (2014). Information systems strategizing, organizational sub-communities, and the emergence of a sustainability strategy. *The Journal of Strategic Information Systems, 23*(1), 11-28.

Holtzblatt, K., & Jones, S. (1993). Contextual inquiry: A participatory technique for system design. *Participatory design: Principles and practices*, 177-210.

Huyler, D., Pierre, Y., Ding, W., & Norelus, A. (2015). Millennials in the Workplace: Positioning Companies for Future Success Symposium conducted at the meeting of the South Florida Education Research Conference (SFERC)

Köffer, S. (2015). Designing the Digital Workplace of the Future – What Scholars Recommend to Practitioners Symposium conducted at the meeting of the International Conference of Information Systems (ICIS), Fort Worth, USA.

Lee, J., Lapira, E., Bagheri, B., & Kao, H.-a. (2013). Recent Advances and Trends in Predictive Manufacturing Systems in Big Data Environment. *Manufacturing Letters, 1*(1), 38-41.

Mavrikios, D., Papakostas, N., Mourtzis, D., & Chryssolouris, G. (2013). On industrial learning and training for the factories of the future: a conceptual, cognitive and technology framework. *Journal of Intelligent Manufacturing, 24*(3), 473-485.

Ng, W. (2012). Can we Teach Digital Natives Digital Literacy? *Computers & Education, 59*(3), 1065-1078.

Normann, R. (2001). *Reframing business: When the map changes the landscape*: John Wiley & Sons.

Payne, A. F., Storbacka, K., & Frow, P. (2008). Managing the co-creation of value. *Journal of the academy of marketing science, 36*(1), 83-96.

Prahalad, C. K., & Ramaswamy, V. (2004). Co-creating unique value with customers. *Strategy & leadership, 32*(3), 4-9.

Sarker, S., Sarker, S., Sahaym, A., & Bjørn-Andersen, N. (2012). Exploring value cocreation in relationships between an erp vendor and its partners: A revelatory case study. *MIS Quarterly, 36*(1).

Silcher, S., Königsberger, J., Reimann, P., & Mitschang, B. (2013). Cooperative service registries for the service-based Product Lifecycle Management architecture*IEEE*. Symposium conducted at the meeting of the International Conference on Computer Supported Cooperative Work in Design (CSCWD), Whistler, Canada.

Spreitzer, G. M., Kizilos, M. A., & Nason, S. W. (1997). A dimensional analysis of the relationship between psychological empowerment and effectiveness, satisfaction, and strain. *Journal of management, 23*(5), 679-704.

Stein, M.-K., Newell, S., Wagner, E. L., & Galliers, R. D. (2015). Coping with Information Technology: Mixed Emotions, Vacillation, and Nonconforming Use Patterns. *MIS Quarterly, 39*(2).

Steinhueser, M., Waizenegger, L., Vodanovich, S., & Richter, A. (2017). Knowledge Management without Management – Shadow IT in Knowledge-intense Manufacturing Practices. Symposium conducted at the meeting of the European Conference on Information Systems Portugal.

Turner, A. N., & Lawrence, P. R. (1965). *Industrial jobs and the worker: An investigation of response to task attributes*. Boston: Harvard University.

Ullrich, C. (2016). Rules for adaptive learning and assistance on the shop floor*IADIS Press*. Symposium conducted at the meeting of the International Conference on Cognition and Exploratory Learning in Digital Age

Vargo, S. L., & Akaka, M. A. (2012). Value cocreation and service systems (re) formation: A service ecosystems view. *Service Science, 4*(3), 207-217.

Vargo, S. L., & Lusch, R. F. (2008). Service-dominant logic: continuing the evolution. *Journal of the academy of marketing science, 36*(1), 1-10.

Vodanovich, S., Sundaram, D., & Myers, M. (2010). Research commentary-Digital natives and ubiquitous information systems. *Information Systems Research, 21*(4), 711-723.

Wamba, S. F., Akter, S., Edwards, A., Chopin, G., & Gnanzou, D. (2015). How 'big data' can make big impact: Findings from a systematic review and a longitudinal case study. *International Journal of Production Economics, 165*, 234-246.

Wang, Q. E., Myers, M. D., & Sundaram, D. (2013). Digital Natives and Digital Immigrants. *Business & Information Systems Engineering, 5*(6), 409-419.

Wasko, M. M., & Faraj, S. (2005). Why should I share? Examining social capital and knowledge contribution in electronic networks of practice. *MIS Quarterly*, 35-57.

Webster, J., & Watson, R. T. (2002). Analyzing the past to prepare for the future: Writing a literature review. *MIS Quarterly*, xiii-xxiii.

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