Conceptualizing industrial workplace learning: an information systems perspective

Charlotte A. Shahlaei
School of Information Technology, Halmstad University, Halmstad, Sweden, and
Ulrika Lundh Snis
School of Business, Economics and IT University West, Trollhättan, Sweden

Received 27 April 2021
Revised 17 October 2021
15 February 2022
26 April 2022
Accepted 29 April 2022

Abstract

Purpose – The purpose of this paper is to identify the constituent parts of learning in the manufacturing work context and understand why these parts are key in the learning of the employees.

Design/methodology/approach – The data was collected from two sources: a literature review of the Information Systems literature to establish an initial picture of what learning in relation to digital technologies entails and in-depth interviews with engineers in the automotive industry whose knowledge-intensive work is exposed to substantial digital transformation.

Findings – The authors first identified three constituent parts for learning: change, reflection and deliberation. When the authors cross-checked the initial findings through in-depth interviews with the engineers, it was found that these three themes trigger learning through three different mechanisms, that is, balancing newness, finding point of reference and organizing actively. Thus, the findings of this paper extend beyond a categorical identification of what constitutes learning to also illustrate why learning entails these constituent parts.

Research limitations/implications – This paper implies that progressive learning requires active organizing of learning stages. The data is limited to the review of the Information Systems field. The authors have also only focused on the automotive industry as the representative sector in the manufacturing industry.

Practical implications – Applying the model of progressive learning can be a primary way to actively plan and organize learning opportunities for employees. This is key for supporting learning culture in organizations that are exposed to continuous and disruptive changes.

Social implications – A significant part of social sustainability is based on sustainable employability and feelings of contentment at work. This paper is an attempt to highlight how sustainable employability can be achieved by providing effective learning opportunities at work.

Originality/value – The originality of this paper emerges from two sources. First, the authors conducted the literature review and in-depth interviews by devising innovative methods because of the challenges of identifying when (informal) learning has occurred at work. Second, the authors owe the in-depth interviews to the first author's extensive familiarity with the automotive industry and the knowledge and rapport acquired through her prior longitudinal research on the engineers' work. It was this background that allowed the authors to find out when these engineers were about to leave the firm because of discontent about their competence development.

Keywords Manufacturing industry, Learning, Workplace learning, Industry 4.0, Digitalization, Work practice

Paper type Research paper

Journal of Workplace Learning
Vol. 35 No. 9, 2023
pp. 1-21
Emerald Publishing Limited
1366-5626
DOI 10.1108/JWL-04-2021-0048

Industry and workplace learning

Organizational and structural features of a sector have a profound influence on developing cogent workplace learning measures (Stroud and Fairbrother, 2008; Billett, 2014). Manufacturing industry, the secondary large-scale industry with labor-intensive and heavy investment requirements, is encumbered more immediately by issues of capital flow than improvement of life quality (Schmiede and Will-Zocholl, 2011). Constant need for bringing in heavy capital to keep the industry going has turned the limits of the organization into a financial one (McKenzie, 2002). This means that the organizational processes, structures, and cultures tend to adapt towards the stakeholders' short-term values, rather than the experts' long-term strategic values (Reardon, 2010).

It is not just capital flow hurdles that treat human expertise lightly. The informatization of the industry and its associated globalization processes also alter the nucleus of human work and redefine its related competences (Baase, 2013; Winter *et al.*, 2014; Tilson *et al.*, 2010). The unfolding of Industry 4.0, as a methodology to turn machine-dominant manufacturing into digital manufacturing (Oztemel and Gursev, 2020), is characterized by the connected world of different enterprises that jointly develop technological projects, build collaboration scenarios and use cases, and coordinate combination of products and services into novel business opportunities (Shamim *et al.*, 2016). This connected world consists of heterogenous enterprises that cooperate on one level (e.g. building hardware platforms) and compete on another level (e.g. offering distinct end-user services). The coalition of heterogeneous or competing businesses signifies that development requirements and work conditions are defined by multiple enterprises each with their specific and often diverging goals and provisions (Winter *et al.*, 2014; Oztemel and Gursev, 2020). Therefore, the ubiquitous informatization of the manufacturing industry calls for learning new collaboration and development practices.

Additionally, what characterizes novelty and innovation is continuous change and loosely defined standards, use cases and, therefore, development requirements that respond to the fast-changing and unexpected future requirements (Oztemel and Gursev, 2020; Shamim *et al.*, 2016). That is, accommodating digital innovation calls for learning how to continuously adapt to fluid work conditions and project requirements. In other words, informatization of the manufacturing industry has consequences for learning at work, as:

- much of the technological development work is novel and unprecedented;
- work structures and guidelines are inherited from multiple contexts; and
- these multiple contexts are loosely defined and fluid, as they tend to be responsive to the fast-changing and unexpected future requirements.

The informatization of the manufacturing industry, thus, prompts us to realize appropriate training strategies that respond to not only the new but also the continuously changing work conditions (Liao *et al.*, 2017; Shamim *et al.*, 2016). To meet the requisites of a new work life, reports on competence development and changes at work have re-emerged in recent years (Susskind and Susskind, 2015; Brynjolfsson and McAfee, 2016; Segal, 2018; World Economic Forum, 2018). Besides training new skills and competences, there is equal emphasis on supporting the upskilling and retraining of the incumbent workforce (European Commission, 2021) and transformative competences of the workforce (OECD, 2019) triggered by the informatization of industry.

However, despite the increasing reliance of Industry 4.0 on knowledge work and the employees who hold this knowledge, the workforce in manufacturing industry struggles to define their learning needs in a focused way (Rangraz and Pareto, 2020; Blayone and VanOostveen, 2021).

Similarly, the extant literature on workplace learning underlines that even when workplace learning opportunities are available, they include more service-oriented and overgeneralized procedures rather than the actual and active organization of learning processes (Stroud and Fairbrother, 2008). We argue that, to contribute to the realization of progressive learning opportunities in this sector, there is a need to address the *learning needs* of the manufacturing industry, i.e. the type of learning that corresponds to the specific conditions of today's manufacturing industry as opposed to general workplace learning concepts and directions. By learning needs, thus, we refer to the appropriate training strategies and organization of work in a way that fosters lifelong workplace learning in correspondence with the digitalization of the manufacturing industry (Liao *et al.*, 2017). To do so, we propose that it is pivotal to a) identify what constitutes learning in the manufacturing industry and b) shed light on the relationship among its constituent parts. Our research question is, thus, "What constitutes learning in industrial work contexts?"

To answer this question, we first conducted a literature review to provide an initial understanding of what constitutes learning in industrial contexts. We then conducted semi-structured interviews with industrial practitioners to cross-check our findings. The interviews were valuable in highlighting how the different identified constructs play out in an industrial context. In light of this, the originality of this paper does not lie in identifying learning constructs. Numerous well-received models and definitions of workplace learning have already contributed to our understanding of what constitutes learning at work in general (Illeris, 2011; Bratton *et al.*, 2004; Marsick and Watkins, 2003). However, the function of these models and definitions is to create abstract and general conceptual frameworks rather than illuminate specific learning needs. Identifying the specific learning needs of a sector relies on a concrete analysis of empirical data obtained from that sector. The objective of this paper is, thus, to establish a concrete analysis of learning needs specifically in an *industrial* context.

The rest of the paper is structured as follows. First, we explain how we conducted the literature review and cross-checked our findings through in-depth interviews. Then, we present the results with examples based on both the review and the interview data. The results are subsequently discussed, and the paper ends with research implications and limitations.

Method

The study of learning at work has traditionally been translated into studies of competence/skill at work and affiliated with disciplines such as human resources, pedagogy (Murawski and Bick, 2017), management (Sandberg and Pinnington, 2009; Sandberg *et al.*, 2017) and workplace learning (Fuller and Unwin, 2011; Illeris, 2011). However, with the focus of this paper being on the context of the industry as affected by Industry 4.0, we intended to review articles that understood the role of digital technologies as central in shaping today's industrial environment. We did an initial search in the *Journal of Workplace Learning*, looking for articles that had investigated the issue of learning in the context of the manufacturing industry. Although *Workplace Learning* would be a logical outlet to look for articles about learning at work, a quick analysis of the industrial papers in this journal revealed that many of these papers had not dealt with the characteristics of the industrial context in depth. These articles had usually selected the manufacturing industry, as, for instance, it was an important sector to a specific country's economy (Coetzer, 2007) or it presented the need to develop certain skills among immigrant workers (Duval-Couetil and Mikulecky, 2011), certain learning challenges among mature-aged workers (Smith *et al.*, 2010), various methods of

producing manufacturing technology (Jalonen, 2016) and specific management styles (Wallo *et al.*, 2021).

To stay closer to the challenges of working in relation to the informatization of the manufacturing industry, we decided to conduct our review in the field of Information Systems (IS). One reason for doing so was that, with the increasing focus on the pervasive role of digital technologies at work, IS has emerged as a new interdisciplinary field to deal with issues of managing various aspects at work in relation to the emerging technologies (Wade and Hulland, 2004). In addition to being interdisciplinary, IS is also an applied discipline that uses, redefines and potentially redevelops the theories developed in other disciplines (Keen, 1980; Vessey *et al.*, 2002). Hence, the literature review would not only reflect the foundations of a wider range of related disciplines but also would provide a mutual ground for the Workplace Learning field to benefit from the practice-driven nature of the IS discipline.

In selecting the search keywords, we found that unlike the workplace learning articles that are familiar with the key term "workplace learning," articles in IS could have discussed learning at work without necessarily using the terms "workplace learning" or even "learning." It must be mentioned that we view workplace learning as a type of "competence development" at work which entails all that it takes (e.g. knowledge, skills and abilities) to perform in a given work context (Illeris, 2011). Given this perspective on workplace learning as competence or the capacity to perform work-related tasks (Billett, 2014; Sandberg, 2017), we looked for a keyword that could more closely capture the learning that occurs in everyday work practices. The established keyword that considers any workplace reality (such as learning) as a production of everyday practices (Pickering, 2001; Leonardi, 2015) – and is quite close to "work" and "workplace" – was "work practice." This strategy concurred with the recent views on workplace learning that emphasize the importance of uncovering the kind of learning which occurs in "everyday participation at work" (Fuller and Unwin, 2011, p. 50), rather than focusing on direct and measurable instances where learning is the objective in a top-down manner (e.g. courses or competence development programs). In IS, the explicit discussion of work practices usually entails commenting on work objectives and the way subjects (individuals and teams) collectively achieve those objectives. Additionally, our initial search with the keyword "learning" did result in a few hits; however, a quick review of the papers revealed that these articles did not necessarily include detailed discussions of workplace learning.

Additionally, we classify our literature review as a hermeneutic literature review in which the objective is to establish a dialogical interaction with the literature to continue interpretation, questioning, and critical assessment (Boell and Cecez-Kecmanovic, 2014). This type of literature review calls for highly intellectual and creative research activities that seek originality rather than a highly structured search process with an emphasis on replicability (Boell and Cecez-Kecmanovic, 2014). In other words, our review is not a systematic literature review with the goal to *exclusively* map a particular literature and provide "replicable and unbiased" or "ultimate" answers (Boell and Cecez-Kecmanovic, 2014, p.261). We believe this type of literature review does not hold up in practice and claiming to conduct such a review countermands our goals for initiating or expanding a focused debate around "industrial" workplace learning. Thus, although our search process is structured and the selected search outlets and keyword are relevant to the study objectives, they are not *exclusively* relevant. Other search strategies can expand and deepen our mapping and classifications which are only aimed at providing the basis for critical analysis. The search phases of our hermeneutic literature review are summarized in Table 1. The search was

Search order in Scopus (IS Senior Scholars Basket of Eight Journals)	Keyword	(Abstract, title, keywords and body) English	(Abstract, title, keywords and body) (2000–current) English	(Abstract, title, keywords and body) (2000–current) English Manufacturing Industry
1	Work practice	166		
2	Work practice		150	
3	"Work practice"	40		
4	"Work practice"		38	
5	"Work practice"			20

Table 1.
Articles mentioning "work practice" in information systems

conducted through Scopus and included top journals selected by the Association for Information Systems (eight top journals known as the senior scholars' basket of eight).

A total of 39 articles with the keyword "work practice" in "abstract, title keywords, body" (2000–current) were checked manually for their relevance. The initial relevance criteria included:

- The articles had to have mentioned "work practice" at least once in their abstract/keyword/title or the main body of the article. Mention of the keyword "work practice" in the references would not qualify the article for inclusion.
- The articles had to be empirically grounded.
- The articles had to deal with work within an industrial context.

Thus, articles which dealt with non-industrial contexts such as school settings, hospitals, call centers, public administration offices or environmental studies were excluded. In the end, 20 of 39 articles included all the above-mentioned criteria and, thus, constituted the basis of our analysis.

Data analysis

The articles were read and summarized carefully in tables based on their authors, year and journal of publication, theory/concept, methodology, context, findings, and possible links with learning/competence/skill. Figure 1 exemplifies the tables developed in this round of data analysis. The next step in a literature review such as this one would have been to categorize the findings based on a previous conceptualization (Webster and Watson, 2002). However, a conceptualization of workplace learning, as discussed previously, did not exist. We, thus, had to develop our own strategies to conceptualize learning in the manufacturing industry in four steps:

(1) *Developing commentary*: We first developed a commentary on the pertinence of each article to the subject of workplace learning based on our own interpretation. To write these commentaries, each of us had to ask ourselves whether we considered the article to present an instance of workplace learning and why we thought so. To complement this step and to establish a comparative criterion,

Author	**Kristine Dery, Darl Kolb, and Judith MacCormick**
Subject	**Working with connective flow: how smartphone use is evolving in practice**
Year/Journal	**2014/European Journal of Information Systems**
Theory/Concept	**Giddens's Duality vs Kolb's Connective Flow** Giddens: connectivity represents a duality of connects and disconnects. Such a duality portrays an image of the smartphone user making intermittent contact (connecting) with others, then disconnecting, re-connecting, and so on. Kolb: In their 'requisite connectivity' model Kolb et al (2008) suggest that having the right kind and amount of robust and reliable connectivity for the task or purpose at hand creates the threshold condition ('requisite connectivity') at which distributed work can be accomplished. Teams will try to make regular adjustments to avoid states of hypo-connectivity (too little connectivity) and hyperconnectivity (i.e., too many emails, phone calls, meetings, etc.) in order to be productive. Once the requisite connectivity threshold has been achieved, members may transcend to another state, which has been referred to as 'connective flow' by several authors.
Gap	While the smartphone has been recognized as a game-changing technology, theorizing about its use is in its infancy. From the neurological threats associated with technological over-stimulation from multiple 'screens' and fragmented attention (the myth of 'multitasking'), to toxic work cultures that threaten core social institutions of family and community, we understand smartphones to be both a blessing and a curse. The literature has extended socio-technical and sociomaterial theories to mobile technologies and these are generally applicable and helpful. But the literature does not delve into the micro-choices that present themselves in mobile technologies.
Method	The study was motivated by two main questions. First, how do smartphone users enact choice (exercise agency) to connect and disconnect in a mobile-enabled world. Second, how responses to these questions changed over time. **A qualitative single-site case study design**: By collecting data soon after the initial implementation of smartphones and then again 5 years later (following the global financial crisis), we were able to construct our study that provided the opportunity to examine how users' approaches to the technology had changed over time. This time lapse is recognized by Pettigrew (p. 273) as a 'social construction of time' where events make up our experience of change and create natural breaks in time. As Urbis emerged from the global financial crisis (GFC) in 2011 there was a sense that they were re-orienting into a new time period and thus it seemed like an appropriate stage to conduct the second round of research to enable the inclusion of both real-time and reflexive (hindsight) experiences of smartphone use.
Context	**A global financial services firm**
Conclusion	Participants generally associated positive attributes such as mobility, flexibility and enhanced connectivity to these handheld devices. However, while they recognized their right and need to moderate their connections with work, they experienced challenges in doing so: Smartphone users in the first round of interviews predominantly referred to their use of smartphones as a connective duality of switching the device 'on' and 'off'. Switching a mobile device on and off could be seen as part of the resistance normally associated with the adoption phase of technology implementation. In agency terms, this reflects Emirbayer and Mische's first and third variations in the triad of human agency, namely iterational (habits informed by the past) and practical-evaluative (demands and contingencies of the present). In the earlier phases of BlackBerry deployment within this financial services firm, users struggled with their new devices in conventional mindsets of 'leaving' work behind (as in leaving an office), even though they understood (and generally appreciated) the fact that these mobile devices were useful primarily because they allow users to 'take work with them'. Choices around early deployment of the BlackBerry seemed heavily constrained by pre-existing notions of work practices, or habits. Therefore, rather than enacting the technological capabilities of the BlackBerry to devise new ways of working, pre-existing patterns of work emerged in more exaggerated forms. The technology itself became synonymous with a lack of control over connectivity, and by extension with work itself. By contrast, during the second round of interviews, responses illustrated more of the practical-evaluative dimension of agency, whereby interviewees framed their choices to connect or disconnect as part of their routine day-to-day practice. In our first interviews, connecting was seen as an obligation of work, while disconnecting represented the enactment of personal boundaries. As such, disconnecting was characterized as a form of personal control and counter-balancing mechanism against the organizational norms of near-constant connectivity. Over time, however, as smartphones had become a common feature of day-to-day life, users found ways to enact connective choices, less as a reaction to oppressive work demands, and more as a practical, ongoing facet of contemporary life.
WIL	**Learning how to regulate and balance the work flow and where and when to set the boundaries by engaging with various affordances of technology.** Interviewees in the second round reported a more fluid approach to boundaries as they juggled work and nonwork more seamlessly, in part through their interaction with multiple mobile devices. Individuals had different approaches to prioritizing work, but work centrality appeared to be less about the need for boundaries and more about engaging with the technology to manage activities in ways that suited individualized needs. Disengaging with technology had not become an object of reacting to workflow. Rather than disengaging straightforwardly with technology, they had learned to have multiple phones for switching between work and non-work.

Notes: Work integrated learning: for me, WIL from as IS perpective includes all the learning point that the employees change of the way doing thing or develop what they had been doing so far into new verions of doing things, as well as attaching new meaning to what they have been doing so far, in order to overcome some work-related challange and improve their working life. In doing so, certain competences appear. In case, gaining control over working hours that had initially been disturbed (as mention by the interviewees) by th introduction of smartphone into work was a challenge. Work flow was overwhelming, and employees would feel obliged to respond to the expectation of being available all the time because because of the affordances blackberries were offering. As a respond, they would switch off their devices.As time had passed and they had engaged longer with technology, they had developed a certain skills: the skill of balancing work and personal life not by disengaging with technology, but by engaging with several smartphone that would still kep them connected with the world, but with that part of that world they wanted to engage with a particular time. In the first round, smartphone were just a part of previous pratices; work. In the second round, smart phones had led to a change in old pratices and the view of the employees towards smartphones

Figure 1.
Analysis tables and notes per article

we also wrote commentaries on articles that we thought did not present instances of workplace learning and why we thought so. Each researcher developed their own commentary independently, and once this round was complete, the notes were detached from the tables and were scrambled to be coded randomly by each researcher.

(2) *Coding the commentary*: The notes were coded with the aim of comparing researchers' personal understanding of the concept of workplace learning. As both authors have had considerable experience in *conducting* research in the field of workplace learning, we thought this strategy would help uncover their tacit understanding of the workplace learning research. In this step, we each closely read the notes independently aiming to find repeated thought patterns that would allow identifying themes we commonly associate with workplace learning. Each researcher found two sets of themes, labeled as "FOR Workplace Learning" and "NOT Workplace Learning." These two sets of codes were also compared. This way, we were able to both select themes that we commonly agreed on and then verify them by commonly agreeing on what was *not* considered to be workplace learning. In the end, three major themes were identified. These themes include: 1. change, 2. reflection and 3. deliberation.

(3) *Industrial verification*: As the review allowed for an indirect approach, that is, analyzing learning in cases where learning had not been directly in focus, we attempted to validate the findings through a more direct approach. The main reason for cross-checking the findings directly was that the first author had already conducted a three-year ethnographic fieldwork study at a Swedish automobile manufacturer. This gave us substantial contact and familiarity with the practitioners' work in an industrial context. While the previous fieldwork is not directly discussed in this paper, the aggregate data has provided indispensable contextual information for the focus of this paper. For example, through her prior research work, the first author was aware of the extensive change that was digitally transforming the work of the engineers. Similarly, the first *author* had observed feedback sessions where the engineers reflected on their work processes and their general progress at work. These sessions were called retrospective sessions in the dominant Agile software development processes. However, the first author's prior fieldwork had revealed that despite change and reflection being a consistent part of the engineers' everyday work, they had continuously reported dissatisfaction with their learning progress at work. Thus, although by analyzing the reviewed literature we understood "change" and "reflection" as important themes and constituent parts for learning, we were not quite sure if, how and when these constituent parts necessarily lead to learning.

Therefore, to make sense of the discrepancies found in the interpretation of the reviewed literature and the first-hand experience of the industrial practitioners, we interviewed the same group of engineers (six people) whose work the first author had followed for years. All the engineers were members of a development team whose industrial knowledge-intensive work included developing autonomous drive functionalities over the past four years. Although the number of interviews is modest, a sample of six interviews can be sufficient to develop "meaningful themes and useful interpretations" (Guest *et al.*, 2006, p. 78). This is especially the case when a homogeneous group of participants is selected purposively (Guest *et al.*, 2006).

(4) *Conducting the interviews:* We conducted behavioral event interviews (McClelland, 1973; Spencer and Spencer, 1993) which are used in competency/skill identification studies. Behavioral event interviews are widely *used* in competency identification studies (McClelland, 1973; Murawski and Bick, 2017) and are useful in identifying competencies/learning points by examining critical past events. This strategy is particularly relevant given our competence view of workplace learning which assumes learning as entangled in everyday practices and non-measurable through any particular performance (Fuller and Unwin, 2011).

We selected this team of automotive engineers, as their work was marked by extensive efforts to develop complex digital technologies, including digitizing a substantial amount of previously hardware-based components inside the car to develop autonomous drive functionalities. Their work would be emblematic of how industrial workplace learning is emerging when the industry is engaged with digital technologies on a large scale. As the team was working according to the Agile software manifesto, the team members' roles were not rigid. Rather these members would define work requirements, roles and processes among themselves in a bottom-up way. However, despite holding their niche expertise, team members worked based on learning and communicating expertise from and to each other. The team members were multi-cultural; however, they all had obtained educational degrees in Sweden and were close in previous experience and age. Through the first author's prior fieldwork study, in-depth familiarity and rapport was already established with this group of engineers.

In conducting the interviews, as it is often difficult for interviewees to self-evaluate in terms of what counts as learning, we asked them to describe one event where they felt they had learned something and one event where they felt they kept working without learning something considerably. This round of data collection resulted in approximately 270 min of audio-recorded interviews which were transcribed and coded subsequently. When we analyzed the interview material, the previously identified themes (change, reflection and deliberation) recurred. However, we also identified three new overarching themes: 1. Balancing newness; 2. Finding point of reference; and 3. Organizing actively.

It must be mentioned that in developing the commentary on the literature review and coding the commentary, we had followed an inductively oriented thematic analysis (Rapley, 2016; Braun and Clarke, 2006). In these two rounds of analysis, we performed two steps in thematic analysis that include *familiarizing* ourselves with the data and then *abstracting* the themes into more overarching themes (Rapley, 2016). In analyzing the interview data, we were initially open to all the themes that we could identify. However, we were also curious to understand how these themes would relate to the previously identified themes (change, reflection, and deliberation). Hence, in the later analysis of the interview data, we followed a more deductively oriented approach (Rapley, 2016; Braun and Clarke, 2006).

In the deductive analysis round, we intended to understand how change, reflection, and deliberation play out in the engineers' work context and how and why they relate to the newfound themes. To do so, we applied the *bracketing* technique which Lee (2017) describes as a way to avoid taking the interpretation of a statement for granted. In other words, bracketing refers to putting one's belief and the validity of one's interpretations into brackets to suspend what they already know and re-investigate their belief. This is where we asked ourselves, "if change is a constituent of learning, and if the engineers' work entails high degrees of change, then why are they dissatisfied with their learning process?" Figure 2 illustrates the iterative bracketing process through which we tried to bridge the three

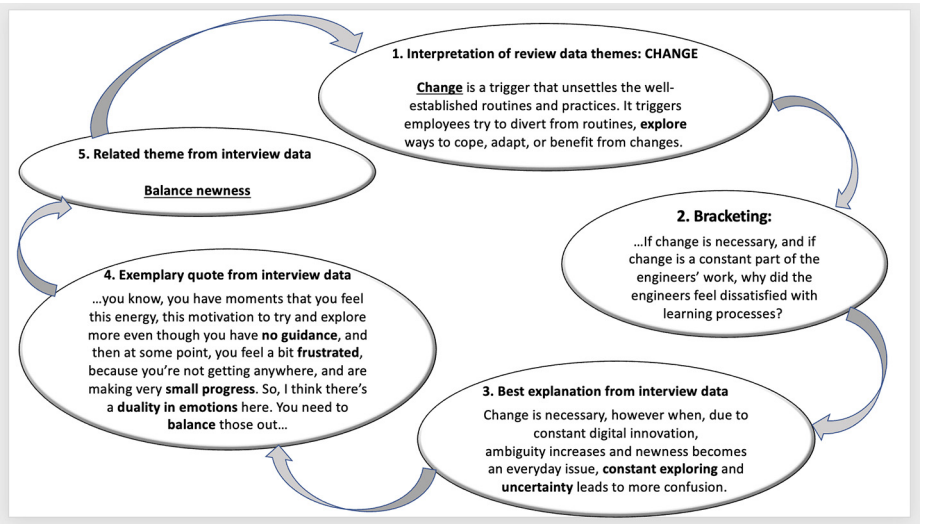

Figure 2.
Bracketing: bridging review and interview data

themes of change, reflection, and deliberation with the themes balancing newness, finding points of reference, and organize actively.

Through bracketing, we juxtaposed our interpretations of the review data with the data from the interviews on how change, reflection, and deliberation could lead to workplace learning. We eventually noticed that the ways through which change, reflection, and deliberation can lead to learning may vary in contexts where degrees of uncertainty and exploration is higher because of more extensive engagement with digital technologies (innovation). For instance, as illustrated in Figure 2, change can no longer lead to workplace learning by "triggering diversion from old routines" (finding based on review data). When change is a constant reality of everyday work (interview data), it can only be effective if, through some mechanisms, one can balance the uncertain and the unknown or, as the engineers put it, "balance the newness" (interview data). Bracketing allowed us to notice that *balancing newness*, *finding point of reference*, and *organizing actively* can be categorized under the previously identified themes of change, reflection, and deliberation. These themes explain *how*, *when*, and *why* change, reflection, and deliberation can be effective in learning in the context of the manufacturing industry with high degrees of digitalization. In other words, balancing newness, finding point of reference, and organizing actively can be understood as *mechanisms* through which change, reflection, and deliberation can lead to workplace learning in such contexts.

Results

As mentioned in the previous section, three workplace learning-related themes were developed that could assist us in achieving an initial conceptualization of industrial workplace learning. We present and exemplify these themes below by excerpts taken from the review commentaries as well as quotes selected from the interviews.

Change

As we reviewed the articles, we noticed that when some technology-related change emerges in the workplace, it is likely that the employees try to find ways to cope, adapt or benefit

from changes. That is, technological change unsettles the well-established routines and practices and can, therefore, trigger learning opportunities. The reviewed articles entailed ample example of how the implementation of technologies at workplace created significant changes in the practice of the employees. One of the early examples refers to an article that discussed the changes of work practices because of introducing smartphones for a more immediate and smooth communication at work. Smartphones facilitated instant communication and longer accessibility of the employees which in turn disturbs the limits of working hours. As the employees try different ways to solve the problem, they realize that the meaning of communication and working hours is changing because of the introduction of technologies and that balancing work and life is turning into a new *skill* that they need to seriously think about:

> Here, employees change their practice or *attach new meanings* to well-established practices to *improve their working life*. In doing so, certain competences appear. At first, they try to gain *control of their workload* by ignoring their ever-present smartphones. As the strategy does not work, they change their way; rather than trying to eliminate the smartphones, they introduce two smartphones; one for work, one for life outside work. By *developing a certain skill – the skill of balancing* work and personal life – smartphones are *no longer associated merely with work*. Rather, smartphones are employed to connect the employees to the intended part of life *on and off*.

In the interviews, as well, change or newness emerged as a manifest example of opportunities for learning. The learning opportunities seemed to be even intensified for the engineers as developing autonomous driving functionalities entails high degrees of digital innovation (e.g. developing new products and services through cloud communication and connection possibilities). With the increasing research and development projects, the work of the engineers relies majorly on new practices and collaborations. The engineers mentioned that rather than an occasional incident, change and newness was a constant situation at work. However, they emphasized that, dealing with constant newness and rapid changes often could lead to frustration in terms of learning. As they explained, engaging in (digital) innovation implied that opportunities for exploiting and benefitting from established knowledge areas become narrow, and engineers are often required to explore new solutions on their own. Constant newness and lack of guidance, thus, can create obstacles when it comes to workplace learning:

> There are kind of mixed feelings around it [learning triggered by change], you know, you have moments that you feel this energy, this motivation to try and explore more even though you have *no guidance*, and then at some point, you feel a bit frustrated, because you're not getting anywhere, and are making very *small progress*. So, I think there's a *duality in emotions* here. You need to balance those out [. . .] Because after a while, if I mean, if people keep being *pushed in one direction* for too long, the bad starts to overcome the good, you know [. . .] if you think about engineering [. . .] we are just *learning new things every day. There's so much that we're still discovering every year*. So, I think, it is on a different level than those professions that handle very *well-defined environments* [. . .]

The downsides of dealing with constant newness and change become highlighted once we consider reflection, that is, the next important theme in relation to workplace learning. As explained in the next section, reflecting on what and how we have always done something is vital for developing one's knowledge and skill. However, with the speed of change and diminishing of established practices, there is little time for reflection.

Reflection

This theme referred to some level of reflection or evaluation of how work was being performed and whether it was the optimal way to continue working. The commentary

excerpt below was written on an article on service co-creation where the authors had adopted an action research methodology. They had consequently been reflective both on the way the work was practiced for offering plausible designs and on their own research methods and phases to guarantee a credible design. This constant reflection meant that the researchers as well as the study participants had to repeatedly negotiate and learn from their mistakes to understand how practices could be accommodated in design. With its extensive reflective approach, this article was a vivid example of extensive workplace learning both for the employees and the action design researchers:

> The research/work in this paper assumes a completely *reflective and evaluative* air from the very beginning. The goal is to consciously experiment and evaluate ways for service development. The researchers/coaches *comment* meticulously on the ways they had conducted the work/research; on whether it's been successful or not; and on what could possibly be a relevant explanation for the success/failure of the methods applied [. . .]. Therefore, the paper with its "meta-processing" approach towards *experimenting*, developing, and *evaluating* applicable work practices is a vivid example of learning through *iterations* and *consideration*.

For the engineers too, iterative processes and methodologies entailed substantial learning opportunities. However, the engineers explained that their development projects entailed high degrees of innovation where past experiences and well-established routines are de-emphasized. They commented that lack of established routines and past criteria posed a real challenge for making sure that they were developing the relevant technical competences. Apart from the diminishing well-established paths, the increasing speed of change from one project requirement to another did not leave the engineers with enough time for reflection on past experiences. This was frustrating to the point that the engineers believed delivering project requirements is not the same thing as learning, as it would not add to the depth of their knowledge:

> The term, *technical depth*, if you know about it, you focus a lot to solve the problem, and in the end a lot of things are just hanging there, because you're taking a lot of shortcuts to solve the problem, and these are not really acknowledged at the end of the project, *you just jump to the next project* and it's really *overwhelming* if you *never get to stop and sort them out*.

As the speed of change and number of R&D projects with different development requirements and working dynamics increased, the engineers felt they needed *points of reference* that would help them reflect on their work more *immediately* and *in situ* rather than *in retrospect*. They mentioned that, rather than reflecting on "How are past things still relevant," they needed to reflect on "How is what we they are doing now relevant in a larger context." The engineers, for instance, mentioned how industry standards and protocols or working with more experienced people in their teams provided them with more immediate points of reference to reflect on their work *in situ* and at short intervals. As protocols and industry standards provide ways to compare and evaluate the technical processes through several iterations, following them provided a sense of compatibility with what one needs to know about the industry, thereby a feeling of personal growth and learning:

> [When you work with industry standards and protocols] the feeling is like that *you are not being left behind*. Because you don't want to be in *your own universe* where you think you're working in a very good way and then in a future circumstance when you need to, for example, change companies, suddenly, you have this shock [. . .] then there is this confidence or a feeling that now, *my personal skills are also going to improve*, and *I won't be in my own world* or universe so to speak.

Lack of time and the increasing speed of change in project requirements and work practices are not only problematic for the ability to reflect on work, but as the next section explains, they also challenge the possibility to deliberately plan and coordinate learning paths.

Deliberation

This theme refers to developing a deeper and fundamental understanding of how and why things happen the way they do and how and why change needs to happen. This theme was particularly important, as we noticed that sometimes change can occur over time without employees having actively and consciously formed a deeper understanding about the changes in their practice. Thus, although some sort of learning might occur in adapting to the emerging situation, yet no substantial learning opportunities are provided without deliberation. The example below shows how in dealing with technology, changes occur over time and without any in-depth consideration of the course of events:

> This paper cannot be an example of workplace "learning" as its major part illustrates how focusing on the characteristics of IT artifacts would *essentially* lead to the development of new theoretical perspectives. *Over time*, *necessity* causes *change in the employees' understanding* of their organizational contexts, and in the *organizational control over how practices need to be arranged.* [. . .] The account of incidents are as they occur during the natural flow of work. No tensions are lifted and discussed in a way as to *consciously overcome problems* and *plan a change* in the way things are being done.

When analyzing the articles, we noticed that, although deliberation requires some form of reflection to lead to the development of a deep and fundamental understanding, it is not necessarily the same as reflection. Unlike reflection that usually occurs on more immediate issues, deliberation entails a longer and more careful consideration of that paths taken. The engineers, too, saw this long and careful consideration of the situation as something that exceeds the immediate evaluation or reflection on a situation at hand. While reflection might produce insights in the mind of the observer to cope with the flow of the things as they happen, it does not necessarily result in a deliberate planning of the longer path one needs to take. For engineers too, deliberation required a long brooding over how things have or might turn up in practice:

> You [should] constantly uncover new methods, new ways of doing things, but you wouldn't be able to do so if you just focus *on what and how to do things now* [. . .] so, for me, it is knowing someone's experience, seeing how they actually use that knowledge in practice, seeing what is really relevant in practice [that constitutes a substantial learning opportunity].

For the engineers, however, the speed of change in project requirements, collaboration needs and team structures created challenges for forming a deeper understanding of the situation. According to the lead engineer, with over ten years of experience in the industry in various countries, such careful consideration and intentionality needed to unfold in the attentive organization of learning opportunities. However, actively organizing mindful approaches to learning required substantial amounts of time for deliberation and exchange of ideas. When asked to elaborate on an event which he had experienced as a great learning opportunity, the lead engineer adamantly lamented the lack of such opportunity at his current workplace. The lead engineer believed that the last learning opportunities he could remember had taken place in his prior workplaces years ago. According to the engineer, the centerpiece of all those substantial learning experiences was careful deliberation and organizing of the learning process:

> The difference was, we really had this *streamlined approach of training for each and every individual*. So, we had this *competence matrix*, and then guys from us would review each and every line we'd written in the software, we had very strict controls, because they wanted to teach us. *And then there was a very careful approach towards increasing the competence* because they really wanted to see the India office delivering something on our own, which we did in a few years [. . .] *just because of the processes my manager put in at that time*.

Thus, deliberation is not merely a longer or deeper form of reflection and evaluation of the situation. It is the formation of a deeper understanding about the direction of things which is then translated into the way learning approaches are organized actively with respect to the work conditions. However, as the engineers explained, fluid work conditions can potentially compromise deliberation, as the subject of deliberation is constantly shifting. Actively organizing learning approaches step by step, for instance, would be more challenging when team structures, and therefore, levels of expertise and combination of knowledge areas change form project to project.

Discussion

We have identified three major themes of workplace learning in the context of industry: change, reflection, and deliberation. Through the analysis of articles as well as in-depth interviews, we found that responding to technological change corresponds to the prime trigger of learning occasions. Industry 4.0, the fourth industrial revolution, incorporates the latest technologies to boost production, offer novel functions, and remarkably improve prices (Yoo *et al.*, 2010). Ubiquitous digital technologies with their affordances to provide extensive connectivity have the possibility to transform the design, production, and distribution of industrial products in shorter cycles. These technologies, thus, call for a faster rhythm of reskilling as well as life-long occupational competence development (Flores *et al.*, 2020). Both the reviewed articles and the engineers discussed extensively how the continuous changes brought by technology exposed them to the need to explore new things constantly.

In the midst of this, reflecting on what has changed and what courses of action need to target those changes seemed to be extremely consequential. For instance, assuming that being exposed to change would necessarily push the engineers to explore new ways and, thus, improve their knowledge led to feelings of frustration or disgruntlement (Reardon, 2010). Four of the six engineers whom we interviewed were about to leave the company at the time of the interviews. On most occasions, the engineers mentioned that they were left to their own agency and willingness to learn. Similarly, the extant literature on occupational learning either emphasizes the importance of individual agency or the importance of contextual factors and, thus, fails to understand how professional development is linked to the jobs the employees are responsible for (Emiliani, 1998; Migliore, 2015).

The engineers believed that the company had once detected the type of change it needed to go through; however, it had failed to continuously and iteratively understand how those changes affect the engineers' day-to-day practices. Being left to their own devices, and in the face of fast-changing work conditions, the engineers lacked the necessary time and tools to reflect on their work in retrospect, and develop deeper technical skills. In the absence of retrospective reflection, they mentioned that, working with more experienced people, or with technical protocols and industry standards would have provided them with more immediate checkpoints to reflect on their work on-the-go. However, without these immediate reference points in most of their prior projects, the engineers had experienced unnecessary loss of time and trial-and-error rounds. Their learning, thus, could be considered defensive and regressive rather than skill-oriented and progressive (Stroud and Fairbrother, 2008). Working with protocols and standards had instead become the *reference points* which reassured the engineers that their actions were in accord with the expected expertise in the industry anywhere outside their current workplace. Hence, the protocols and industry standards were mentioned as checkpoints that equipped the engineers with immediate reflection tools to evaluate their actions in shorter intervals.

While reflection includes thinking about what we say or do and evaluating the outcome or possible outcomes for a brief period of time (Emiliani, 1998), deliberation appears to be a

more methodical process. Deliberation, as our results show, consists of what Emiliani (1998) considered to be a more "labored and detailed" analysis process during the course of a longer time to formulate a particular understanding (p. 31). While successful reflection can uncover useful lessons learned and, thus, provide direction (Emiliani, 1998) for the present issues, our results indicate that it does not necessarily lead to the formation of a fundamental understanding of how learning should be planned and executed. Rather than a one-time reflection, deliberation entails a series of reflections and combined with intentionality, as well as focused and streamlined approaches to respond to change. Unlike the protocols and industry standards which provide checkpoints for the prevalent tasks, as the lead engineer exemplified, a substantial competence development is the result of a streamlined and organized approach to build and increase competence step-by-step. The constituent parts of learning and their indicators are summarized in Table 2.

Although each and every constituent part of learning in this study is consequential, our analysis proposes that without deliberation, change or even reflection provide only regressive forms of learning at best. That is, in the absence of mindful and coordinated approaches, learning becomes principally a matter of meeting narrowly focused and immediate workplace-related needs and situated problems (Stroud and Fairbrother, 2008). Based on these constituents, we propose the following conceptualization for workplace learning, keeping a manufacturing context in mind:

> Workplace learning constitutes the formation of a fundamental understanding of change through iterative reflections and a mindful approach to react to its consequences.

Table 2.
Attributes qualifying an article as an example of workplace learning

Themes	WPL	Not WPL
Change	• Actively find ways for auditing mistakes and changing the results • Prompt new kinds of knowledge transfer • Deal with problems beyond those initially identified • Develop certain skills because of change/ challenge	• Practices emerge over time as users engage with the IT artifacts • No discussion of tensions or challenges created by change are presented
Reflection	• Operational knowledge vs diagnostic knowledge • Knowledge brokers turn into knowledge blockers if direct access to knowledge is blocked • Compare your practice and your priorities with that of others • Prioritize the essentials to be accommodating towards those of others • Compare what goes on at the company with industry standards	• Lack of an understanding of why a practice was needed • How employees take advantage of the IT artifact to do what they are expected, and no assessment is included
Deliberation	• Bring about attitude and belief in the staff • Actively make the implicit aspects explicit • Negotiate a common ground • Identify what you think you can compromise • Arrange and mobilize stages of improvement	• No conscious overcoming of problems or making a change in the way things are being done • Over time, necessity causes change in the understanding of employees • The change in understanding is a result of passing time and not an active approach

Theoretical implications

Multiple recent and comprehensive models have presented holistic views and categories for the required workplace competences and learning paths. However, these views and categories are often generalized and lack information on how the categories relate to each other (Flores *et al.*, 2020). For instance, the identified themes such as change or reflection are mentioned in several well-received models of learning such as the adaptive and developmental learning model by Ellström (2011) or sequence of learning actions in an expansive learning cycle (Engeström, 2011). What is missing, however, is the way change and reflection are interrelated in contexts that are not marked by well-defined objectives and processes. An example is how Ellström's (2011) model separates adaptive learning from developmental learning and maintains that adaptive learning at work occurs when employees perform routine-based actions and developmental learning occurs when, upon the emergence of a problem, employees deviate from the routine-based actions and engage in reflective actions while questioning the old ways. Although Ellström justly points out that, in reality, the well-separated categories of action and learning are fuzzier than the model shows, adaptive learning and developmental learning remain essentially separate categories of learning built upon separate categories of action.

The results of this study, however, show that developmental learning cannot be so neatly separated from adaptive learning. In fact, lack of routines and well-defined processes had created serious impediments in the engineers' learning process. In other words, the study results show that rather than being separate categories of learning, adaptive learning constitutes developmental learning. The objective of this study, however, is not to dispute the validity of the categorical learning models. On the contrary, our literature review exemplifies the validity of these categories on a general level once more. It is based on the insights provided by these models that we argue for the importance of theorizing the relationship among these well-established categories for the specific conditions that govern the manufacturing context.

For instance, this study proposes that given the characteristics of the manufacturing industry and its digitalization, change, reflection, and deliberation result in developmental learning under certain circumstances and through certain mechanisms. These categories and their relationship are presented in Figure 2. As the figure illustrates, although our literature review revealed change as an important trigger of learning, the engineers made us aware of the paradox of continuous newness inherent in their industrial sector. The need to balance the constant newness in their work pushed them to seek re-assurance in more experienced people or in structured ways of working present in industry standards and protocols (Figure 3).

That is, the constant changes in the manufacturing industry create the need "to balance newness." This need, in turn, impels the engineers to seek "points of reference" to iteratively

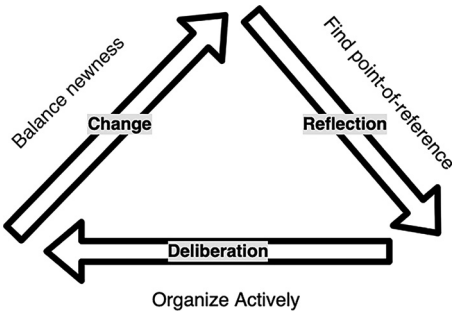

Figure 3.
Mechanisms of progressive learning

reflect on the appropriateness of the technical processes. Finally, the need to identify points of reference continuously and iteratively requires suspending the individuals' subjectivity and agency (Emiliani, 1998) and organizing streamlined approaches towards competence development. In other words, the prevalent reliance on subjectivity and individual agency in the workplace learning literature (Migliore, 2015) needs to be balanced by external and streamlined approaches. However, the mere existence of formal/informal learning opportunities is no longer an adequate factor for learning. Instead, providing learning services should be replaced by organizing learning stages accumulatively (Stroud and Fairbrother, 2008; Rangraz and Pareto, 2020). Hence, while change, reflection, and deliberation are the constituent parts of workplace learning, we argue that "balancing newness," "finding points of reference", and "active organizing" of cumulative learning are the mechanisms of progressive learning (Figure 2).

These mechanisms extend the literature on workplace learning beyond a categorical model of learning and illustrate the mechanisms through which such constituents play a role in learning in contexts that are defined by high degrees of innovation and volatility. As explained in the next section, focusing on learning mechanisms, rather than learning categories, highlights that although the identified categories of learning are already well-established and recur in different contexts, their meanings and implications change in specific learning circumstances.

Implications for practice

With the informatization of the manufacturing industry, and the increasing digital innovation in products and services, the number of R&D projects is increasing. The model of organizations is shifting from production firms to development firms with very different logics and strategies for learning. This is important because the decision to allocate resources to workplace learning is highly related to management's view of what is desirable in terms of supporting the firm's operational model (Ellström, 2011). For instance, learning in production organizations is based on exploiting the existing knowledge areas and making sure that the employees adapt to the best practices and established ways of doing things that lead to optimized production. Development organizations, on the other hand, promote learning activities that are based on exploring new areas to afford new possibilities and opportunities for ongoing development (Ellström, 2011).

This is problematic, as learning for employees happens as a result of a balance between these two types of learning. Adaptive learning happens when employees adopt the established best practices, while developmental learning happens when a problem occurs, and employees reflect on the old ways to find a new way to solve the problem. However, with digital innovation, ongoing novelty finds primacy to ongoing continuity, change becomes a constant, routines and established way of doing things diminish, fluidity in internal and external collaboration increases, the structure of teams becomes fluid, and there is little time to think, observe, and exchange ideas to form deliberate learning plans.

Thus, adaptive learning on top of which developmental learning can be offered shrinks. Change is no longer a trigger for learning; it is the new everyday routine that clashes with the way learning occurs. Once the past and established practices shrink and innovation and the speed of internal and external collaboration increases, there is little time to reflect on past practices in retrospect. Reflection becomes a matter of finding immediate reference points that quickly review what is being done at the moment. Finally, deliberately designing learning activities to offer opportunities for competence development relies so much on the values that are remote in time and, therefore, less definitive. This is hard to cope with depending on the employees' years of experience and position (Ellström, 2011). Apart from the remote values and lack of time, the constantly changing structures of the teams affect

the team members' relationship and trust which are key in planning feasible workplace learning plans (Eraut, 2011). In summary, the mechanisms through which change, reflection, and deliberation can be effective elements in workplace learning transforms with the increasing digitalization of the manufacturing industry. The significance of capturing this transformation is that workplace learning should be understood with respect to not only the conditions of the manufacturing industry but also its *temporal* conditions. That is, with the speed of change brought by increasing digitalization of the industry, learning approaches need to be evaluated and revised in shorter intervals.

However, our study is limited in the context of the reviewed literature. We merely selected the IS literature to establish an initial picture of how learning is addressed in the manufacturing workplace. We did so, as we believed that the IS literature with its focus on digital technologies in the workplace provides a closer picture of the characteristics of the manufacturing industry today. Future research can focus on other contextual specifications and extend this review to the research domains that more closely represent those specifications. We hope that this type of research contributes to the work environments where sustainable employability is valued through the active *organization* of learning opportunities. Industrial managers can arguably benefit from practical learning models that:

- are developed with exclusive attention to the specific conditions of the industry; and
- provide guidance by summarizing not only categories but also overarching mechanisms through which workplace learning objectives can be realized.

References

Baase, S. (2013), *A Gift of Fire: Social, Legal, and Ethical Issues for Computing Technology*, Pearson.

Billett, S. (2014), "Learning in the circumstances of practice", *International Journal of Lifelong Education*, Vol. 33 No. 5, pp. 674-693.

Blayone, T.J. and VanOostveen, R. (2021), "Prepared for work in industry 4.0? Modelling the target activity system and five dimensions of worker readiness", *International Journal of Computer Integrated Manufacturing*, Vol. 34 No. 1, pp. 1-19.

Boell, S.K. and Cecez-Kecmanovic, D. (2014), "A hermeneutic approach for conducting literature reviews and literature searches", *Communications of the Association for Information Systems*, Vol. 34 No. 1, pp. 256-287.

Bratton, J., Helms Mills, J., Pyrch, T. and Sawchuk, P. (2004), *Workplace Learning: A Critical Introduction*, Garamond Press, Toronto.

Braun, V. and Clarke, V. (2006), "Using thematic analysis in psychology", *Qualitative Research in Psychology*, Vol. 3 No. 2, pp. 77-101.

Brynjolfsson, E. and McAfee, A. (2016), *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*, WW Norton and Company.

Coetzer, A. (2007), "Employee perceptions of their workplaces as learning environments", *Journal of Workplace Learning*, Vol. 19 No. 7, pp. 417-434.

Duval-Couetil, N. and Mikulecky, L. (2011), "Immigrants, english, and the workplace: evaluating employer demand for language education in manufacturing companies", *Journal of Workplace Learning*, Vol. 23 No. 3, pp. 209-223.

Ellström, P.E. (2011), "Informal learning at work: conditions, processes and logics", in Malloch, M., Evans, L.C.K. and O'Connor, B.N. (Eds), *The Sage Handbook of Workplace Learning*, SAGE Publications, London, pp. 105-119.

Emiliani, M.L. (1998), "Continuous personal improvement", *Journal of Workplace Learning*, Vol. 10 No. 1, pp. 29-38.

Engeström, Y. (2011), "Activity theory and learning at work", in Malloch, M., Evans, L.C.K. and O'Connor, B.N. (Eds), *The Sage Handbook of Workplace Learning*, SAGE Publications, London, pp. 86-105.

Eraut, M. (2011), "How researching learning at work can lead to tools for enhancing learning", in Malloch, M., Evans, L.C.K. and O'Connor, B.N. (Eds), *The Sage Handbook of Workplace Learning*, SAGE Publications, London, pp. 181-197.

European Commission (2021), "Digital skills and jobs coalition", available at: https://digital-skills-jobs.europa.eu/en/about/digital-skills-and-jobs-coalition

Flores, E., Xu, X. and Lu, Y. (2020), "Human capital 4.0: a workforce competence typology for industry 4.0", *Journal of Manufacturing Technology Management*, Vol. 31 No. 4, pp. 687-703.

Fuller, A. and Unwin, L. (2011), "Workplace learning and the organization", in Malloch, M., Evans, L.C.K. and O'Connor, B.N. (Eds), *The Sage Handbook of Workplace Learning*, SAGE Publications, London, pp. 46-59.

Guest, G., Bunce, A. and Johnson, L. (2006), "How many interviews are enough? An experiment with data saturation and variability", *Field Methods*, Vol. 18 No. 1, pp. 59-82.

Illeris, K. (2011), "Workplaces and learning", in Malloch, M., Evans, L.C.K., & O'Connor, B.N. (Eds), *The Sage Handbook of Workplace Learning*, SAGE Publications, London, pp. 32-46.

Jalonen, M., Ristimäki, P., Toiviainen, H., Pulkkis, A. and Lohtander, M. (2016), "Between product development and mass production: tensions as triggers for concept-level learning", *Journal of Workplace Learning*, Vol. 28 No. 1, pp. 33-48.

Keen, P.G. (1980), "MS research: reference disciplines and a cumulative tradition", *Procs. Of the First International Conference on Information Systems*, Philadelphia PA, pp. 9-18.

Lee, A.S. (2017), "Philosophy and method: making interpretive research interpretive", in Galliers, R.D. and Stein M. (Eds), *The Routledge Companion to Management Information Systems*, Routledge, London, pp. 30-46.

Leonardi, P.M. (2015), "Studying work practices in organizations: theoretical considerations and empirical guidelines", *Annals of the International Communication Association*, Vol. 39 No. 1, pp. 235-273.

Liao, Y., Deschamps, F., Loures, E.D.F.R. and Ramos, L.F.P. (2017), "Past, present and future of industry 4.0-a systematic literature review and research agenda proposal", *International Journal of Production Research*, Vol. 55 No. 12, pp. 3609-3629.

McClelland, D.C. (1973), "Testing for competence rather than intelligence", *American Psychologist*, Vol. 28 No. 1, pp. 1-14.

McKenzie, J. (2002), *Perform or Else: From Discipline to Performance*, Routledge, London.

Marsick, V.J. and Watkins, K.E. (2003), "Demonstrating the value of an organization's learning culture: the dimensions of the learning organization questionnaire", *Advances in Developing Human Resources*, Vol. 5, pp. 132-51.

Migliore, M.G. (2015), "Older workers' workplace learning in manufacturing industries: subjectivity", *Journal of Workplace Learning*, Vol. 27 No. 8, pp. 583-595.

Murawski, M. and Bick, M. (2017), "Digital competences of the workforce – a research topic?", *Business Process Management Journal*, Vol. 23 No. 3, pp. 721-734.

OECD (2019), *Transformative Competencies Concept Note. Transformative Competencies for 2030*, OECD, Paris.

Oztemel, E. and Gursev, S. (2020), "Literature review of industry 4.0 and related technologies", *Journal of Intelligent Manufacturing*, Vol. 31 No. 1, pp. 127-182.

Pickering, A. (2001), "Practice and posthumanism: social theory and a history of agency", in Schatzki, T.R., Knorr-Cetina, K. and von Savigny, E. (Eds), *The Practice Turn in Contemporary Theory*, Routledge, London, pp. 163-174.

Rangraz, M. and Pareto, L. (2020), "Workplace work-integrated learning: supporting industry 4.0 transformation for small manufacturing plants by reskilling staff", *International Journal of Lifelong Education*, Vol. 40 No. 1, pp. 1-18.

Rapley, T. (2016), "Twenty some pragmatics of qualitative data analysis", in Silverman, D. (Ed.), *Qualitative Research*, SAGE, pp. 30-46.

Reardon, R.F. (2010), "The impact of learning culture on worker response to new technology", *Journal of Workplace Learning*, Vol. 22 No. 4, pp. 201-211.

Sandberg, J. and Pinnington, A.H. (2009), "Professional competence as ways of being: an existential ontological perspective", *Journal of Management Studies*, Vol. 46 No. 7, pp. 1138-1170.

Sandberg, J., Rouleau, L., Langley, A. and Tsoukas, H. (2017), *Skillful Performance: Enacting Capabilities, Knowledge, Competence, and Expertise in Organizations*, Oxford University Press.

Schmiede, R. and Will-Zocholl, M.C. (2011), "Engineers' work on the move: challenges in automobile engineering in a globalized world", *Engineering Studies*, Vol. 3 No. 2, pp. 101-121.

Segal, M. (2018), "How automation is changing work", *Nature*, Vol. 563 No. 7733, pp. 132-135.

Shamim, S., Cang, S., Yu, H. and Li, Y. (2016), "Management approaches for industry 4.0: a human resource management perspective", in *2016 IEEE Congress on Evolutionary Computation (CEC)*, IEEE, pp. 5309-5316.

Smith, E., Smith, A. and Selby Smith, C. (2010), "Old dogs, new tricks: training mature-aged manufacturing workers", *Journal of Workplace Learning*, Vol. 22 No. 5, pp. 277-291.

Spencer, L.M. and Spencer, S.M. (1993), *Competence at Work: Models for Superior Performance*, John Wiley and Sons, New York, NY.

Stroud, S. and Fairbrother, P. (2008), "Workplace learning: a trade union failure to service needs", *Journal of Workplace Learning*, Vol. 20 No. 1, pp. 6-20.

Susskind, R.E. and Susskind, D. (2015), *The Future of the Professions: How Technology Will Transform the Work of Human Experts*, Oxford University Press.

Tilson, D., Lyytinen, K. and Sørensen, C. (2010), "Research commentary – digital infrastructures: the missing is research agenda", *Information Systems Research*, Vol. 21 No. 4, pp. 748-759.

Vessey, I., Ramesh, V. and Glass, R.L. (2002), "Research in information systems: an empirical study of diversity in the discipline and its journals", *Journal of Management Information Systems*, Vol. 19 No. 2, pp. 129-174.

Wade, M. and Hulland, J. (2004), "The resource-based view and information systems research: review, extension, and suggestions for future research", *MIS Quarterly*, Vol. 28 No. 1, pp. 107-142.

Wallo, A., Kock, H., Reineholm, C. and Ellström, P.E. (2021), "How do managers promote workplace learning? Learning-oriented leadership in daily work", *Journal of Workplace Learning*, Vol. 34 No. 1, available at: https://doi-org.ezproxy.server.hv.se/10.1108/JWL-11-2020-0176

Webster, J. and Watson, R.T. (2002), "Analyzing the past to prepare for the future: writing a literature review", *MIS Quarterly*, Vol. 26 No. 2, pp. 13-23.

Winter, S., Berente, N., Howison, J. and Butler, B. (2014), "Beyond the organizational 'container': conceptualizing 21st century sociotechnical work", *Information and Organization*, Vol. 24 No. 4, pp. 250-269.

World Economic Forum (2018), "The future of jobs report", available at: www.cdi.org.pe/pdf/IGC/2018/The_Global_Competitiveness_Report_2018.pdf

Yoo, Y., Henfridsson, O. and Lyytinen, K. (2010), "Research commentary – the new organizing logic of digital innovation: an agenda for information systems research", *Information Systems Research*, Vol. 21 No. 4, pp. 724-735.

Further reading

Clarke, R. and Davison, R.M. (2020), "Through whose eyes? The critical concept of researcher perspective", *Journal of the Association for Information Systems*, Vol. 21 No. 2, pp. 483-501.

Lee, A.S. (2001), "MIS quarterly's editorial policies and practices", *MIS Quarterly*, Vol. 25 No. 1, pp. 3-7.

Rowe, F. (2014), "What literature review is not: diversity, boundaries and recommendations", *European Journal of Information Systems*, Vol. 23 No. 3, pp. 241-255.

Van der Heijden, B.I.J.M., Gorgievski, M.J. and De Lange, A.H. (2016), "Learning at the workplace and sustainable employability: a multi-source model moderated by age", *European Journal of Work and Organizational Psychology*, Vol. 25 No. 1, pp. 13-30.

Appendix

Almklov, P.G., Østerlie, T. and Haavik, T.K. (2014), "Situated with infrastructures: interactivity and entanglement in sensor data interpretation", *Journal of the Association of Information Systems*, Vol. 15 No. 5 (SPEC. ISSUE), pp. 263-286.

Baptista, J., Newell, S. and Currie, W. (2010), "Paradoxical effects of institutionalization on the strategic awareness of technology in organizations", *Journal of Strategic Information Systems*, Vol. 19 No. 3, p. 171183.

Davis, C.J. and Hufnagel, E.M. (2007), "Through the eyes of experts: a socio-cognitive perspective on the automation of fingerprint work", *MIS Quarterly: Management Information Systems*, Vol. 31 No. 4, pp. 681-703.

De Albuquerque, J.P. and Christ, M. (2015). "The tension between business process modelling and flexibility: revealing multiple dimensions with a sociomaterial approach". *Journal of Strategic Information Systems*, Vol. 24 No. 3, pp. 189-202.

Dery, K., Kolb, D. and Maccormick, J. (2014), "Working with connective flow: how smartphone use is evolving in practice", *European Journal of Information Systems*, Vol. 23 No. 5, pp. 558-570.

Hsu, C.W. (2009), "Frame misalignment: interpreting the implementation of information systems security certification in an organization", *European Journal of Information Systems*, Vol. 18 No. 2, pp. 140-150.

Hu, Q., Hart, P. and Cooke, D. (2007), "The role of external and internal influences on information systems security – a neo-institutional perspective", *Journal of Strategic Information Systems*, Vol. 16 No. 2, pp. 153-172.

Leonardi, P.M. and Bailey, D.E. (2008), "Transformational technologies and the creation of new work practices: making implicit knowledge explicit in task-based offshoring", *MIS Quarterly: Management Information Systems*, Vol. 32 No. 2, pp. 411-436.

Lindgren, R., Andersson, M. and Henfridsson, O. (2008), "Multi-contextuality in boundary-spanning practices", *Information Systems Journal*, Vol. 18 No. 6, pp. 641-661.

Maruping, L.M. and Magni, M. (2015), "Motivating employees to explore collaboration technology in team contexts". *MIS Quarterly: Management Information Systems*, Vol. 39 No.1, pp. 1-16.

Monteiro, E. and Rolland, K.H. (2012), "Trans-situated use of integrated information systems", *European Journal of Information Systems*, Vol. 21 No. 6, pp. 608-620.

Oshri, I., Henfridsson, O. and Kotlarsky, J. (2018), "Re-representation as work design in outsourcing: a semiotic view", *MIS Quarterly: Management Information Systems*, Vol. 42 No. 1, pp. 1-23.

Pawlowski, SD, Robey, D. (2004), "Bridging user organizations: knowledge brokering and the work of information technology professionals", *MIS Quarterly: Management Information Systems*, Vol. 28 No. 4, pp. 645-672.

Sarker, S. and Sahay, S. (2004), "Implications of space and time for distributed work: an interpretive study of US-Norwegian systems development teams", *European Journal of Information Systems*, Vol. 13 No. 1, pp. 3-20.

Schultze, U. and Boland Jr., R.J. (2000), "Knowledge management technology and the reproduction of knowledge work practices", *Journal of Strategic Information Systems*, Vol. 9 Nos 2/3, pp. 193-212.

Stein, M.-K., Newell, S., Wagner, E.L. and Galliers, R.D. (2015), "Coping with information technology: mixed emotions, vacillation, and nonconforming use patterns", *MIS Quarterly: Management Information Systems*, Vol. 39 No. 2, pp. 367-392.

Subramaniam, N., Nandhakumar, J. and Baptista John, J. (2013), "Exploring social network interactions in enterprise systems: the role of virtual co-presence", *Information Systems Journal*, Vol. 23 No. 6, p. 475499.

Wagner, E.L., Newell, S. and Piccoli, G. (2010), "Understanding project survival in an ES environment: a sociomaterial practice perspective", *Journal of the Association of Information Systems*, Vol. 11 No. 5, pp. 276-297.

Wales, R.C., Shalin, V.L. and Bass, D.S. (2007), "Requesting distant robotic action: An ontology for naming and action identification for planning on the Mars Exploration Rover Mission", *Journal of the Association of Information Systems*, Vol. 8 No. 2, pp. 75-104.

Watson-Manheim, M.B., Chudoba, K.M., and Crowston, K. (2012), "Perceived discontinuities and constructed continuities in virtual work", *Information Systems Journal*, Vol. 22 No. 1, pp. 29-52.

Corresponding author
Charlotte A. Shahlaei can be contacted at: charlotte.arghavan-shahlaei@hh.se