Professional and Practice-based Learning

Christian Harteis *Editor*

The Impact of Digitalization in the Workplace

An Educational View

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Professional and Practice-based Learning

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- analytical explications of those processes that support learning at an individual and an organisational level.
- understanding how learning experiences and educational processes might best be aligned or integrated to support professional learning.

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Christian Harteis
Editor

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Editor
Christian Harteis
Institute of Educational Science
University of Paderborn
Paderborn, NRW, Germany

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Series Editors' Foreword

A major goal of this book series is to provide contributions to the debate on learning in the context of daily work. Workplaces provide tasks, resources and barriers that all may have effects on the learning and development of the persons who participate in these workplaces. This volume focuses on the digitalization of work – a mega-trend of societal development – and its contributions discuss issues about how changes in workplace environments influence workers and employees from an educational perspective.

The digitalization of work does not only mean supporting production processes through computer technology but also refers to the implementation of cyber-physical systems that autonomously communicate with machines, humans and other cyber-physical systems (i.e. Internet of things). Complex software shapes this communication on the basis of immanent, hidden algorithms. In this way, work processes change as well as business organization. A major concern here is that in complex software-controlled systems, machines make decisions on the basis of their implemented algorithms. People, then, have either to monitor and control those systems or they have to react on them. The educational consequences of those changes are the core focus of this volume. The contributions discuss different aspects on how digitalization in work contexts transforms and modifies occupational practices. The overwhelming consensus is that there will be workplaces (and occupations) that become dispensable, on the one hand, whereas other novel workplaces (and occupations) will emerge, on the other hand, through these changes. However, the discussion remains more abstract than precise and confident conclusions being made. The contributions to this volume take up this issue and provide arguments from diverse perspectives. These contributions, hence, are highly relevant to the book series.

The current discourse on digitalization is dominated by contributions from technological domains (e.g. software engineering, systems engineering, robotics). However, digitalization generates technological challenges for individuals, organizations and societies. Hence, digitalization of work is a topic of interdisciplinary interest and relevance. This volume comprises contributions written by researchers from different academic disciplines who discuss the effects of digitalization of work

at individual, organizational and societal levels. They provide considerations for the still open discussion on how individuals, organizations and society want to shape the transformation processes related to digitalization. It is the opportunity to contribute to this discussion now and – thus – to participate in the development of the public, legal and ethical framework for digitalization that makes this volume both timely and important.

The book series aims at understanding and explaining problem- and practice-based learning, to learn about how best to prepare individuals for work and how best to maintain their skills and capabilities across lengthening working lives. This volume addresses digitalization of work as a challenge for occupational practices and vocational education and training. It comprises attempts that specify possible changes through digitalization of work, arising opportunities and limitations and approaches to secure the required skills and capabilities. The particular educational view implies a humanistic idea that aims at supporting individuals to act independently and to make decisions and choices autonomously. The contributions of this volume explore consequences of digitalization that challenge such an ideal. Hence, this compilation of contributions provides exemplary viewpoints on a current and highly relevant issue of technological and societal development. It is important to acknowledge not only technical problems but also educational problems, to establish conditions for the digitalization of work that are socially shared and respected. To support the understanding of problem- and practice-based learning in digitalized work may provide a valuable contribution to the scientific and the societal discourse. This volume, hence, addresses researcher and practitioner audiences.

Brisbane, Australia — Stephen Billett
Regensburg, Germany — Hans Gruber
Paderborn, Germany — Christian Harteis
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Chapter 1
Machines, Change and Work: An Educational View on the Digitalization of Work

Christian Harteis

1.1 Introduction into the Book

The history of industrial development is also a history of technological, economic and societal changes which at each of their phases had crucial impacts on workplaces and work practices. Most important driver always had been technological development that ended up in the invention of new machines that improved industrial production. The current transformation of industrial production to digitalized work often is called fourth industrial revolution (e.g. in Germany *Industrie 4.0*), even though there is a debate about the rationality of this counting system (e.g. Wilkens 2017). This counting system considers the invention of steam power and its utilization for mechanical production systems (i.e. the first mechanical loom "power loom" in 1784) to be the first industrial revolution. The second followed in 1870, when the implementation of the principle of division of labour was combined with the use of electric power for driving a conveyor belt in the Cincinnati slaughterhouse. As third revolution counts the application of the first programmable logic controller in 1969 for the broad use of IT and electronic systems to increase the automation of industrial production. Nowadays, information and communication technologies developed so far that the fourth industrial revolution is supposed to appear in recent times by using cyber-physical systems for industrial production (Brynjolfsson and McAfee 2014). Hence, the question arises what the particular quality of implementing cyber-physical systems is.

Cyber-physical systems are arrangements that combine software components and mechanic parts that communicate autonomously via the intranet or internet. Such combinations allow production arrangements that flexible vary according to affordances or constraints in the order books or production systems without being

C. Harteis (✉)
Institute of Educational Science, University of Paderborn,
Warburger Str. 100, 33098 Paderborn, NRW, Germany
e-mail: christian.harteis@upb.de

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necessarily directed by workers. In car manufacturing, e.g., the combination of software components with mechanical parts is already widely used. A regular model of a western car manufacturer can be ordered in several million formats when considering all possible combinations of configuration. In the production plants, all these differently configured cars run consecutively on the production belt – and the information on required components are sent from the production unit, in order to have all components available at the production plant just in time. However, future scenarios describe production units that allow the production of goods in batch size 1 – that means fully unique components – within a production system that organizes resources and processes autonomously and automatically. Such a system sets new requirements that workers have to achieve: They have to be flexibly disposable which means that they have to be permanently contactable and they have to be able to cope with varying tasks. On the one hand, flexible working times may allow to arrange work after individual needs and demands; on the other hand, the boundary between the private sphere and working sphere may blur due to a constant contact to the employer. However, such flexible working arrangements may still be difficult to realize, because they may violate employment laws.

Digitalization does not only change industrial work but affects all economic sectors, i.e. also the primary sector of natural resources and the third sector of services. In consequence, workers or employees of all kinds of occupations and professions are potentially subject of changes through digitalization. Technological innovations always had raised questions on the effects for workers and working life. There are examples where technological progress really improved working life, e.g. by replacing dangerous jobs through machines. However, currently existing attempts of implementing digitalization are usually not distinct in this respect (Brynjolfsson and McAfee 2014), so that the discourse on effect of digitalization either emphasizes improving the quality of work-life by alleviating workers' daily life or denigrating the quality of work-life by making existing skills and occupations redundant. Hence, any emerging technological development – even in its early phases – becomes the object of interest and speculation about its overall impacts on work and working life. The emergence and effects of digitalization of work for workers in particular and societies in general are no exception here.

1.2 Dimensions of Change Through Digitalization

Even if probably for the majority of workers and employees immediate effects of digitalization may not be visible, yet, there are convincing indicators for the progress of digitalization within economy. A look at the most valuable companies on earth (Gandel 2016) reveals that the top five list contains Apple (534 $bil), Alphabet (504 $bil), Microsoft (413 $bil), Exxon Mobil (326 $bil) and Facebook (321 $bil). Four of these five companies create their business through digitalization; Exxon

Mobil as a petroleum refining company represents the traditional industry within this list. If one understands stock value as a bet or a promise on the future, investors scent biggest chances for profits in the sector of digital economy. In parts, the dominance of digital economy became reality already: The world's largest taxi company Uber does not own any car, the world's most popular media owner (Facebook) does not create content, the world's most valuable retailer (Alibaba) does not have any good, and the world's largest provider of accommodations (Airbnb) does not own any property.

From an educational perspective, questions arise if and how work in digitalized workplaces raises new challenges for the preparation of people for this kind of work (i.e. vocational education and training), for maintaining a quality of individual employability across working life and for further education and learning at workplace in order to develop and maintain required skills and capabilities. In general, digitalization and its effects can be considered on three different levels: (1) technology, (2) organization and (3) workers and employees.

1.2.1 Level of Technology

In the extent technology changes the machines used for industrial and other work, in that extent requirements for the workers change, too. Whereas former developments mainly resulted in an increase of speed and power, information and communication technology may also lead to not only more efficient (quicker or denser) processes but may also merge processes, introduce a variety of new processes and requirements and, thus, may lead to an intensification of work.

This may firstly come from increasing processing speed and storage capacities which allow the application of increasingly complex software. Secondly, software solutions become increasingly complex and, thus, better and better problem solutions. Thirdly, the quality of sensory technology increases quickly, so that adaptive assistance systems for a variety of challenges can be developed. This does not only apply for sensors recording technical or geographical data (e.g. for autonomous cars) but also for sensors recording crucial characteristics of people operating a digital machine (e.g. robots). Crucial for all these opportunities are the algorithms that are implemented within the software that basically define the scope of options that are realizable in a concrete setting. From an educational viewpoint, it is interesting and relevant which kind of anthropology or idea of man guided the software developers. Since humans utilized tools and started production of tools, a specific anthropology was implicit to these tools. A hammer owes its specific shape firstly its main purpose and secondly the physiology of a human body. Analogously, each software solution is at least one idea of user inherent – probably often without being explicitly elaborated.

1.2.2 Level of Organization

As a matter of course, technological change has effects on the level of organization. As long technological progress increased speed and power of singular working steps, changes of work organizations applied only terms of human or mechanical capacities. However, the final vision of cyber-physical systems foresees fluctuating and autonomously organized work processes that interpret singular production units within an organization as flexibly available resources. Depending on the list of orders and the current availability of resources, singular production units are supposed to be allocated flexibly to different tasks as parts of the order list.

Fundaments of such a way of organizing production (and work) can be found in the late 1990s concepts of lean production with just-in-time deliveries (Hirano and Makota 2006) and fractal enterprises (Bider et al. 2016). Both claim temporary and completely flexible organizational structures that arise when necessary and disappear when no longer necessary. Theoretically, those structures allow minimizing machine downtimes that usually arise in traditional linear production processes. The constraints of this way of organizing work and production arise not only from humans' and machines' capacities but also from their capabilities. The question arising is not only if humans and machines can cope with speed and power of production processes, but they rather refer to the issue if tasks and capabilities fit. Additionally, the optimization of tasks (orders) and resources (capabilities) will be calculated through algorithms, which finally brings machines to organize (human) work. It is yet an open question if digital leadership differs from well-established management concepts of leadership and control.

1.2.3 Level of Workers and Employees

From an educational perspective, the individual level of workers and employees is of particular relevance, since the effects of digitalization have direct influence on work tasks and processes. As soon work processes change, they require workers to adapt and to learn. Some work processes will change, some become obsolete, and some new will be established. Depending on the quality of such changes, a need for workplace learning, for further education or for a modified preparation for work through vocational education and training arises. It is still an open question if the demands of digitalized work will require a higher or a lower level of qualification and capabilities. Probably, both directions will occur; some assistance systems aim at providing workers all necessary instructions and guaranteeing safety in work processes, so that an individual just needs to follow the instructions of the system. Those assistance systems do not require highly skilled workers – except they do not need to overlook the entire system. As soon as assistance systems require workers who hold control over a system, they need to have an understanding of (probably in transparent) processes and algorithms. The digitalization of work, hence, raises the

issue who will control and manage work processes: computer systems or workers. The first alternative would describe a renaissance of Ford's concept of division of labour but under control of computers; the second alternative requires workers' capabilities and commitment.

Digitalization of work not only influences skill requirements but also the character of vocational, occupational or professional job profiles. Lewis (2011) investigated truck drivers in Australia and observed that they immediately switch of all digital assistance systems of a truck as soon as they are on overland road. They also – despite air conditioning – open the window just to hear the machine, what is impossible in modern high-tech trucks with noise-isolated cabins. These observations raise three issues:

1. Technological development may annihilate parts of work activities that create identity (i.e. contact to the rough work of an engine).
2. Technological development also may annihilate parts of work activities that actually are important for the experience of competence (i.e. the sense of feeling the engine).
3. Technological development simply may be eluded by workers.

Finally, digitalization of work raises on an individual level the issue of data privacy and informational autonomy. An interaction between workers and digital systems generates a plenitude of data that can be utilized for controlling workers and for analysing their performance. It still appears unclear who the owner of those kind of data is – the worker him- or herself? The owner of the machines or the software provider? At least, it appears as if the worker has the lowest chances to get access to these data.

1.3 Educational Challenges

The discussion about digitalization of work is widely dominated by contributions from technological (e.g. software engineering, robotics) and business domains (e.g. work studies, management). However, transformation processes of digitalization are of educational relevance, too, since they raise challenges that are of particular educational relevance.

1.3.1 Philosophy of Education

There are two major ideas that guided several approaches of philosophy of education:

1. The autonomy of the individual is an important idea of education. The individual is to be acknowledged in its individual development as an own value; hence, the

individual has the right to decide what to do. Kant (1999) introduced the idea that it is the goal of education (and enlightenment) to encourage the individual to utilize its own understanding without direction from another. However, there are limitations in individual freedom that arise from the social environment.

2. The second important idea of philosophy of education, hence, refers to the integration of an individual into the social community as major goal of education (e.g. Dewey 1966). An educated individual is considered to understand and to accept social rules – socially accepted behaviour results from insight into the value of social rules as maturity.

Many of the above-mentioned open questions directly challenge such an understanding of education. Digitalization may result in intransparent work or decision processes as soon as machines directed by (hidden) algorithms organize work processes. The debate about issues of control indicates the possibility – and perhaps the probability – of prioritizing machines over humans. In a work situation of machine-controlled organization of work processes on the basis of hidden algorithms, it becomes impossible for the worker to overlook the system and to develop and (matured) understanding of the entire whole. The educational idea of maturity becomes inappropriate and replaced by proficiency that describes successful individual subordination under external (intransparent) goals.

1.3.2 Value of Work and Individual Competence

In moment when machines control work processes as well as the creation of value and, thus, generate surplus, the issue of payment for work arises with a novel problem. A solution of this problem only via market mechanisms would bring a kind and extent of payment for machine work that reflects the gain of efficacy the machines generate. However, since machines and algorithms usually work faster and permanently with same precision, machine work then is better paid than human work. Some researchers call for a new societal deal about what kind of work people are willing to pay for (e.g. Ellis 2007; Wunder 2013). The extreme scenario in which machines generate all wages for a society – independent if a person works in industrial, commercial or honorary context – appears fantastic. It appears more realistic that some occupations will become obsolete and some others will emerge (Frey and Osbourne 2013); in consequence, there will be winners and losers.

Payment for work also reflects societal acknowledgement of competences, skills or capabilities. Work requires particular individual competences, be it work in industry, service area or any other field of business. Machine work reflects engineers' competences that were necessary to develop machines and software. From an educational point of view, it becomes relevant what kind of competences, skills or capabilities receive what extent of public acknowledgement reflected in the amount of payment. Historically, the domains of ICT, technology and engineering receive higher wages than large areas of service (i.e. logistic, care work or education).

1.3.3 Preparation for Occupations, Vocations and Professions

If the digitalization of work requires new skills and particularly such that were not part of workers' vocational preparation, then it might be necessary to modify the curricula of vocational education, particularly in countries with a strong system of vocational education (e.g. Germany, Austria, Switzerland). Those curricula developed over a long period of time and complex negotiations between stakeholders and may, thus, (still) comprise components that are no longer needed in digitalized work.

A modification of vocational preparation by adding new requirements probably is the easier way of adapting vocational education. It is rather difficult if the digitalization replaces human work at fundamental, basic working steps that particularly contribute to a comprehensive understanding of a domain. Computer numeric control of lathes, e.g., does not require lathe operators to get into direct contact with the material they work on. However, such a direct contact, i.e. feeling, touching and working, to material with manual tools enables workers to develop a sense of quality of the material (e.g. capacitance, resistance). The problem of this option is that the realization that some crucial work activities vanished does not occur without a noticeable delay – if it does occur at all. An example should illustrate this problem: Modern assistance systems in cars allow fully automated reverse parking. It will take a certain while before we realize that the majority of car drivers lost the manual skill of reverse parking, and it will take an additional while before we realize that the manual skill is important for other aspects of competent car driving.

Hence, it is obvious that the digitalization of work will require adjustment in the systems of vocational education and preparation for work, and it is a challenge as well as a duty of educational research to contribute to and shape necessary changes.

1.4 Significance of Educational Contributions

Lacking a broad base of sound empirical evidence so far, the debate on the effects of digitalization of work fluctuates between optimism and pessimism. The optimistic view highlights the increase of opportunities raising from the digitalization of work for both workers and enterprises, whereas pessimists fear dangers resulting from the opaque nature and unknowable consequences of digitalization that leads to situations in which workers are at the mercy of those who control the systems. The protagonists of each position often represent special interest groups. There is an immense need for research to provide empirically grounded insight on the effects of digitalization.

However, the consensus of moderate positions is that digitalization of work will not lead to workplaces without human beings, but perhaps will lead to new ways of working and knowing (e.g. Brynjolfsson and McAfee 2014). Hence, the salient educational question is how best to prepare workers for this future of work and how to

design curricula and vocational education and training. However, it also becomes interesting for educational research to investigate and understand transformation processes and their side effects, particularly how they influence the individual.

If the digitalization of work really changes work structures and the organization of enterprises to a fundamental extent, then educational research becomes relevant in order to generate knowledge about appropriate organizational structures and leadership. Educational research focuses workers' opportunity for participation, the experiences of competence and self-efficacy and development. Hence, it is important that educational researchers contribute to the debate in order not to leave the field to the disciplines of business, engineering and ICT. It is the traditionally humanistic perspective of educational research which needs to be acknowledged besides all legitimate economic and technological concerns.

As we are so far just in the starting phase of the transformation towards digitalized work and the implementation of cyber-physical systems within enterprises and organizations still is in its beginning, the society still needs to start a discourse about rules for digitalization which are societally accepted. That discourse needs to be fed from different disciplines. Hence, it is important that educational research generates insight on this issue in order to contribute to the societal discourse about rules of digitalizing work.

1.5 Book Overview

Changes in workplaces and their implications for vocational education and professional learning have been widely discussed since the 1990s, when concepts of business and work organization more and more focused the individual employee and worker as resource. Work became more than the execution of tasks of procedures; work was considered as complex problem-solving. Additionally, since the paradigm of globalization became widely acknowledged, workers and employees have to cope with permanent change in increasing competition. Hence, a huge body of research on consequences of changing workplaces exists in the domains of social sciences. However, recently the digitalization of work seems to establish new qualities of changes. What is already reality in digitalization of work is the design of complex production processes, e.g. in automotive industries, where car manufacturers implemented production systems that allow the offer millions of options for the production of one singular car. The future promises flexibility in working times, working tasks, etc. which allows on the one hand an individual (perhaps) to work around private needs (e.g. work-life balance); on the other hand, does such kind of flexibility require readiness and (permanent) availability? Few is known so far about consequences for work and workers, respectively employees. This reader, thus, aims at summarizing the state of knowledge from different perspectives, in order to provide a fundament for decisions how best to organize the transformation of work through digitalization. What will be sure is that technical development will continue to develop and that opportunities will be realized. It is a challenge and a

task for social science research to analyse these transformation processes from the individuals' perspective in order to contribute to a responsible design of future work.

This edited volume brings together researchers from various disciplines (i.e. education, psychology, sociology, economy, information technology, engineering) discussing elementary changes at workplaces occurring through digitalization and reflecting on educational challenges for individuals, organizations and society. The book comprises four parts.

Part I comprises three articles which deal with changes that are caused by digitalization from a general perspective. *Petri Nokelainen*, *Timo Nevalainen and Kreeta Niemi* discuss general developments in the automation of work and draw conclusions about effects for the labour market. *Raija Hämäläinen*, *Minna Lanz and Kari Koskinen* reflect upon technological development and refer to PIAAC data when developing educational approaches. *Martin Schneider* focuses the concepts of human and organizational capital for describing prerequisites for making digitalization an economic success.

Part II brings together four articles dealing with challenges on an individual level. *Franz Lehner and Mathias Sundby* describe in their first article for this book individual skills and capabilities required from small and medium enterprises that need to handle IT systems. *Anne-Dorothee Warmuth and Ilke Glockentöger* analyse the relation between work and private spheres and effects of digitalization for parenthood. *Sin Sing Ang*, *Mariana Orozco*, *David Gijbels and Piet Van den Bossche* describe learning practices of adults supported through digital media. A concrete example for the use of digital technology to support professional learning is presented by *Yoriko Kikkawa and Timothy J. Marvin*.

Part III moves the focus to three contributions arguing on the organizational level. In their second article, *Franz Lehner and Mathias Sundby* discuss required IT capabilities for small and medium enterprises on an organizational level. *Christoph Fischer and Alexander Pöhler* plead for implementing a strong learning culture in order to cope with digitalization. *Katja Vähäsantanen and Anneli Eteläpelto* analyse interactions between workers in a company producing digital business applications.

Part IV finally raises issues on societal level and comprises three contributions. *Franz Lehner and Aleksandra Dzepina* discuss the issue of information privacy; *Stephen Billett* reflects educational means to secure the necessary knowledge for digitalized work. Finally, *James Avis and Cheryl Reynolds* raise the topic of digitalization and social justice.

The contributors to this volume are scholars who all conducted research on the influence of technological change on work and individuals for a long time. They come from different domains and different theoretical backgrounds and provide their view on educational challenges of the digitalization of work. The book seeks to highlight selected issues of digitalization in order to address researchers as well as practitioners in the field of adult education and human resource development.

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Christian Harteis, Dr. phil., is professor of educational science, educational management and research on further education at the University of Paderborn (Germany). His research interests comprise workplace and professional learning, intuition and learning from errors. He is member of the interdisciplinary graduate school *Arbeit 4.0* at the University of Paderborn.

Part I
Changes in the Workplaces Through Digitalization

Chapter 2
Mind or Machine? Opportunities and Limits of Automation

Petri Nokelainen, Timo Nevalainen, and Kreeta Niemi

2.1 Introduction

It is common to see headlines with menacing titles such as "Will YOUR job be stolen by a robot?" or interactive calculators that estimate when technology will make certain jobs redundant. This information is based on a study by the University of Oxford (Frey and Osborne 2013), which categorized 70 occupations based on risk for automation to provide training data for probabilistic classification and to predict the probability of automation for 702 occupations.

This calculator even indicates that the current researchers are at small risk of losing their jobs to technology; the closest job profile (education—college professors) produced a 3.2% chance of automation in the next 20 years. Although this is a small number compared to production (e.g., baker, 88.8%) and legal (e.g., legal assistant, 94.5%) occupations, we expected teaching jobs to be less replaceable by machines.

Why is this? The answer lies in statistical procedures by Frey and Osborne (2013), who analyzed the US Department of Labor data. First, they selected the following nine variables as predictors of job automation: (1) assisting and caring for others, (2) persuasion, (3) negotiation, (4) social perceptiveness, (5) fine arts, (6) originality, (7) manual dexterity, (8) finger dexterity, and (9) cramped work space. These variables fit into three categories: social intelligence (I, variables 1–4),

P. Nokelainen (✉)
Laboratory of Industrial and Information Management, Tampere University of Technology, Tampere, Finland
e-mail: petri.nokelainen@tut.fi

T. Nevalainen
Proakatemia, Tampere University of Applied Sciences, Tampere, Finland
e-mail: timo.nevalainen@tamk.fi

K. Niemi
Faculty of Education, University of Tampere, Tampere, Finland
e-mail: kreeta.niemi@jyu.fi

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creative intelligence (II, variables 5 and 6), and perception and manipulation (III, variables 7–9), which revealed that occupations demanding social or creative intelligence (categories I and II) are quite safe from automation. Thus, academics are at low risk of losing their jobs to automation, although the machine-learning approach that Frey and Osborne used found that student essays (Rudner 2009) and written research (Kersting et al. 2014) scoring systems have been developed.

Automation of work is not a new phenomenon and has advanced in waves during the past 200 years (Autor 2015). Mechanization has influenced occupations that involve both cognitive (analytic/interactive) and manual routine tasks (Autor et al. 2003), such as those found in knitting and automotive factories. As a result, requirements for workforce skill level and flexibility were lowered as work tasks were simplified. The second wave of automation occurred during the early twentieth century and was introduced by electrification, which automated low-skill level production processes but increased demand for skilled workers to operate machinery (Goldin and Katz 1998.) Currently, automation has eliminated (switchboard operators or door-to-door sales workers) or affected (agricultural workers and cashiers) a number of occupations.

The current wave of automation has made it difficult to predict which occupations will remain manual. According to Frey and Osborne (2013), advancements in machine learning and mobile robotics challenge Autor et al. (2003) prediction that nonroutine manual tasks, such as truck driving, are safe from automation. Thus, many occupations that contain nonroutine tasks (e.g., legal writing) might change in future.

In this chapter, we discuss the general development of automation and reflect on forecasts of how automation will change the labor market. We begin by investigating different skills that are desirable in future working life. Then, automated, assistance, and augmenting technologies related to education will be discussed. Finally, ethical challenges of workplace automation and a discussion of topics presented earlier will be related to the wider context of technological advancement based on the seminal 2 × 2 model of cognitive/manual and routine/nonroutine tasks proposed by Autor et al. (2003).

2.2 Skills and Automation

The consequences of new technology include increasing automation of low-skill tasks, potential elimination of current work practices, and the new significance of highly cognitive skills in the workforce, all of which may lead to labor market polarization. This polarization will lead to a growing demand for employment in highly cognitive-based jobs and manual low-income jobs, hollowing out of middle-income jobs requiring routine manual and cognitive skills (Frey and Osborne 2013; Goos and Manning 2007).

Highly cognitive skills that are in demand include sophisticated ICT skills as well as more generic skills requiring creativity and social intelligence. Maintaining

a high skill level can be challenging for both new employees and senior workers, who must continuously update their skills. To remain valuable, people must have the skills to use novel innovations and the ability to make decisions in self-organizing learning environments (Brynjolfsson and McAfee 2014). Highly cognitive skills include creative thinking, problem-solving, entrepreneurship, negotiation, and learning (World Economic Forum 2016), which are generic and transverse multiple industries, providing lifelong learning opportunities and requiring adaption to new transformative working environments (Frey and Osborne 2013).

New technologies also require collaboration and a set of soft skills from human operators, such as emotional intelligence, empathy, altruism, and reciprocity. These skills are built into the mechanics of everyday interpersonal exchanges. Workers need to communicate, network, and make collaborative decisions to distribute and maintain collective knowledge. At the same time, they need to understand the perspectives of others, and the fastest growing cognitive occupations, such as physicians, lawyers, teachers, and therapists, include a remarkable amount of social interactions and sustained intersubjectivity (Frey et al. 2016).

The features of social interaction are difficult to automate (Deming 2015). A person's ability to read and react to others' needs, intentions, and emotions is primarily based on tacit knowledge and hidden social orders. Thus far, computers are very poor substitutes for tasks that require an underlying set of rules unknown to programmers (Autor 2015). Computers are unable to do anything outside a frame of programming, and human interaction can be based on creating novel ideas and building rapport (i.e., thinking outside the box; Brynjolfsson and McAfee 2014). The labor market increasingly rewards workers who have high cognitive and social skills.

The growing demand for these skills creates an educational challenge for preparing individuals. Increasing opportunities to develop high-level cognitive and social skills narrows the gap between experienced and inexperienced workers and reduces inequality, aligning societal and labor market needs. Success in education has been based on measuring achievement of cognitive skills, using tests such as PISA and OECD, and the results are utilized in policy making. Although these scientific analyses provide important information, many other skills taught and learned in school have been ignored. For institutions to be able to respond to future educational challenges, research is needed on how these skills evolve over time and what motivates people to acquire and develop these skills.

The Future of Jobs report published by the World Economic Forum (2016) contains an analysis of the top ten skills required for a successful working life in 2020. Many of the skills listed are the same as those included in the report for 2015 and are indicative of the increasing complexity of global and digital working life. At the top of the list are skills such as complex problem-solving (1), critical thinking (2), and creativity (3).

The complexity of work tasks in global and digital working contexts, coupled with rapid development and increasing availability of digital technologies that assist or augment human problem-solving, is radically improving the productivity of cognitive labor distributed between humans and algorithms (Frey and Osborne 2013).

Development and wider availability of learning algorithms and robotics is threatening to diminish the value of human manual labor and make certain types of workers redundant. Skills needed in complex working tasks are followed by those needed for collaborating with others in increasingly flexible work contexts, such as people management (4) and coordinating with others (5). The ranking of creativity changed from a rank of 10 in 2015 to 3 in 2020, because creativity plays a crucial role in how workers benefit from new products, technologies, and ways of working. The role of strategic decision-making became slightly less prominent due to the development of machines that are able to make strategic decisions based on very large sets of data and deep-learning algorithms (World Economic Forum 2016).

2.3 Education and Automation

Any teacher that can be replaced by a machine should be! – Arthur C. Clarke

The role of education is more important as skill demand increases (Goldin and Katz 2007). More than 10 years ago, Rintala and Suolanen (2005) noticed that the effects of automation on job descriptions were evident in three ways: (1) the transfer of tasks, (2) the fusion of job descriptions, and (3) the adding of tasks. Tasks for professional groups were transferred to the job descriptions for fused jobs that were previously performed by two or more separate professional groups. The new tasks were primarily related to the emergence of new media and were created and added to existing job descriptions.

Vocational education is an example of a profession in which automation can both present a challenge to existing working practices and create opportunities for new ones. When examining the current and possible future effects of automation on teaching profession, for example, it is easy to be pessimistic because of increasing use of technology to reduce the need for human contact in teaching and learning. A more optimistic outlook would be to consider the possibilities of educational technology to facilitate new pedagogical practices, such as flipped classrooms (Strayer 2012), e-learning, informal learning, project-based learning, or other inductive teaching and learning methods (Prince and Felder 2006). These practices develop academic but also nonacademic skills, such as social–emotional skills (Liu and Huang 2017) that are needed in working life. Thus, developing technology can give rise to new skills.

To examine the actual impact rather than possible future challenges of machine learning and automation on education, we need to dig deeper and examine this phenomenon on a granular level, to determine the different tasks involved in teaching and learning (Fig. 2.1).

First, even in vocational teaching, there are simple and mechanistic coordination and information sharing tasks that ensure that students are in the right place at the right time or that correct information in a suitable format. For example, mechanistic tasks related to monitoring and control of coursework and student achievement

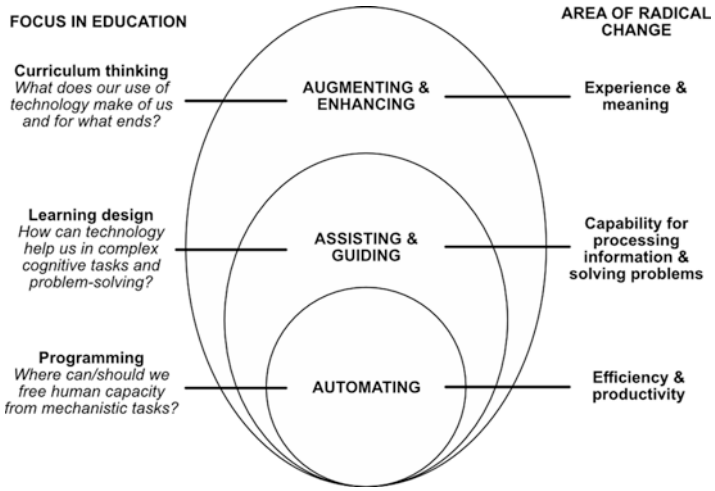

Fig. 2.1 Automating, assisting, and augmenting education

require grades to be input into a school information system or a spreadsheet file. Technology that automates these relatively simple, instrumental tasks already exists, and in the near future, the time and resources needed to complete these tasks manually will be reduced. Automation of these tasks will have a radical effect on efficiency and productivity in education.

Second, there are more complex but still instrumental and relatively repetitive tasks related to information retrieval, filtering and sharing, and moderately complex problem-solving in many work processes. For these tasks, technology can be an intelligent agent that assists and guides teachers and students during information gathering and processing (Nenkov et al. 2016). Use of intelligent agents, such as IBM Watson (IBM 2016), will have a radical effect on human capability for information processing and problem-solving.

Third, there are tasks in education that are deeply connected to human meaning and the meaningful *ends* of education (in contrast to instrumental *means*). Especially in the educational contexts, meaning-related tasks often involve cognitively demanding decision-making in an environment where social and psychological, even existential, factors introduce uncertainty and complexity. Technological capacity required for full automation or even meaningful assistance by artificial intelligence agents for these tasks is still quite far from being realized; however, technologies, such as augmented and virtual reality appliances, and wearable devices connected to the Internet can be used to augment and enhance human perception and experience of meaningful things in new ways. The question to consider about enhancing technologies for these tasks is not how we can use innovation to work more efficiently but how will using such technology change us and to what (or whose) end are such changes beneficial?

Encouraging entrepreneurship has been identified as a key policy to effectively offset the risks of automation for the labor market and distribution of wealth (Frey

et al. 2016). Creating new business when existing businesses are being automated and require less human labor seems like an intuitively viable option. However, human labor plays different roles in different industries. While startup companies leverage effective use of digital platforms, they rarely employ a significant number of people, which may still enable people to create new forms of employment based on the use of a platform for offering products or services to other users of a platform. This employment often takes the form of part-time freelancing for extra income, which results in little stability or the job security associated with more traditional forms of employment.

Relevant to vocational education is the push toward entrepreneurship education. This push is often motivated by ideological reasons connected to neoliberalism (Komulainen et al. 2011) or the perceived need to grow a private sector through creation of new enterprises. Alongside this ideologically or economically motivated push for entrepreneurship education, there is a perceived need to train more entrepreneurially minded specialist workers and managers for existing companies. This entrepreneurial mindset consists of the ability to spot opportunities for creating value and willingness to take a measured degree of personal risk to realize these opportunities (Hagel 2016).

2.4 Ethics and Automation

Rapid automation of labor poses different challenges for societies with different economic conditions. In economies based mainly on industrial production without the support structures of a welfare state, the platform economy may help people find paid work in flexible services when the need for industrial labor becomes scarce due to automation. In Nordic countries, where the state economy is based on taxation of regular and relatively high monthly wages, this very same flexibility threatens the social support structures of the welfare state.

Automation and development of extremely efficient social media communication tools will enable emergent forms of organization to flourish, where hierarchical structures were previously required to maintain effective communication. Now everyone has access to communication that was previously available only to leaders of states and large corporations. Social networking has given knowledge-power to the majority, who have become active information seekers and producers (Spencer-Scarr 2014).

In societies where automation challenges the established structures of the labor market, there is an increasing need to educate citizens who are able to take responsibility for their own economic well-being, as well as that of others. One possible answer to this need is entrepreneurship education that focuses on increasing students' abilities to find opportunities to create value and to withstand the risk required to take these opportunities. The success of this approach depends on the capabilities of individuals and organizations to use and expand both individual and cultural

strengths to their fullest, including the ability to use and work together with new technologies.

Entrepreneurship education should go beyond teaching students about the financial management of the current forms of corporations. Even if these corporations play a central role in the current economy, the platform economy or whatever comes after may challenge this role. In fact, the role of traditional companies is already being challenged by emerging platforms that cooperate economically. Entrepreneurship as the creation of a living for oneself or one's community, as the ability to find opportunities to create value, and as the willingness to take risks to take advantage of these opportunities goes beyond the current forms of corporation and financial management.

Economic forecasts and reports have identified relevant and skill requirements for workers, such as being able to tolerate instability and adapt to new ways of working and working environments. This requires an open and flexible mindset from the employee to constantly update their skills and change professions more frequently throughout their careers. No matter how qualified a person is, he or she must be able to adjust and upgrade their career paths and update skills through sophisticated learning tools, both formally and especially informally, shaped by ICT. Open mindsets also require the ability to think and act globally, which can mean accepting situations that one would not normally experience.

An ethical challenge of automation is how to redefine the human meaning of work and what to do about the human need to feel that their work is needed by their communities when robots and algorithms are equally able to perform the same tasks. Another aspect of the human meaning of work is that human beings have certain capabilities (Nussbaum 2011) that are, alongside the capability for learning, required to live a fulfilling life within a society. These central capabilities include, according to Nussbaum (2011), life, bodily health, bodily integrity, senses, imagination and thought, emotions, practical reason, affiliation, other species, play, and political and material control over one's environment. For many people, these capabilities are actualized and developed in the context of daily work or based on being employed and earning sufficient wages. If we take the expectation of employment out of the equation, there must be alternative structures in place to ensure that people feel needed by their communities and that they still have the ability to actualize and develop the capabilities that are critical to living a human life with dignity.

2.5 Discussion

In the past, working people competed with each other in the labor market. Nowadays, people compete against machines, and professional careers have become more flexible for all workers, no matter how highly qualified they are. In this sense, people must take charge of the development of their skills and qualifications and accept the role of technology that allows learning to happen anywhere and anytime, in multiple learning environments. According to the mindset theory (Dweck et al. 1995), people

may be more or less fixed to certain traits (entity) or open for change (incremental). Empirical studies (Yeager et al. 2011) have shown associations between the entity and incremental mindsets and the desire to behave in certain ways. However, workers with an entity mindset might be in greater danger of losing their jobs to automation compared to workers with an incremental mindset. Current research on the development of expertise (Hytönen et al. 2016) supports this assumption and stresses the importance of workers actively expanding their skills and competencies to dynamically adapt to changing professional environments (i.e., adaptive expertise).

In public discourse, both in traditional press and in blogosphere digitalization, the automation of work is usually discussed based on its effect on jobs and the job market. We suggest that it would be fruitful to discuss the impact of digital technologies on the more granular levels of tasks. Any meaningful occupation consists of professional or work ethics; different social, cultural, and physical contexts; and relationships between different people and organizations. The effects of automation on work ethics and situational and relational aspects of work are beyond the scope of this short introduction.

It has been suggested that routine tasks with a lower level of cognitive complexity are more likely to be automated than cognitively more complex tasks that involve a higher degree of uncertainty (Autor et al. 2003; Frey and Osborne 2013). Goos et al. (2014) agreed with this view and proposed that skill-biased technological change hypothesis only partially explains job polarization.

While tasks that require fine mechanical accuracy and skill, such as medical surgery or electronic repair, have previously been difficult for robots, recent developments in soft robotics have created technology that equals the skills of human specialists. Artificial structures and materials that emulate soft tissue in animals enable robots to receive more detailed feedback from physical interactions to fine-tune reactions (Laschi et al. 2016). Recent developments in deep machine learning indicate that predicting future automation of work tasks on the basis of simplicity or complexity is no longer enough. Computers based on deep machine-learning algorithms are increasingly capable of strategic decision-making; for example, the AlphaGo algorithm developed by DeepMind Technologies (a subsidiary of Alphabet, formerly Google) beat the top Go player in the world, Lee Sedol, four out of five games in March 2016 (Liu and Huang 2017). Go had previously been thought to require such a level of strategic creativity that it would take artificial intelligence at least 50 years to win over professional human players. What makes AlphaGo especially interesting is that it is based on a general deep-learning algorithm, not one that was built for the sole purpose of playing Go like earlier artificial intelligence applications that won over grandmasters in chess (Chen 2016). Currently, similar algorithms are being developed for different strategic decision-making contexts in both business and medicine. What is common to these contexts is that there is a fairly limited number of known variables for which value is optimized through strategic action.

We suggest human *meaningfulness* as another factor that could play a role in determining how likely a task is to be automated and the nature of automation.

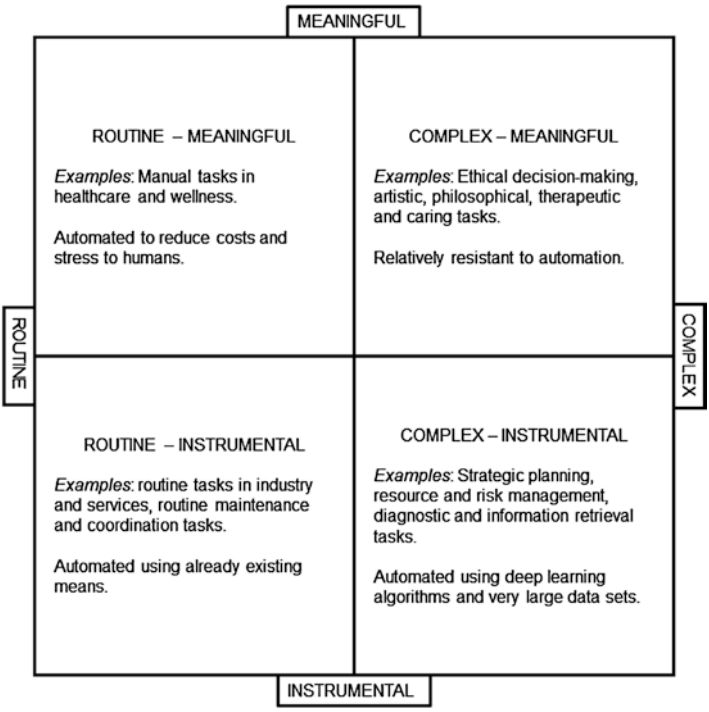

Fig. 2.2 Framework to predict automation of work tasks (Adapted from Autor et al. 2003, p. 1286)

Tasks that are meaningful add meaning either in or through the process of being completed. Meaning can be added to tasks through social relationships and specific social, cognitive, and embodied human practices. We contrast this meaningfulness with the *instrumentality* of tasks. Here, an instrumental task is one for which purpose is optimized to a limited number of known variables, often to accomplish something that may or may not be a meaningful task. An instrumental task is a means to an end that does not add to the meaningfulness of the process or its outcomes, while the specifically human way a person completes a meaningful task adds to the meaningfulness of the process or its outcomes. If we compare routine–complex and instrumental–meaningful distinctions, most tasks in any profession can be categorized relatively easily (Fig. 2.2).

When starting from the bottom-left quadrant (routine–instrumental) of Fig. 2.2, many of the tasks falling into this category have already been automated or are in the process of being automated. This is the category in which human work adds little value and where tasks are often relatively easy to automate. Moving to the top-left quadrant (routine–meaningful), we find tasks for which human work adds meaning to the process or outcomes but for which algorithms and machines are gradually being introduced to reduce labor or other costs or physical or psychological stress to human workers. Tasks falling into this category include manual tasks in healthcare, such as lifting patients, and many tasks in service industry, such as

working at the counter in a supermarket or hotel reception. Human interaction in these tasks often adds value to the process but can also be costly or stressful. This category is especially important to monitor to assess the ethical effects automation; for example, professional human care should be available to all elderly individuals regardless of their ability to pay a premium for human care.

In lower-right quadrant (complex–instrumental) are tasks that were previously too complex for automation but for which human work does not add intrinsic value to the process or its results. This includes most strategic and tactical coordination and management tasks for which immediate personal human contact does not add meaningfulness. Automating complex decision-making requires learning algorithms that are capable of learning from the results of their previous actions and interactions with other actors and of estimating probable outcomes based on all information available. Examples of this include algorithms that use very large databases to assist doctors in medical diagnostic tasks and deep-learning algorithms used to assist decision-making by corporate boards.

Future applications could include any strategic decision-making that optimizes a limited number of variables, such as minimizing casualties in warfare. The ethical implications of having an algorithm make decisions over military forces would be as complicated as choosing a human general, and it would risk the loss of human life due to inefficient decision-making. This same problem applies, less drastically, to corporate financial decision-making.

Where human work is relatively resistant to being replaced by learning algorithms or robotics is in the top-right quadrant (complex–meaningful). This category includes complex tasks for which a human specialist adds meaning of the process or the outcome. Examples include ethical decision-making, for which decisions are not simply a means to optimize for a limited number of variables, such as minimizing casualties or maximizing profit, but contribute to the meaningful end of the activity. Other such tasks include artistic, philosophical, therapeutic, and care tasks that are deeply intertwined with the human experience of meaningfulness.

The categorizations in Fig. 2.2 provide an overly simplistic view but expand on the previous ways of assessing the probable impact of automation by taking into account the value of experienced meaning of work activities and outcomes. When thinking about the possibilities of increasing work efficiency through automation, it must be noted that many people experience work as one of the most meaningful aspects of their lives (Csikszentmihalyi 1997).

Advances in automation have surprised us in many ways over the last two centuries. According to Goldin and Katz (2007), technological change as the engine of economic growth creates winners and losers as new technologies increase the relative demand for more skilled workers. As a solution to this, they suggest that workers have flexible skills and access to expansive educational infrastructure: “Growth and the premium to skill will be balanced and the race between technology and education will not be won by either side and prosperity will be widely shared” (p. 26). As technology races ahead, it is only a matter of time before current limitations or bottlenecks related to originality, creativity, and social skills are solved. To prepare the workforce for the next wave of automation, vocational education should

identify and acknowledge competencies that are least susceptible to automation in both generalist (knowledge of human heuristics) and specialist (development of novel ideas and artifacts) occupations and modify curricula accordingly.

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Petri Nokelainen, Dr. phil., is Professor of Engineering Pedagogy at the Tampere University of Technology (Finland). His research interests include investigation of professional growth, development of professional and vocational excellence, technology enhanced learning, and applied Bayesian methods.

Timo Nevalainen, M.A., is a Senior Lecturer in Degree Programme in Entrepreneurship and Team Leadership (Proakatemia) in Tampere University of Applied Sciences (Finland) and a Ph.D. candidate in Tampere University of Technology. His research interests comprise learning in teams and team coaching in tertiary education, research of lived experience and the roles of digital technology in workplace and education.

Kreeta Niemi, Dr. educ., is a Researcher at the Faculty of Education, University of Tampere (Finland). Her foci of research interests and expertise include practices and methods through which interaction and learning are organized in diverse settings.

Chapter 3
Collaborative Systems and Environments for Future Working Life: Towards the Integration of Workers, Systems and Manufacturing Environments

Raija Hämäläinen, Minna Lanz, and Kari T. Koskinen

3.1 Introduction

The driving force for research in the area of technology-enhanced learning in work contexts is that the world of work changes rapidly. In Europe, digitalisation involves essentially all types of working life. Technology industry's urgent challenges range from the integration of new technologies' demographic change over to volatile business environments in general. The technology industry in Finland employs 290,000 people, and if counting indirect employment, the overall impact of the technology industry employs 700,000 persons, constituting 30% of the workforce and 50% of exports. According to Eurostat, around one in ten (9.4%) of all enterprises in the EU-28's nonfinancial business economy was considered a manufacturing company in 2012: a total of 2.1 million enterprises constituting 30 million skilled and unskilled jobs and generating EUR 1620 billion of value added. The EU exports consist mainly of manufactured products: their share has annually been around 80% of total EU exports.

The European manufacturing has been moving steadily to smaller lot sizes. This requires more flexible and agile production methods, adaptive systems and human know-how (Järvenpää et al. 2016; Lanz and Tuokko 2017). The key challenge in addressing the evolution of future education in the manufacturing sector involves developing skills and expertise as well as pedagogical and technological approaches that match the changing needs of today's and future workplaces. In order to stay competitive, companies and their workers need to be able to quickly adapt to new market conditions and customer needs, which require more and more problem-solving

R. Hämäläinen (✉)
University of Jyväskylä, Jyväskylä, Finland
e-mail: raija.h.hamalainen@jyu.fi

M. Lanz • K.T. Koskinen
Tampere University of Technology, Tampere, Finland
e-mail: minna.lanz@tut.fi; kari.t.koskinen@tut.fi

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skills (Eberhard et al. 2015). To meet these needs, education calls for novel pedagogical and technological leaning approaches to enhance and trigger workers' skills. From a technological perspective, the emerging technologies include digital manufacturing, industrial Internet and cyber-physical systems (CPS). These technologies are characterised as having real-time, adaptive, decentralised decision-making and self-optimising features. Future work-life technologies are considered disruptive by nature; thus, when applied to practice, they will demand a completely new set of skills and mind-sets from workers (Berlin et al. 2016).

From a pedagogical perspective, the digital landscape influences society and its necessities regarding workers' skills (OECD 2016). The requirements of ever-evolving, technology-intensive working life are fluid and constantly transforming, and education should focus on teaching, enhancing and triggering these kinds of skills in future workers. The current trend seems to be that the importance of competency and skills is growing (Hilton 2008). More and more often in a dynamic manufacturing environment, work is based on the abilities to solve complex problems in technology-enhanced settings as well as inter-professional expertise and the shared construction of new knowledge. As a direct result of this advancement, the manufacturing sector is facing a need to improve shared problem-solving in technology-enhanced work settings to reach effective processes and work principles of future work-life needs (Berlin et al. 2016). For example, while individual skills of driving a machine were previously required in the manufacturing work for adults who have vocational education, in addition and even instead of these kinds of skills, future work-life requires that these workers have various kinds of multidomain knowledge and expertise in which they produce a new and useful output (an idea, understanding or solution) for the work community, i.e. workers with different backgrounds need to operate a machine as a team. Furthermore, it has been claimed that workers are also expected to promote innovations and shared work practices for work communities by uniting different social and technological resources. In sum, the requirements for professional skills and competences are increasing in all forms of work (Billett 2006; OECD 2016).

In the manufacturing sector, the current trend in workplaces seems to be that robotic and AI-based technologies are taking over routine tasks, leaving workers to accomplish non-routine tasks (Goos 2013). While the amount of blue-collar workplaces is decreasing, the increasing trend for future workplaces is within ICT-based manufacturing, automation and manufacturing servitisation (Manufacturing statistics 2016; Eberhard et al. 2015). Based on these trends, factories of the future are believed to need more skilled workers to meet future demands, while at the same time, a huge loss of corporate knowledge can occur if too many experienced workers retire simultaneously. The imperative to carry out economically profitable business remains a priority, but it will become more and more dependent on increasing the skills of the workforce. These global changes in work-life mean that the collective and individual success of workers depends not only on having discipline-based skills (such as practical maintenance expertise of a machine) but also on socio-cognitive skills (such as critical thinking, self-regulation and collaboration skills; Cress et al. 2015; Hyytinen 2015; Järvenoja et al. 2015). Currently, socio-cognitive

skills and strategies for handling and producing new information play a crucial role in the emerging manufacturing environments. For example, the need for problem-solving abilities in technology-enhanced settings as well as the ability to use ICT tools in decision-making is increasing. Regarding decision-making, it is not only the need for the use of technology that is increasing but also the need for higher-order thinking and collaboration skills. It is crucial that workers understand cause-effect impacts in manufacturing chains. As a direct result of this advancement, companies must attract the right talent, successfully recruit them and then keep their skilled workforce for longer to achieve long-term business success. In essence, this means that employers must ensure the healthy working conditions for the personnel, cultivate the motivation and support the competence building of the workforce through continuous training (Berlin et al. 2016; Eberhard et al. 2015).

The aim of this chapter is to summarise the research in the integration of adults' skill and competences in problem-solving in TRE and future manufacturing environments. This is done particularly from the perspective of twenty-first-century skills and learning that the development of the new technologies in the workplace has forced us to rethink. In the following, first, adults' skills and competences are discussed based on our previous results of the large-scale assessment PIAAC data to make sense of the current state of the art. Second, based on this grounding, it will be further elaborated what this means to the technological and pedagogical design of workplace learning practices utilising emerging technological landscapes. Related to that, two different empirical examples will be presented to illustrate the variety of emerging technological landscapes meeting the needs of learning in the manufacturing context. We will illustrate the teaching factory approach focusing on collaboration between inter-professional workers with different education levels (vocational, applied, higher and continuing education) to improve future labour force skills to meet the needs of evolving manufacturing. Finally, we will illuminate how a simulation-based learning environment can be applied to understand complex machine systems in future manufacturing environments.

3.2 Adults' Skills and Competences Based on PIAAC

Work in the manufacturing sector is increasingly based on inter-professional teams working together. In practice, workers with different educational backgrounds (e.g. vocational education and training (VET) and higher education) are more and more often embedded to work together. Additionally, the manufacturing sector involves workers just starting their careers as well as those who are already midst of their careers. Keeping up with changing requirements of working life applies to all workers. In practice, this means providing learning experiences for workers from whom there are no course provisions to support their occupational development. It has been argued that workplace learning experiences offer the promise of realising important personal, social and economic purposes, including important equity outcomes—interests that are often closely intertwined (Billett et al. 2008). At the same

time, from individual workers' perspective, opportunities for them to get involved in and remain in working life are dependent on their personal competences and skills (Keeley 2007). To be able to respond to the needs of learning in the context of manufacturing workplaces, we need to understand the relationship between the students' and workers' skills and their educational needs in these same realms. Adults' skills and competences are becoming an essential and fundamental prerequisite for prosperity and competitiveness. Furthermore, it has been suggested that the ability of companies and countries to respond to the information society's municipal challenges is essentially associated with workers' skills and competences.

The results of the PIAAC (the most comprehensive study of adult skills ever undertaken, led by the Organisation for Economic Co-operation and Development (OECD) showed that students' and adults' skills in literacy, numeracy and problem-solving in technology-rich environments (TREs) vary among the European countries. The general trend was that literacy, numeracy and problem-solving skills in TREs were highly correlated with each other at the individual level (see OECD 2013; Malin and Hämäläinen 2015). In short, adequate literacy is a prerequisite for good numeracy skills and problem-solving skills in TREs. Good numerical skills are also associated with good problem-solving skills, but the association is not quite as potent as literacy and the other two of these areas. Associations between literacy, numeracy and problem-solving skills in TREs and key socio-demographic background factors (gender, age, education, occupation, principal of activity, income, language and place of residence) are very similar to each other (OECD 2013; Malin et al. 2013). In Finland ($N = 5464$), literacy skills correlated with numeracy skills (0.86) and problem-solving skills in TREs (0.81). The correlation between the numeracy skills and problem-solving skills was 0.71 (Malin et al. 2013). This shows that people who have good reading skills, on average, also have good numeracy and problem-solving skills in TREs. Finally, in Finland adults seem to have overall high proficiency in problem-solving in TREs ($N = 4503$), which is highly needed in the future working life in the manufacturing sector (Hämäläinen et al. 2015). Thus, in general regarding meeting the needs of changing workplaces, the basic key competences of literacy, numeracy and problem-solving skills in TREs seem to be in reasonably good shape.

Despite the above advances, already in 2008 industrial companies were worried about the quality and quantity of vocational education and training (http://yle.fi/uutiset/3-5103963). Recent analysis of the PIAAC data establishes a genuine concern to be true (Hämäläinen et al. 2014, 2015, 2017, in press). Our analysis underlined the serious issue that, despite Finns' high proficiency in general for problem-solving in TREs, the majority of adults with a vocational education background have weak skills or lack the skills needed to solve problems in TREs. In detail, the results indicate the serious concern that more than two thirds of VET adults have weak skills or lack skills in solving problems in TREs. Furthermore, our

findings indicate that over one fifth of VET adults are at risk regarding very weak problem-solving skills. To finish, our findings indicated that the likelihood of having weak problem-solving skills is six times higher for adults with VET than for those with at least upper secondary qualifications.

In our other study ($N = 50,369$), we focused on 11 European countries that participated in the PIAAC study (Hämäläinen et al. 2014). This same trend of VET adults' weak problem-solving skills to all these countries, as only 2.7% of the employed VET adults in the data showed strong problem-solving skills. Thus, the problem-solving skills of adults with a VET background in TREs seem to be often inadequate. In addition to describing differences in problem-solving skills, our research focussed also on understanding these variations (Hämäläinen et al. 2015) and finding the associations explaining good problem-solving skills (see Hämäläinen et al. 2017, in press). We found out that using skills and learning taking place in the workplace explained 10% of the variation. In particular, practicing numeracy at work and participation in job-related adult education and training seem to have a positive association with the likelihood of strong problem-solving performance. Finally, our analysis of VET adults ($N = 12,929$) with strong problem-solving skills in 11 European countries illustrated new knowledge with respect to the socio-demographic, work-related and everyday life background factors that contribute to successful VET adults' problem-solving skills. Specifically, a continuous process of development including non-formal and informal activity as well as learning taking place at work is associated with strong performance in problem-solving skills in TREs (Hämäläinen et al. 2017, in press).

In line with these challenges and possibilities, according to Billett et al. (2008), the whole the desired educational outcome is shifting from preparation for a specific occupation skills to the capacity to demonstrate professional skills and competence upon graduation, the need to ensure learning from the contributions of both settings means a greater focus on work-related learning and its effective integration in all forms of education. In practice, workers need to learn how to operate in changing environments (Dall'Alba 2009) and how to develop integrated knowledge and skills that allows them to understand the whole labour process and to deal with new and unpredictable situations (Eraut 2004). To meet these needs, in the future, companies must be able to make better advances in technological (e.g. smart machines and systems), contextual and social resources through effective working methods and the utilisation of context-aware information. However, the use of workplace learning technology, such as social software with built-in social intelligence for supporting inter-professional problem-solving in the work context(s), in a meaningful way is still needed in the Finnish manufacturing sector. As a timely solution for this, the following two research-based examples will illustrate how to integrate these design principles within the work environments of the manufacturing sector in a novel way.

3.3 Meeting the Needs for Continuous Learning in the Manufacturing Sector

To develop employees' competencies for manufacturing environments, traditional teaching methods have limited effects (Cachay et al. 2012; Eberhard et al. 2015). Manufacturing education, as identified by Manufuture (2006), will comprise a major driver towards that direction. As noted by Rentzos et al. (2014), teaching and training have not kept pace with the advances in technology, e.g. in integrating the theory and practice (Tynjälä et al. 2014). The current practice may not be adequate in providing the workers with the continuous delivery of engineering competencies and a strong multidisciplinary background. In addition, the lack in soft skills in comparison with IT skills has been widely acknowledged by employers (Tether et al. 2005) and more recently by the PIAAC study. Since the 1990s, sets of continuous education concepts have emerged. The learning factories for education, training and research have been built up in industry and academia. In recent years, learning factory initiatives have been elevated from a local to a European and then to a worldwide level (Eberhard et al. 2015).

The learning factories were first to emerge in the 1990s led by Penn State University with a concept called a 'learning factory'. It referred to interdisciplinary hands-on senior engineering design projects with strong links and interactions within the industry sector. The main goal of the learning factory concept is to provide an industrial production environment for education purposes inside the real industrial site. A college-wide infrastructure and a 2000 m^2 facility equipped with machines, materials and tools were established and utilised to support hundreds of industry-sponsored design projects in 1995 (Eberhard et al. 2015). The learning factory is to be used for systems that address both parts of the term—it should include elements of learning or teaching as well as a production environment (Wagner et al. 2012). The learning factory concept has been realised around Europe in various forms; however, they do not belong to any official curriculum. One of the successful concepts is a teaching factory. The teaching factory concept (Rentzos et al. 2014) is based on the knowledge triangle notion supporting both academic and industrial learning. The mission is to provide engineering activities and hands-on practice under industrial conditions for university students while taking up the research results and industrial learning activities for engineers and blue-collar workers. As an extension from the other approaches, a teaching factory involves two-way communication: factory-to-classroom (Rentzos et al. 2015).

A recent study (Järvenpää et al. 2016) conducted among Finnish manufacturing companies summarised that for the large OEM companies, one of the greatest challenges was the lack of information transparency between different departments and actors in the network. On the supplier side, the difficult forecasting and unexpected disturbances, e.g. rush orders or machine breakdowns, were identified as root causes for uncertainties in manufacturing operations management. In general, the identified challenges hindering competitiveness were very similar in different company types. One of the most visible challenges was that most of the companies did not

have proper IT systems for production planning and control, such as a manufacturing execution system (MES) and advanced planning and scheduling (APS), to support rapid reactions to changes (Järvenpää et al. 2016). The adoption readability and competence level for utilising modern ICT tools was not very high among the companies. Furthermore, the study revealed that the understanding of the possibilities of current and emerging ICT technologies is relatively limited. The complexity of the emerging technologies and security (including both technical aspects and trust to partner) was considered a barrier. At the same time, the companies have realised the importance of continuous learning by adopting job circulation on the factory floor. Several of the interviewed companies mentioned that they intend to extend the job circulation among their workers on the factory floor.

Example 3.1 Integrating Physical and Virtual Learning Environment
A model for the teaching in industrial environments is the flexible manufacturing systems training centre (FMS TC) concept, which, unlike many others, has been an economically sustainable environment. The FMS TC is an industrial education environment that was established in 1997 by three different education providers, Tampere University of Technology, Tampere University of Applied Sciences and Tampere Vocational Education Institute and a local factory automation company. The driver behind establishing the FMS TC was the gap between education and work-life (Tynjälä 2008). The main focus of the environment is to provide a real-life factory environment for practical learning in different levels of education. In addition, in developing the factory environment, the critical points of TEL at work, such as easing the of use, flexibility and adaptability of the system, increasing learners' motivation, taking into account learners' needs as a starting point, creating managerial support, rethinking organisational culture, increasing the interaction between learners, facilitating learning and the inclusion of face-to-face components, were considered (see Tynjälä et al. 2014). The FMS TC is located within the company factory floor, yet it is separated from the daily production. The FMS TC provides a realistic production environment for learning different manufacturing and assembly processes, without compromising the real factory operations. The environment is constantly updated with the latest technologies (machinery, control architectures, user interfaces, etc.). The research results from the collaborative projects are implemented into the environment and demonstrated for the users. For example, the challenges of integrating new technologies in the authentic manufacturing context will indicate the technologies' maturity levels as well as their acceptance based on the students' and operators' feedback.

Table 3.1 summarises the usage of the environment on a yearly basis.

The aim of the environment is to trigger inter-professional teamwork and workplace learning (Collin et al. 2010). Specifically, from the company point of view, the environment is used for training their own customers to use the available machinery and control systems. For the Tredu, the main learning outcomes for students are the ability to operate flexible manufacturing systems and provide maintenance for single machines. The focus is on the skills relating to the management of daily operations in a semiautomated environment. The learning outcomes for TAMK students

Table 3.1 FMS TC use and user profiles

Partner	Learning goals	Education levels	Use (h/year)
Tampere University of Technology (TUT)	Problem-solving skills, decision-making, utilisation of ICT, FMS concept introduction, simulation of the system functionalities, programming of the system	3rd year to 4th year mechanical engineering and automation students (MSc Education)	64
Tampere University of Applied Sciences (TAMK)	Utilisation of ICT, programming of the system, robotics off-line programming	3rd year students (BSc Education)	132
Tampere Vocational College (Tredu)	Problem-solving skills, decision-making, maintenance of automation systems, off-line programming	Adult education	415
Fastems Oy Ab	Testing of the control software (SW) and user interfaces, training of FMS operators	Continuous education, system introductions to customers	232

are the ability to program the FMS and create off-line programs for the numerically controlled machines. The learning outcomes for the TUT students are to be able to program real and virtual systems. On the virtual side, different bottleneck simulations are used to create realistic problems to train students' critical thinking and problem-solving skills. These skills range from the mathematical problem modelling, constraints definition and implementation into the virtual production system. An example of this would be to model the part routes and material flow for the estimated production orders, run the simulation based on the defined constraints and then analyse bottlenecks and waiting times in the production. Then, apply different production control methods to existing model or change the layout of the factory; or product and material routing by adding new storage areas, warehouses or machinery; or combination of all in order to reach desired target state (Fig. 3.1).

Example 3.2 Simulation-Based Learning Environment for Understanding Complex Machine Systems

Traditionally in formal education, the emphasis has often been on reproducing what is already known, whereas workplace learning is striving for the creation of new knowledge (Goggins and Jahnke 2013). Future intelligent machines are semiautonomous or autonomous robotic systems, which are continuously adapting to working environments and self-learning tasks and processes. The continuous development of shared intelligence will change the role of many workers and their learning in this context. In practice, this enables them to create learning environments whereby the basic elements of professional expertise (i.e. practical, theoretical, self-regulative and sociocultural knowledge) can be integrated to enable workers to engage in innovative and transformative forms of learning rather than reproducing what is already known (Tynjälä et al. 2014). For example, in moving working machines, the role of the driver will more closely approximate an operator, who is controlling the operation via different user interfaces and makes control actions

Fig. 3.1 The physical environment (*left*) and digital twin of it (*right*)

only when needed. This means that the machine is capable of carrying out more complex tasks and operation chains, and therefore the operator is able to make decisions on a more general level. Thus, wider expertise related to the operation process is needed from the operator. In practice, workers need skills for acting in complex working entities in which they are surrounded by a variety of resources distributed across different technological settings and utilised both in individual and collaborative learning activities.

Illustrative working and learning environments are one solution for triggering above mentioned skills, and today, we can apply 3D techniques to empower the integration of different forms of expert knowledge (Söderström et al. 2012). A concrete example can be found from an automated mining system in which the loading of the minerals is fully automatic and the operator controls the loading process and the whole traffic of the loading machine fleet in mine (Schweikart and Soikkeli 2004). Another example of changing work descriptions is the maintenance technician who has to handle wider technology areas of intelligent machines. In his/her case, the machine will have more self-diagnostic tools to find possible items to be fixed or replaced. The industrial Internet will increase the data and knowledge of the machines significantly, creating a need to interpret the data. As a direct result of such advancement, in practice, simple routine tasks are performed automatically by computer-controlled machines, and workers need to tackle the specific problems that cannot be tackled automatically by computers or robotics. This means that workers face rapid and unexpected problem-solving situations in which knowledge is somehow implicit and directly integrated into practice. Therefore, we need novel learning solutions, such as virtual reality to help workers to developed adequate knowledge that guides them in future workplace problem-solving situations.

Virtual technologies allow students to learn in a way that is not possible in real life. From the perspective of learning, the crucial point relates to triggering competences. In particular, workers with limited previous experiences and low problem-solving skills in TREs need to develop complex arrangements that enable them to respond quickly to problem-solving situations in changing work conditions. Harteis and Billett (2013) suggested that high-level experts recognise patterns in complex arrangements that enable them to better respond spontaneously in ways that novices

would not be able to in intuitive problem-solving situations. At their best, intelligent e-learning environments can trigger learners' abilities to react in these situations. In the following picture, we can see MetViro as an example of a virtual and intelligent e-learning environment for forest machine mechanics (Palonen et al. 2007). It is possible to see inside a 3D component while it is in use to see the fluid flow and pressure changes. 3D models created from production drawings allow viewers to see components as they appear in reality. Visualisation is backed by verified dynamic real-time simulation, which creates the movements of the components. The simulation guarantees rigorous response of motion caused different given control signals. Exact 3D models and verified, dynamic real-time simulation allow testing ground for new products or constructions. The generic structure in a virtual environment enables different new components to be tested in old systems or an entirely new system to be created. Furthermore, it is possible to disassemble and assemble components from parts, create and fix faulty situations and measure flow and pressure (Fig. 3.2).

3.4 Conclusions and Discussion

The digital landscape influences the necessary skills of workers in the manufacturing sector. In this chapter, we have summarised the challenges that Europe and Finland are facing in regard to future employment in the technology industry. Based on the PIAAC findings, it is evident that a considerable portion of the workforce will have increasing challenges in the future due to the lack of knowledge, analytical mind-set and practical competence in problem-solving. There is a critical notion that people with few prior successful experiences with fully applying the key information-processing skills may not have developed adequate knowledge that guides them in the structural changes in their future workplaces. At the same time, the job markets for uneducated and unskilled workers are decreasing. In the future, the manufacturing-related jobs in Europe are increasingly knowledge based, and

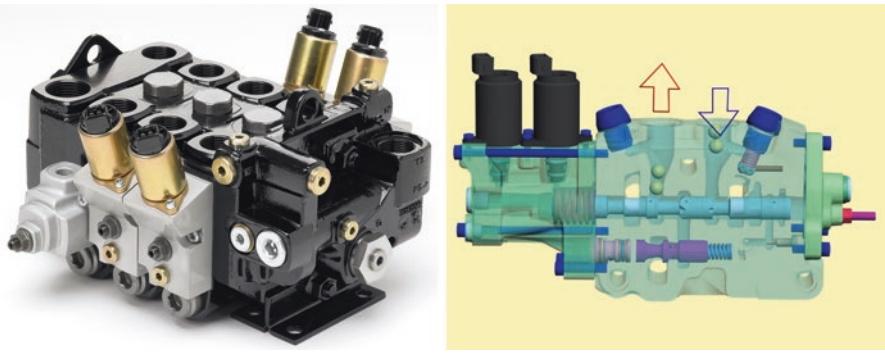

Fig. 3.2 The physical control valve (*left*) (Parker 2016) and digital twin of MetViro (*right*)

there is less need for manual labour due to the increasing level of automation in factories. Currently, approximately 10% of all employees in the automotive sector are regarded as 'highly skilled' (ACEA 2015). The share is increasing in the automotive as well as other sectors through digitalisation. Companies' ability to benefit from the emerging technologies is also highly dependent on the ability of employees on all hierarchy levels to be self-organised in unknown situations and to find creative solutions (Adolph et al. 2014).

To respond to these changes in working life, it is necessary to recognise the need and magnitude for the change. In this chapter, we have highlighted how robotisation and digitalisation will change the skills needed in the future, especially in the field of industrial processes and environments. The systems will become more complex and autonomous, not only when designing but also when maintaining and upgrading the systems. As the complexity of the systems rises, so does the amount of design faults, malfunctions and other errors in operation. Future workers must be able to cope with the multitude of possibilities when operating and maintaining them. This will require the following:

- Strong problem-solving skills
- The ability to use ICT tools
- Decision-making skills (understanding cause-effect-impact chains)
- Multidomain knowledge
- Inter-professional collaboration skills

As a direct result of this advancement, workplaces and workers need to increase their flexibility and the adaptability of the jobs and effective work. This calls for novel learning approaches. According to Tynjälä (2013), future forms of learning should enable workers to engage in social and networked rather than individual learning, as well as in innovative and transformative rather than reproductive learning. However, moving to social and networked learning is not easy. For example, problems in social interaction have been identified as the most severe barrier to collaboration (Muilenburg and Berge 2005); therefore, it is clear that enabling interaction is not sufficient, but it should be stimulated and enabled. Recent research has highlighted the kinds and qualities of interactions, such as collaboration (Tynjälä et al. 2014) and experience sharing (Collin and Paloniemi 2008), that need to be triggered to meet the needs of future workers. Therefore, research-based knowledge needs to be fully applied in enhancing the pedagogical and educational development of vocational and higher education as well as workplace learning and lifelong learning to respond to the changing needs of the workplace. The chapter provided two research-based perspectives, continuous education in a training centre or in a teaching factory and an example of CPS, as evidence-based novel learning approaches that can guide educational efforts in designing 'future' learning at manufacturing sector.

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A Full Professor Raija Hämäläinen works in the field of technology-enhanced learning at the Center for Research for Learning and Teaching at the University of Jyväskylä, Finland. Belonging to the elite or the top 5% in the world, JYU research center is among the leading European research groups in learning and teaching. Hämäläinen's research interests include workplace-learning and learning at the technology-enhanced settings.

Minna Lanz Dr. (Tech) is Associate Professor at Laboratory of Mechanical Engineering and Industrial Systems in Tampere University of Technology (Finland). Her research area includes formal knowledge representations and semantic information modelling in manufacturing domain, production system design, planning and control, and human-robot collaboration in heavy metal/discrete part manufacturing.

Kari T. Koskinen, Dr. Tech. is Professor of Fluid Power at the Tampere University of Technology (Finland). His research interests are in design and analysis of mechatronic systems, aircraft systems, aerial and underwater robotics, life-cycle management of machine and production systems, and future intelligent machines. He is Head of Laboratory of Mechanical Engineering and Industrial Systems and Director of Smart Machines and Manufacturing Competence Centre (smacc.fi) at Tampere University of Technology.

Chapter 4
Digitalization of Production, Human Capital, and Organizational Capital

Martin Schneider

4.1 Introduction

According to an old Indian story, the emperor was grateful for the invention of the chessboard and asked the inventor to name the reward he wished to receive. With the remark "All I desire is some rice to feed my family" he suggested: "Place one single grain of rice on the first square of the board, two on the second, four on the third, and so on […] so that each square receives twice as many grains as the previous." The emperor conceded the wish and was surprised to hear that he had to give away more than 18 quintillion grains of rice (Brynjolfsson and McAfee 2014, p. 44).

Brynjolfsson and McAfee (2014) retell this story to illustrate the logic of exponential growth and to explain a puzzle in the arrival of what they term the "second machine age." The second machine age is the result of a digital revolution based on a small number of general purpose technologies (Bresnahan and Trajtenberg 1995), in particular computers, communication technologies such as the Internet, and digital sensors. The new technologies are combined with each other and other inputs to create new processes, products, and business models such as e-books, intelligent robots, fully automatized factories, or e-mobility. Digitalization will eventually affect all industries and create new ones; this is after all the idea of general purpose technologies. But for now, the digital revolution seems surprisingly slow in coming. In many firms and countries, the productivity increase through digitalization has not materialized (Bloom et al. 2012).

To explain why the digital revolution will develop much like the increase in the number of rice grains when doubling from one square to the next on a chessboard, Brynjolfsson and McAfee (2014) quote the idea of "organizational capital."

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M. Schneider (✉)
University of Paderborn, Paderborn, Germany
e-mail: martin.schneider@upb.de

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Originally developed by Tomer (1987, 1990), organizational capital refers to the written and implicit routines that enable a firm to combine all other resources including technology in a productive way (Ludewig and Sadowski 2009). It overlaps with, but is not identical to, "human capital," which refers to individual worker skills and knowledge (Becker 1962). Organizational capital has considerable inertia; it changes slowly, through individual and organizational learning. To join the digital revolution, firms need to adjust their organizational capital. As this takes time, the revolution may develop slowly in the beginning.

The twin concepts of human and organizational capital are developed more fully in this paper in order to derive important implications on individual and organizational learning in the digital revolution. The second chapter argues that new digital technologies need to be complemented by human and organizational capital in order for firms to gain and defend competitive advantages in the second machine age. The third chapter argues that successfully combining IT capital, human capital, and organizational capital is subject to a number of isolating mechanisms. For example, it is socially complex and needs to be accumulated in a slow learning process. Paradoxically, competitive advantage can be achieved because its sources are ill-understood even by a firm's own management. This paradox also explains the slow arrival of the second machine age. The fourth and final chapter discusses the strengths and weaknesses of German firms in the digital revolution, based on the history of firms and their institutional environment.

4.2 IT Is not Enough: An Economic Perspective

In Sect. 4.2 it is argued that on the way to the second machine age, IT capital needs to be complemented by human and organizational capital. Section 4.2.1 discusses puzzling empirical evidence according to which digitalization has affected productivity in a surprisingly slow way. The answer to the puzzle is the need to combine IT capital with human and organizational capital. These concepts are explained in Sect. 4.2.2. In Sect. 4.2.3 it is argued that the human capital and organizational capital necessary in the second machine age are based on a so-called holistic work organization. Section 4.2.4 summarizes the literature that supports the view that a holistic work organization is widespread today and is necessary to reap the benefits of digitalization.

4.2.1 The Productivity Paradox

New computer-based technologies have been introduced since the 1970s, but at the level of the macroeconomy, the new technologies do not appear to pay off in terms of higher productivity. Pessimistic authors point out that macroeconomic productivity has actually slowed down during the time in which IT capital has been

introduced. This is considered as evidence for a secular decline of growth rates (Gordon 2015). Other authors take issue with the idea of a secular decline. They also look at data at the firm level. These show that by the 1990s, firms in the USA had been able to transform digitalization into productivity gains (Brynjolfsson and Hitt 1996). By now, there is more evidence that digitalization increases productivity at the firm level (Brynjolfsson and McAfee 2014) and the macroeconomic level (Chen et al. 2016; Niebel et al. 2017). Even in this more optimistic interpretation, however, the findings show that the second machine age is arriving slowly. The pattern resembles the chessboard example: digitalization increases productivity, but at first the effects appear negligible. Only later, in the second half of the chessboard does the digital revolution take off.

The main reason for the productivity paradox is the finding that IT is not enough: digitalization must be complemented with other investments in so-called intangible assets (Brynjolfsson and Hitt 2000; Brynjolfsson and McAfee 2014). New technology will not unfold its full potential unless it is combined with training, new work organization, and appropriate management techniques. Numerous studies have supported this view. Investment in digitalization increases productivity, but a much bigger effect is triggered by combining digitalization with other investments that enable a particular work organization (e.g., Arvanitis 2005; Bloom et al. 2012; Brynjolfsson and Hitt 2003; Brynjolfsson et al. 2002; Niebel et al. 2017). As a rule of thumb, Brynjolfsson and McAfee (2014) estimate that for every euro invested in hardware, around ten euros need to be invested in other intangible assets, most importantly human capital and organizational capital.

4.2.2 Human Capital and Organizational Capital

Traditionally, economists explained the productivity of firms by focusing on labor and capital, i.e., hours worked and machinery used. These were modeled as inputs in a production function describing the transformation of inputs into output. However, productivity increases largely stem from factors not considered in the original production function: good ideas to economize on raw materials, better work organization or communication, and better trained workers. All such factors were consigned by economists to an amorphous residual, called “technical progress” or “total factor productivity.” The residual may be thought of as the aggregate effect of intangible assets, i.e., resources that differ from the tangible assets of labor and capital.

Some of the intangible assets that today are crucial for the productivity gains are incorporated in the general purpose technologies of digitalization. IT capital is not simply more tangible, but qualitatively better capital. As the productivity paradox implies, however, even IT capital alone will not increase productivity immediately. IT capital – to unfold its productivity effect – needs to be complemented by investments in organizational and human capital, which also hide in the residual (Brynjolfsson and McAfee 2014).

"Human capital" refers to knowledge, abilities, and skills that can be used productively in firms (Becker 1962). This definition is virtually identical with the idea of individual "action skills and capabilities" (*Handlungskompetenz*, Gruber et al. 2006). Similar to competencies, human capital is based on learning and experience, and it is also a summary term for the individual resources that enable a person to fulfill a professional role or task (except perhaps for motivation). It includes information memorized by workers, their manual abilities, writing or calculating skills, and their cognitive intelligence. Becker (1962) emphasizes the distinction between general and specific human capital. General human capital refers to those competencies that can be employed in various firms and specific human capital to those competencies that can be employed only in the firm of present employment. Specific human capital, for example, can refer to information on colleagues' expertise or personality, skills in operating a machine that is only found in the firm, and an intimate familiarity with the firm's routines and culture. Human capital will always consist of an amalgam of general and specific human capital. But the analytical distinction is important in accounting for workers' and employers' willingness to finance training. As will be shown below, the specificity of human capital and of intangible assets more generally is also an important argument to explain the productivity puzzle.

"Human capital" is regularly criticized by noneconomists for reducing a human being to the monetary market value of his or her abilities. In 2004, it was chosen as the "ugliest word of the year" (*Unwort des Jahres)* in Germany (http://www.unwort-desjahres.net/index.php?id=18). Though these criticisms are plausible, "human capital" still is an instructive metaphor because it illustrates that, similar to the physical capital of machines, the resources embodied in worker's hands and minds are also productive. They are worth investing in through training, by workers, employers, and the state, because this will usually yield private and social returns. Differing from other assets, however, human capital by definition cannot be separated from the person and cannot be owned by the firm (unless we accept slavery). Of course, individual knowledge or the product of certain skills can be stored in software programs and databases. Then this knowledge also becomes an ingredient of the second type of intangible assets: organizational capital.

"Organizational capital" extends the human capital idea to the organization (Tomer 1987, 1990). In addition to the employees' individual human capital, organizations also hold productive knowledge and abilities at a collective level. "Organizational capital" refers to the productive resources that reside in organizational structures and relationships. It includes employees' willingness to cooperate, the knowledge storages, the work practices and routines, and other processes in the firm. It is part of human capital when workers know the routines and processes applied in the firm; it is stored in files, software, and handbooks of the firm; and it is embodied in the physical outlay of the factory.

Human capital and organizational capital overlap. For example, information about individual workers' skills – their human capital – that is stored in a personnel database forms part of the organizational capital. Similarly, a large part of specific human capital consists of knowledge about the firm's routines and culture. Human

capital and organizational capital in combination allow a firm to combine other inputs such as machines and IT capital in more productive ways and to improve the products and processes continuously. Furthermore, human capital and organizational capital render each firm unique. While computers and machinery are often generic, organizational relationships, work climate, routines, and individual skills are to a large part firm-specific.

4.2.3 Holistic Work Organization

Though each firm is unique, it is clear that digitalization calls for strong changes in human and organizational capital. In particular, digitalization needs to be accompanied by a fundamental change from a Tayloristic to a holistic work organization (Lindbeck and Snower 2000). A Tayloristic work organization, based on Fredrick Taylor's idea of scientific management, consists in a strong specialization of individual tasks, an emphasis on hierarchical control, a clear division of planning and executing, and minimized training requirements (e.g., Littler 1978). A holistic work organization, by contrast, emphasizes broad jobs, few hierarchical controls, decentralized decision-making, and multitask learning. The widespread transition to a holistic work organization which we observe cannot be explained by digitalization alone. It was originally spurred by more sophisticated products and more highly skilled workers. Some trends toward the holistic work organization have been noted since the 1980s, for example, the transition in many US firms from a control to a commitment human resource management system (Walton 1985) or country-specific examples of a non-Tayloristic work organization in the car industry (Jürgens et al. 1993). But the recent digitalization wave has helped holism to become a broader movement.

Two aspects of digitalization in particular spur the transition to a more holistic work organization (Lindbeck and Snower 2000). First, better information and communication technologies such as the computer and the intra- or internet enable workers to be much better informed about the entire production process. The recent "internet of things" extends the information and communication networks directly to machines and products inside and outside the firm (Atzori et al. 2010). As a result of these changes, better informed workers are able to coordinate activities with each other, customers, and suppliers. But there is also a higher need to use the available information and communicate, thus leading to more demanding jobs. Second, flexible machine tools and programmable equipment in manufacturing have changed the production process. Rather than exploiting economies of scale through large batch sizes, firms often produce differentiated, customized products in small batches. Production may be decentralized in networks of workplaces. Firms also change their business models to include services connected to the products such as maintenance or delivery (Roy et al. 2009). These trends call for a functionally flexible worker who adapts to changing products, coordinates between different steps in the production process, and continuously responds to customers.

Therefore, a holistic organization that makes full use of the new, digital technologies follows three interrelated principles (Lindbeck and Snower 2000).

Teamwork: Tasks are usually assigned not to individual workers but to teams. Teams can be permanent or project-based. In permanent teams, job rotation is often involved, i.e., team members rotate between different single jobs. Project-based teams are often formed to develop new products, improve the production process, or deliver a customized solution.

Flatter hierarchies: Holistic organizations are less hierarchical. Compared to Tayloristic organizations, there are fewer levels of supervisors to which workers have to report. Direct control becomes less important, since tasks are often assigned to self-managed teams and since the new information and communication technologies supply workers with information sufficient to decide on their own.

Decentralized decision-making: Both flatter hierarchies, and an emphasis on teamwork points to a strong delegation of decision-making to the shop-floor worker. Decisions need to be taken locally because small batches and customized products demand continuous adjustments, which would take too long in a more traditional chain of command. At the same time, decentralized decision-making is now enabled by the communication technologies.

These principles imply two important features of the typical job in a holistic organization (Lindbeck and Snower 2000).

Broader jobs: Jobs become broader and less clearly defined. Workers take on more tasks, and these include execution as well as planning and decision-making. Communication becomes more important for workers at all levels. Since products and processes evolve continuously, so does the job. Static job descriptions are obsolete. Occupational boundaries, therefore, become blurred.

Multitask learning: In addition to learning by doing the same task, workers are now requested to learn across tasks. Workers who rotate between different jobs in their team acquire broader skills than the specialized worker. Similarly, talking to customers can inform workers about necessary changes in the product, and producing a product may spark ideas for the development of related products.

Overall, broad jobs and multitask learning will shape the human capital necessary to benefit from digitalization. Then firms need more highly skilled employees who continuously update their expertise. Similarly, teamwork, flatter hierarchies, and decentralized decision-making will shape the organizational capital which digitalized firms need. Then firms' organizational capital will be much more based on direct, network-like cooperation and information exchanges among employees rather than on vertical chains of command and control.

4.2.4 Empirical Evidence

The discussion so far can be summarized in two propositions: a holistic work organization will be widespread, and it is the form of human and organizational capital which may enable firms to reap the benefits of digitalization. Both propositions are supported by substantial empirical evidence.

The "EU European Survey on Working Conditions" administered by the European Foundation for the Improvement of Living and Working Conditions provides cross-country comparative evidence for workers in 15 member countries of the European Union (EU 15). Based on data for 2000, Lorenz and Valeyre (2005) identified different types of work organizations and their relative importance in the EU 15. In addition to a Tayloristic work organization, they also find in many firms a "learning organization" and "lean production." These are similar to holistic organizations described above. The learning organization and lean production differ from taylorism in a number of important ways (Lorenz and Valeyre 2005, p. 428): workers have more discretion in choosing methods and work pace; they conduct more complex tasks, engage in more problem-solving activities, and learn more new things at work. The findings confirm the idea that holism is a widespread work organization which workers in the EU 15 encounter in their job. Furthermore, holistic organizations are the most important types of work organization – they account for 67% of all employees, compared to 14% of employees in a Tayloristic work organization (Lorenz and Valeyre 2005, p. 435).

There is also supporting evidence for the second proposition, namely, that a holistic work organization will be more common in digitalized workplaces. Based on the EU European Survey on Working Conditions in the years 1995, 2000, 2005, and 2010, Eurofound (2015) compared important job characteristics between jobs with high and those with low computer use. They find that in jobs with high computer use, workers hold more job discretion or autonomy, conduct more complex cognitive tasks (but fewer physical tasks), are more involved in training, and report more interdependencies of their tasks with other workers or customers (Eurofound 2015, p. 56). Similar evidence comes from fine-grained data on the tasks performed by workers. For western Germany, Spitz-Oener (2006) shows that in a given occupation, workers today conduct more complex tasks than by the end of the 1970s, and the change is stronger for occupations with stronger computerization. Hence, in the present digitalization wave, a pattern reappears which has characterized past episodes of new technology such as electrification of factories around 1900: new technology tends to increase the demand for skilled labor as opposed to unskilled labor ("skill-biased technological change," e.g., Goldin and Katz 1998). Overall, the evidence suggests that a transition to a holistic work organization accompanies the digitalization process.

4.3 The Slow Revolution: A Resource-Based View

The economic perspective has argued that IT alone will not be enough to trigger the transformation to the second machine age and that the necessary human and organizational capital will involve a holistic work organization. Section 4.3 adds insights from the resource-based view in strategic management, a view that helps understand the mechanisms that render it so difficult for firms to develop the intangible assets necessary to excel in the second machine age. Section 4.3.1 argues that these intangible assets, by definition, are not traded on markets and must be developed through a learning process inside firms. Section 4.3.2 identifies isolating mechanisms, i.e., important factors that inhibit follower firms to imitate advantages of pioneering firms. Overall, this view helps us to understand the paradoxical nature of human and organizational capital as a source of success.

4.3.1 Competitive Advantages

As argued in the previous chapter, the human capital which workers need in the second machine age consists of the ability to conduct more complex tasks and engage in multitask learning. Similarly, new organizational capital that firms need involves flat hierarchies, teamwork, and decentralized decision-making. There is some evidence that digitalization and a holistic work organization are complements. If this is well-known, why is it that the second machine age is so slow in coming? Why does it apparently take firms 6 years to fully reap the benefits of IT investments, and why do many workplaces still remain Tayloristic (Brynjolfsson et al. 2002)?

These questions are addressed in this section from the so-called resource-based view of the firm in strategic management (Peteraf 1993). Strategic management seeks to understand the sources of "sustained competitive advantages." Sustained competitive advantages refer to a firm's superior performance in terms of profits that a firm may defend against competitors over a number of years (Peteraf and Barney 2003). In the resource-based view, it is mostly intangible assets that can form the basis of sustained competitive advantages because such resources cannot be imitated easily by competitors (Hall 1992; Schneider 2001). The main reason for this is the specificity of intangible assets. The human capital and organizational capital bases are unique to every firm and specific to it. Therefore, there is no market for these assets; you cannot buy a holistic work organization. Such assets need to be developed and built inside the firm. As we have seen, the type of human and organizational capital important in the second machine age differs markedly from that of the first machine age. Hence, developing the necessary human and organizational capital bases implies a substantial and time-consuming effort. It is an interrelated process of individual learning and "organizational learning" (Robey et al. 2000).

By contrast, the general purpose technologies – computers, sensors, and communication devices – are much easier to build. These tangible resources are generic. They can be bought instantly and for competitive prices. Because they are so easy to acquire, however, holding these tangible assets will not endow firms with an advantage over other firms.

4.3.2 Isolating Mechanisms

In the absence of markets for intangible assets, followers of pioneering firms need to imitate these by accumulating similar human capital and organizational capital bases. Conversely, pioneering firms are isolated from followers when these find it difficult to accumulate similarly valuable intangible assets. Isolation from competition results from a number of particular mechanisms that are at work when trying to accumulate intangible assets (Dierickx and Cool 1989; Rumelt 1984):

Time compression diseconomies: Introducing holistic work organization and adapting the multitask learning approach – the learning process – may take a certain strict minimum amount of time. Hence, for followers there is no shortcut to imitate a pioneer's success. Holistic jobs are broad and involve multitasking. This is a strong challenge for manufacturing with a more traditional, Tayloristic work organization. Furthermore, the skill needs of the firm as a whole are still unclear. Technological change has traditionally led to a higher demand for highly skilled workers ("skill-biased technological change"), and digitalization will also cause a strong demand for highly skilled academics. However, the composition of skills in demand may be more complicated. Recent work has detected a polarization of the skill demand (Acemoglu and Autor 2012; Autor and Dorn 2013). According to that hypothesis, in a holistic organization it is not only workers with high formal skills, in particular engineers and other workers with academic degrees, who will be in higher demand but also workers with very few formal qualifications ("unskilled labor"). Employing the right composition of workers in terms of skills is in an important element of organizational capital. Finding this composition takes time and effort.

Social complexity: Since organizational capital resides in social relationships including organizational climate and culture, it is socially complex and cannot simply be managed, enforced, or imitated. For example, an organizational culture has been described as a possible source of competitive advantage because it is so difficult to foster; it must be created through a socialization process and defies managerial control (Barney 1986). Similarly, a holistic organization involves more teamwork than a Tayloristic organization. This calls for more cooperation among workers. Furthermore, when new technology is introduced and organizational structures are changed, certain jobs may be threatened. Job anxiety may undermine workers' willingness to cooperate in teams. More generally, the social complexity in creating human and organizational capital results from the fact that these assets are embodied in, and cannot be separated from, workers and their relations (Coff 1997).

Factors such as a lack of motivation, anxiety, conflicts, and job dissatisfaction render it difficult for firms to imitate successful firms in fostering a productive combination of human and organizational capital.

Interconnectedness of asset stocks: The process involves change and learning in a number of interconnected areas including hardware, software, individual skills, communication channels, and decision-making rights. Lagging in one area may lead to a bottleneck or suboptimal results (Milgrom and Roberts 1995). In particular, investments in hardware may be futile if workers are not able to use the new technology or if they are not allowed to decide on the basis of the new information which they receive from the IT equipment.

Asset mass efficiencies: Building intangible assets is a cumulative process in which success breeds success. The larger the stock of knowledge, the better the individual IT skills, and the more efficient digitalized processes are, the easier it will be to further improve in all these dimensions. For example, digitalization is characterized by strong network effects. Productivity gains in the Internet of things may be larger when all machines and products rather than only 80% are connected (Sauter et al. 2015). Such asset mass efficiencies will also lead to time compression diseconomies. In addition it implies that progress may be easier, the more of the way has been covered already. The latter effect closely resembles the chessboard example.

Causal ambiguity: Overall, building the human and organizational capital necessary for competitive advantage is a complex learning process. Success hinges on change in many areas. The degree of change may matter because of the network effects. The changes are interconnected. Perhaps there is only one successful combination, but perhaps there are also many successful equilibria (Milgrom and Roberts 1995). Hence, gaining competitive advantage is a trial-and-error process which nobody is fully able to oversee. Then the sources of competitive advantage will be poorly understood – not only by follower firms but even by the manager team of the pioneering firm holding the advantage. This degree of uncertainty or even ignorance is probably the best mechanism to shield off competitors.

The analysis has two important implications. First, the sources of competitive advantage of certain firms often remain opaque and ill-understood. Paradoxically, opaqueness is the very reason why intangible assets can create the foundation of competitive advantages. Second, building competitive advantages though human capital and organizational capital is a cumulative process. Firms learn and thereby become unique in their intangible assets. The ways in which they develop further depend on history and path dependence (e.g., Hall and Soskice 2001).

4.4 Implications for German Firms

In Germany, public debate on digitalization focuses on *Industrie 4.0* – the question how the proven strengths of the German economy carry over to the second machine age. The analysis in this paper has important implications for this issue. Firms develop patterns of human and organizational capital which form the basis for their

competitive advantage. The patterns are shaped by the country-specific institutional environment including labor market regulation and the system of education and training (Hall and Soskice 2001; Schneider et al. 2010). Then existing patterns of human capital and organizational capital – the path covered so far – as well as the institutional environment influence the way in which firms in Germany react to digitalization and are able to defend or establish competitive advantages. Given this institutionally embedded path dependence, what are the main strengths and weaknesses of German firms on the way to the second machine age?

In the past, many German firms in the mechanical engineering and car industry have been successful in implementing strategies of "diversified quality production" (Streeck 1991); they have been able to specialize in certain up-market niche products that yield relatively high prices. They have done so by developing a basis of intangible assets conducive to innovation and quality. This was supported by an institutional framework facilitating incremental innovation: the successive improvement of products and processes (Hall and Soskice 2001; Schneider and Paunescu 2012). Important elements of this German "variety of capitalism" are relatively strong, but cooperative industrial relations institutions (*Gewerkschaften*, *Betriebsräte*, i.e., trade unions and works councils) and a system of education and training geared toward vocational training (*Berufsausbildung*). This institutional setup, and the resulting stock of human and organizational capital accumulated by German firms, will likely enable firm to accommodate the IT capital of the second machine age. A case in point is the mechanical engineering, in particular the machine tool industry. It has successfully integrated during the 1990s computer numerically controlled (CNC) machines as well as computerized systems of production planning and management in their processes (Schneider 2008). The firms that also implemented a lean organization focusing on teamwork have been comparatively successful (Schulze-Bentrop 2013).

However, the argument that the German economy specializes in processes of incremental innovation cuts both ways. The institutional setup of the German economy is less suited, in comparison, for example, to the USA, the UK, or Denmark, to engage in processes of radical innovation (Hall and Soskice 2001; Schneider and Paunescu 2012). In electronics, software, or biotechnology, German firms are therefore not particularly successful (Schneider and Paunescu 2012; Schneider et al. 2010). Industries such as automobiles are now changing in radical ("disruptive") ways. German firms may find it difficult to reconfigure their intangible assets in appropriate ways. The difficulty may stem from a failure in some firms to adopt a holistic work organization. The findings on types of work organization in EU 15 support this view. In Germany, 64% of employees work in a holistic work organization (learning organization or lean production), compared to 75% in the UK and 82% in Denmark (Lorenz and Valeyre 2005, p. 435).

The deficit in German firms in terms of a holistic work organization can be overcome within the German institutional framework. Clearly, trade unions and works councils need to support rather than inhibit workplace transformation. But a particular challenge is workers' ability and their willingness to engage in multi-skill learning and job rotation. In terms of ability, the German system of initial training offers

a sound springboard to master the challenges of digitalization and, by international comparison, job-related continuing training is also quite frequent in German firms. However, employers need to encourage workers with occupational rather than academic skills to participate more in training (Wozny and Schneider 2014). In terms of workers' willingness to engage in learning, job or employment security seems essential to reduce job anxieties among production workers. The German institutional framework combines relatively strict employment protection with an education and training system geared toward firm-specific skills. In this variety of capitalism, a policy of "internal flexicurity" may be suitable: it expects from workers a strong engagement in learning and offers a high degree of job security in return (Heyes 2013). An important example of internal security is the combination of short-time work combined with continuing training during the crisis in 2009 (Flore 2014).

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Martin Schneider, Dr. rer. pol., is Professor of Personnel Economics at the University of Paderborn (Germany). His research interests include HR analytics and international-comparative employment relations. He is member of the interdisciplinary graduate school *Arbeit 4.0* at the University of Paderborn.

Part II
Educational Challenges on Individual Level

Chapter 5
ICT Skills and Competencies for SMEs: Results from a Structured Literature Analysis on the Individual Level

Franz Lehner and Mathias With Sundby

5.1 Introduction

Today, globalisation and the constant expansion of international infrastructure and communications have become a salient part not just of our daily life but of business activities, too. Advances especially in information and communications technologies (ICTs) are therefore of increased importance (OECD 2004, 13 ff.). SMEs are often called "the backbone of a country's economy" (EC 2014, 10). Yet, all SMEs struggle to husband their scarce resources and to allocate them efficiently (EC 2016). A clear gap has been identified between actual ICT skills and competencies, on the one hand, and the perceived importance of ICT as an important tool in perfecting organisational business strategy and boosting business success, on the other (e.g. Ambola et al. 2010; Arendt 2008; Paraskakis and Hatziapostolou 2014).

Small to medium-sized enterprises (SME) may not be large, but they are nevertheless a very powerful and important driver for the economy. The number of SMEs totals to 21.2 million in Europe: they account for almost 67% of overall jobs and as many as 99.8% of all enterprises in the non-financial business sector. Their knowledge, skills and abilities in handling IT systems have become an indispensable asset and success factor. Yet, despite the importance of IT to SMEs, skills gaps and competence shortages amongst the workforce result in it not being sufficiently exploited. This applies to companies of all sizes, although SMEs are known to be slower than large organisations in adopting new information technologies. On the other hand, SMEs could benefit much more from using IT were it not for the barriers and challenges in the areas of management skills, technological capabilities and productivity that hold them back and prevent them from achieving innovation, growth and profitability. The lack of qualified IT workers is, then, a major problem for smaller com-

F. Lehner (✉) • M.W. Sundby
Faculty of Economics, University of Passau, Innstraße, 43, 94032 Passau, Bavaria, Germany
e-mail: Franz.Lehner@uni-Passau.De

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panies. In order to get an overview of the state-of-the-art knowledge, an analysis of relevant scientific studies will be conducted in this chapter, and possible solutions will be identified. The goal is to derive concepts for SMEs that could enable them to manage their specific challenges in a highly competitive environment.

As is illustrated perfectly in the survey "Der Zeit voraus" conducted by the Boston Consulting Group (2013), early ICT adopters attain higher turnovers and create more employment than later adopters. Moreover, the ICT leaders' turnover growth advances far more compared with the average rate of GDP growth achieved by the country as a whole. SMEs are therefore under pressure to adopt and integrate both new technology and technological processes swiftly, before the gap between skills and the technology increases still further. This can only be realised if they consistently work on improving their skills and human capital, on applying innovations and on aligning ICT with their corporate strategies (OECD 2004).

The knowledge, skills and abilities needed to profit from ICT and align the company's systems to business demands have become an indispensable asset (Dorner and Lehner 2008). This applies to companies of all sizes, although SMEs are known to be slower than large ones in adopting new ICTs (OECD 2004). Despite the importance of ICT in SMEs, their exploitation at present is suboptimal, as a result of skills and competence shortages amongst the workforce (e.g. Yanqing et al. 2002; Lee et al. 2002; OECD 2004; Dorner and Lehner 2008; CompTIA 2012). On the other hand, SMEs can benefit even more than their larger competitors from using ICT to maximise their potential (e.g. Vieru et al. 2015), were it not for the barriers and challenges in the areas of management skills, technological capabilities and productivity that hold them back (OECD 2005, 4). The lack of qualified workers is a gap that SMEs need to close if they are to keep up with fast-developing technology (e.g. OECD 2004/2005; BCG 2013; CompTIA 2012; Scholarios et al. 2008, 1037; Arendt 2008; Cullen 2001; Petrova & Medlin 2009). To ensure that SMEs grow continuously, it is important to identify the barriers and search for solutions to optimise ICT usage and maximise profitability (CompTIA 2012). The OECD (2005, 10) notes how the advantages gained from doing this can be even greater for SMEs than for larger firms.

Research on ICT skills and competencies in SMEs is to be found in several sources, from 1980s up to the present day (e.g. Nelson 1982; Vieru et al. 2015), but the literature in this area so far has not been reflected upon or analysed systematically with respect to the situation at SMEs. There is a glaring and explicit need for ICT professionals (Sainsbury 2005), and this shortage is considered to pose an even higher risk to SMEs, as changes in the business environment have a bigger impact on the latter (Bernaert et al. 2014). This chapter aims to close the gap by providing specific insights and a research summary on the relevance of IT skills and IT competencies for SMEs. It can form a basis for further exploration of the topic (Fig. 5.1).

Company Category	Employees	Turnover	or	Total volume of assets
Medium-sized	< 250	≤ € 50 million		≤ € 43 million
Small	< 50	≤ € 10 million		≤ € 10 million
Micro	< 10	≤ € 2 million		≤ € 2 million

Fig. 5.1 SME characteristics (EC 2003)

5.2 Definitions and Related Work

In order to understand the challenges of ICT skills and competencies in SMEs better, it is necessary to keep the terminological demarcations apart and carefully consider the terminology. The different definitions pose an obstacle to this chapter, and indeed to this field of research in general, as the different fundamental principles are applied to samples based on disparate baselines. The existence of a number of different definitions of what constitutes a small- to medium-sized enterprise (SME) (e.g. Wielicki 2007; Ambola et al. 2010) means that some clarification is required. In this chapter, the general definition used by the European Commission will be applied (EC 2003).

It has already been stated that ICT is the backbone of modern enterprises' organisation. The framework elaborated by Caldeira and Ward (2003, 1166) shows that research results can be assigned to three levels: the individual level (skills and personal knowledge), the organisational level (organisational competencies and processes) and the business level (business capabilities and the allocation of resources to gain value). This differentiation is highly practical and is well suited to being applied as new relevant models are evaluated for further research. We follow this argumentation and distinguish between the employee level, also known as the individual level, and the organisational level. The organisational level relates to the core competencies of an enterprise, often named capabilities. The individual level addresses the employees of the firm and their individual abilities, which are often treated as skills and competencies (see Fig. 5.2).

There are several different frameworks that can be used to assess and enhance the ICT skills and competencies in enterprises. The CEN Workshop Agreement (CWA) attempts a synthesis of several of the frameworks by first presenting an in-depth analysis of the current state of ICT practitioner skills frameworks, with the long-term target of producing a European ICT skills meta-framework and clarifying its relationship to the proposed European Qualifications Framework (EQF). To find the barriers and solve the ICT skills shortage problems directly, managers prefer assessment frameworks (ICT skills assessment tools or frameworks), such as the Skills Analysis Tool (SAT), the Business Operations Skills Analysis (BOSA) or Skills Framework for the Information Age (SFIA Foundation) (Hay 2003).

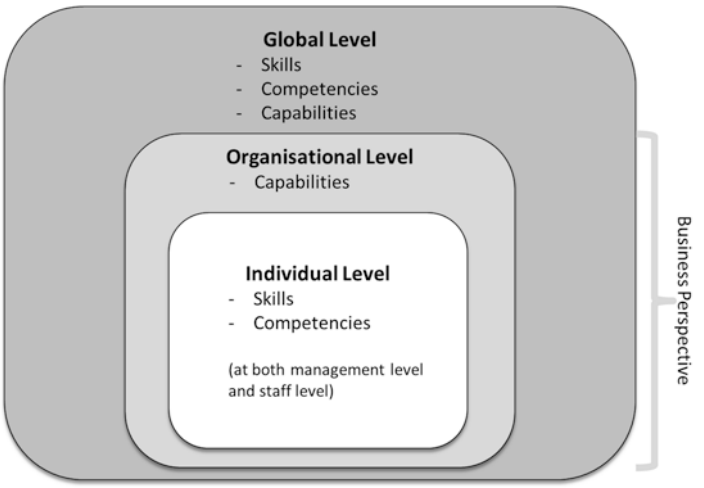

Fig. 5.2 ICT skill assessment levels (Based on Caldeira and Ward 2003)

5.3 Literature Search and Analysis Framework

The frameworks mentioned above mostly provide short-term solutions designed to enhance the skills level of the employees (Hay 2003). The frameworks there are thus focussed on the daily business and help firms to understand where the skills barriers are located. Interestingly, though the skills demanded have changed over the years (Gallivan et al. 2004), the situation in SMEs has remained largely unchanged (Bullen et al. 2007). In addition to that, the frameworks do not meet the requirements for structuring the research field overall. A specific analysis framework therefore had to be derived, together with a systematic literature analysis.

In order to identify the relevant studies, literature research was conducted along the guidelines laid down in Webster and Watson (2002). The literature databases Google Scholar, IEEE Xplore, ACM Digital Library, Springer Link and Emerald Insight were searched using the keywords "skills", "competencies", "capabilities" and "SME" and combinations of these terms with both "IT" and "ICT" and their German equivalents. The extensive search involved nearly 300 publications that dealt with ICT skills and competencies being evaluated. In a second step, they were narrowed down to a number of highly relevant sources listed in Table 5.1.

The resulting research papers were then checked with respect to their academic quality, and the final list of relevant publications was rigorously classified on the basis of the number "hits" for the different subjects. At the end of this process, it proved possible to identify 13 categories (partially comprised of subcategories) as being relevant in the context of SMEs' IT skills and competencies and to form the analysis framework:

Table 5.1 Publications included in the analysis

No.	Author(s)	Title	Year
1	Ambola, T., Goh, S. L. and Muhammad, M. Z.	Roles of UMS-LIC in overcoming ICT development challenges among SMEs in Labuan	2010
2	Antlová, K., Popelínský, L. and Tandler, J.	Long term growth of SME from the view of ICT competencies and web presentations	2011
3	Antlova, K., Gregorovič, T., Tandler, J. and Popelinský, L.	Web competencies in SME	2009
4	Arendt, L.	Barriers to ICT adoption in SMEs: how to bridge the digital divide?	2008
5	Dorner, V.	How can the value of IT skills in SMEs be assessed?	2009
6	Hay, D. B.	Skills gaps and training needs for information and communications technology in small and medium sized firms in the South East of England	2003
7	Lange, T., Lange, M. and Ottens, A. T.	SMEs and barriers to skills development: a Scottish perspective	2000
8	Marks, A. and Huzzard, T.	Employability and the ICT worker: a study of employees in Scottish small businesses	2010
9	Murphy, L., Thomas, B., Swayne, H., Metcalfe, R. and Jones, J.	An exploration of the skill and competence issues of an e-Business directed graphic design industry	2007
10	Mutula, S. M. and van Brakel, P.	ICT skills readiness for the emerging global digital economy among small businesses in developing countries: Case study of Botswana	2007
11	OECD	Skills Development and Training in SMEs, Local Economic and Employment Development (LEED)	2013
12	Paraskakis, I. and Hatziapostolou, T.	The Elevate Framework for Assessment and Certification Design for Vocational Training in European ICT SMEs	2014
13	Scholarios, D., Van der Schoot, E., and Van der Heijden, B. I. J. M.	The employability of ICT professionals. A study of European SMEs	2004
14	Scholarios, D., Van der Schoot, E., and Van der Heijden, B. I. J. M.	Employability management of ICT professionals	2006
15	Vieru, D., Bourdeau, S., Bernier, A. and Yapo, S.	Digital Competence: A Multi-dimensional Conceptualization and a Typology in an SME Context	2015
16	Yanqing, D., Mullins, R., Hamblin, D., Stanek, S., Sroka, H., Machado, V., Araujo J.	Addressing ICTs skill challenges in SMEs: insights from three country investigations	2002

- Training (to boost employability)
- ICT skills gaps
- Education (lack of knowledge)
- ICT skills
- Adoption
- Investment and value gained from ICT
- E-skills and their assessment
- ICT competence
- Supply of skills and demand for them
- ICT workforce
- ICT in organisations
- Globalisation of ICT
- Capabilities

The categories are partially overlapping and represent the different research streams related to IT skills and competencies in the context of SMEs. They form a framework model which can be applied both at the organisational and the individual level. In the next section, it will be used to analyse the selected publications at the employee level with a view to highlight the current state of knowledge with respect to IT skills and competencies for SMEs.

5.4 Analysis of the Findings at the Individual Level

5.4.1 Training (on Employability)

Training is one of the most widely debated topics at the individual level of SMEs (and at the organisational level, too), which underlines the importance of educational measures in relation to employability. As this issue is discussed in nearly every paper in the subject area, the correlation to the other topics on the subject is strong.

Almost all of the sources (except Scholarios et al. 2006) mention training, though from different points of view (Vieru et al. 2015; Marks and Huzzard 2010; Lange et al. 2000; Hay 2003; Dorner 2009; Scholarios et al. 2004). Marks and Huzzard (2010) additionally mention the changing nature of employment and employability as a factor influencing on-the-job employability. As employability itself changes, the training also has to be adapted to these changes. In order to manage the impact on employability of any on-the-job training assessment, a proper planning will be needed (Antlova et al. 2011; Lange et al. 2000; Paraskakis and Hatziapostolou 2014; Hay 2003; Dorner 2009; Murphy et al. 2007; Mutula and Van Brakel 2007; Scholarios et al. 2006).

The publications on this topic are strongly interlinked with topic 2, the ICT skills gaps. Lack of training to cope with skills shortages is mentioned in several studies (e.g. Vieru et al. 2015; Ambola et al. 2010; Antlova et al. 2011; Paraskakis and

Hatziapostolou 2014). In order to support its long-term goals and contribute to growth, the SMEs need employees with proper ICT competencies, which can be gained from educational activities (Antlova et al. 2011, 136). Arendt (2008) argues that the digital divide (formerly identified as being the main problem created by the lack of ICT knowledge revealed in SMEs) today is more affected by the "…needed education, training and management skills" (Arendt 2008, 105) than by lack of access to, and funds for, the technology.

5.4.2 ICT Skills Gaps

The digital divide (Arendt 2008), the competence gap (Ambola et al. 2010), the skills development barrier (Marks and Huzzard 2010; Lange et al. 2000) and the ICT skills gap (Hay 2003) are different terms used to describe the same shortage of ICT skills. The message is that the level of ICT knowledge in SMEs is too low, or that is has not even yet been perceived (Arendt 2008).

This subject truly addresses the main problem with respect to the ICT knowledge situation in SMEs today, with severe perception gaps existing between the actual and the perceived situation with regard to the supply of skills in SMEs. Several authors have embraced this subject as the most important, while others search for solutions in order to enhance the ICT skills level within the enterprise and ultimately gain value from ICT usage.

Several authors also describe an ICT skill development barrier (Ambola et al. 2010; Arendt 2008; Marks and Huzzard 2010; Lange et al. 2000; Hay 2003; Mutula and Van Brakel 2007; OECD 2013; Scholarios et al. 2004). In order to solve the skills shortages in the enterprise, this development barrier first has to be eliminated. As an immediate consequence of fast-changing technology, the demand for new skills is on the move, too. Arendt (2008), Lange et al. (2000) and Hay (2003) additionally point out the explicit need to close the digital divide as an overall issue, whereas Lange et al. (2000) and Mutula and Van Brakel (2007) identify the lack of governmental strategies as one of the main reasons for the current ICT skills gap.

5.4.3 Education (Lack of Knowledge)

Education is discussed in 50% of the sources based on employee numbers in the SMEs, and it is far more often discussed at the individual level than at the organisational level of SMEs. Within this subject, two directions can be distinguished:

- From an academic point of view (Ambola et al. 2010; Vieru et al. 2015; OECD 2013), there is a debate over how educational curricula can be developed so that in the future they meet the business requirements.

- From an enterprise's point of view (Arendt 2008; Antlova et al. 2011; Paraskakis and Hatziapostolou 2014; Antlova et al. 2009; OECD 2013; Scholarios et al. 2004, 2006), vocational training and improved employability in the SMEs are proposed as measures that could be taken to reduce the ICT skills gap.

5.4.4 ICT Skills

The issue of ICT skills was discussed in all publications either directly or indirectly and is closely related to the subject of training and employability.

Several models have been suggested to assess or validate ICT skills (Paraskakis and Hatziapostolou 2014; Vieru et al. 2015; Hay 2003; Dorner 2009). The assessments are supposed to identify skills shortages and consequently improve the ICT skills level. In addition to that, several sources point out the importance of the ICT skills boasted by managers (e.g. Antlova et al. 2011; Dorner 2009; Murphy et al. 2007; OECD 2013). The ICT skills sets are in constant development and are not stable (Marks and Huzzard 2010; Lange et al. 2000; Paraskakis and Hatziapostolou 2014; OECD 2013; Scholarios et al. 2006), which makes it even more difficult to evaluate the ICT skills shortages in SMEs today.

5.4.5 Adoption

Publications in this category reflect the use of ICT in SMEs, or to be more precise the low degree of ICT usage. Arendt (2008, 96) discusses the barriers to ICT adoption with the emphasis resting on the "…lack of awareness and skills…"; although the barrier is perceived to be a lack of funds, it is further argued that this gap has to be closed in order to reduce the ICT skills gap and enhance the value gained from ICT.

Vieru et al. (2015, 4681) conclude that "…in order for SMEs to benefit from ICT, SME employees need to better understand the challenges confronting SMEs that hamper the adoption and use of ICT": the problem is identified as lying in the fact that SME employees do not have the proper digital competence which is important for value creation through ICT innovations in SMEs. The only option is to boost training and education on ICT so that SMEs can "…keep up with the new economy" (Vieru et al. 2015, 4689). Antlova et al. (2011) cite poor organisational readiness, insufficient skills and knowledge as reasons for a slow adoption of ICT – leading to slower improvements in the areas of decreasing costs, cutting the number of errors, slashing inventories, creating new market opportunities and improving communications and cooperation with customers and suppliers.

5.4.6 Investment and Value Gained from ICT

The value to be gained from ICT is seen as one of the main reasons for implementing ICT in the firm (e.g. Vieru et al. 2015; Arendt 2008; Antlova et al. 2011; Dorner 2009; OECD 2013; Scholarios et al. 2004). Antlova et al. (2011), Antlova and Popelinsky (2009) and OECD (2013) further identify long-term growth as a motivation. Competitiveness is added by Dorner (2009) and Vieru et al. (2015) as well as Hay (2003), who also points to innovations as an important tool in order to gain value from ICT.

Investment and value gained from ICT is discussed from several different perspectives. Dorner (2009) proposes a model for assessing the value of IT personnel and suggests that "…if SMEs had more information about their competitive position and their IS/IT position, they would be more willing to invest in IT personnel" (Dorner 2009, 169). Vieru et al. (2015) discuss the value creation through innovation in SMEs and investments made at the employee level of ICT skills. Sufficient ICT knowledge is also felt to be important by Arendt (2008) and is rooted in the importance of investing in training employees in order to increase the capacity for ICT to be adopted and implemented in SMEs, which in turn has an impact on the business success of SMEs.

5.4.7 E-Skills and Their Assessment

Web competencies and skills are without doubt most important today. Hay (2003) argues that E-skills "…should be the focus for significant staff development and training in innovative firms". The connection to the ICT skills gap is also cited by Yanquing et al. (2002, 439), who argue that "…SMEs are eager to embrace e-commerce and e-business and attempt to turn the e-commerce opportunities into real business benefits, lack of skills and expertise [thus] become a major barrier…".

The ICT skills gap can very much be seen as being located at this "new" level of the skills demanded, "…although SMEs are increasingly better equipped with computers and access to the internet, the extent of their use of ICTs for business purposes, particularly including e-commerce and e-banking and most importantly training of employees with the use of e-learning, is still insufficient" (Arendt 2008, 106).

5.4.8 ICT Competence

This issue is considered from two different points of view. Vieru et al. (2015) and Scholarios et al. (2006) both consider the individual digital competencies to be an important focus of general ICT competencies deliberations, in order for the firm to

be able to focus on the employees in the larger context and enhance their individual knowledge and competencies.

Vieru et al. (2015) create a conceptual framework that addresses digital competencies (DC) in SMEs. This framework will ease the process of business planning, along with the mapping of what skills are present in the enterprise, which is linked by Antlova et al. (2011) to the increased competitiveness of the SME, in the long-term, too. Antlova et al. (2011, 139) further argue that "The ICT competencies refer to a firm's capacity to deploy its material and intangible resources, usually in combination with skills, to reach desired goals", as these competencies have been associated with enhanced commercial performance by SMEs.

Marks and Huzzard (2010) examined the nature and requirements for employability in the ICT sector SMEs and found that entry-level qualifications were important. The skills shortages are not eliminated with current competence development, which "…occurs informally on the job, for example, through self-tuition via the Internet and not through formalized classroom learning" (Marks and Huzzard 2010, 178). Paraskakis and Hatziapostolou (2014) also discuss vocational training, proposing a methodology to support SMEs in the design of their training. Furthermore, it is stated that "Vocational education and training must equip young learners with skills directly relevant to evolving labor markets, such as e-skills, and highly developed key competences" (Paraskakis and Hatziapostolou 2014, 59).

5.4.9 Supply of Skills and Demand for Them

Scholarios et al. (2004) feel that the supply of skills, and the demand for them, is governed by the ICT skills shortage in the market. Ambola et al. (2010) emphasise the importance of communications between academia (universities and other educational institutions) and the job market (source of demand). Marks and Huzzard (2010) and Hay (2003) consider the importance of balancing both hard and soft skills in education. Marks and Huzzard (2010, 176) discuss, moreover, the importance of formally providing ongoing competence development, as private-based solutions often lead to "…skills stagnation within the industry".

Both Hay (2003) and Ambola et al. (2010) mention the skills shortage. Hay (2003) suggests using an assessment framework for the workers to analyse academic and vocational skills. Ambola et al. (2010), on the other hand, study the different perceptions that exist between academia (UMS KAL University) and the job market (SMEs in Labuan) and how they, in turn, can organise related programmes in order to supply the job market with the actual skills needed. Marks and Huzzard (2010, 178) argue, "The sector is not open for those straight out of education or those wishing to transfer or update their skills". This is extremely unfortunate for the economy and from a macroeconomic perspective of ICT skills and competencies, as the ICT skills gap consequently continues to grow.

5.4.10 ICT Workforce

The employee level is naturally more likely to discuss the skills and competencies with regard to the workforce in the SME than publications concentrating on the organisational level. Marks and Huzzard (2010, 175) link up the issues of employability, skills and training with the ICT worker employability, arguing that "…technology-based qualifications are becoming less important for employability and that non-technical graduates could be trained to possess the relevant skills".

The link between employability and the ICT workforce is also found in Hay (2003), but with the focus on the lack of ICT skills in SMEs and the importance of "…promoting individual and employer participation in learning" (Hay 2003). Dorner (2009) elaborates a testable model for assessing the value of IT personnel, which the SME managers may use "…as a guide in their strategic IS/IT planning process" and for "…IT personnel investment by SMEs" (Dorner 2009, 169).

5.4.11 ICT in Organisations, Globalisation of ICT, and Competence

No significant studies were found discussing the remaining issues in the analysis framework at the individual level. In order to avoid a repetition of already-cited arguments, a further discussion of these issues has been omitted.

5.5 Conclusion

The analysis of the relevant literature shows that an ICT skills gap does indeed prevail and is considered to be a major problem in most of the articles. The skills gap needs to be closed, both with the aid of greater awareness amongst enterprises of the importance of individual learning measures (suppliers of employability and training) and, at the educational level in academia, by improving the coordination and communication of the skills needed (Petrova & Medlin 2009). The real challenge is "…to facilitate changes in attitude, improve access and provision and alter the current financial incentives for skills development" (Lange et al. 2010, 11). Closing the gap is the responsibility of all agents participating: on the demand side (job market), there is a need for vocational training to be boosted, and on the supply side (academia), there is a need for the curricula and education to be updated (Petrova & Medlin 2009; Wielicki 2007).

Investment and value gained from ICT is generally an important issue for SMEs, if only because of their scarce resources and the fierce competition they face (Bernaert et al. 2014; EC 2016). Vieru et al. (2015) summarise the reasoning by explaining how ICT innovation creates value: however, today SMEs suffer more than ever from their inability to acquire relevant skills and expertise in new tech-

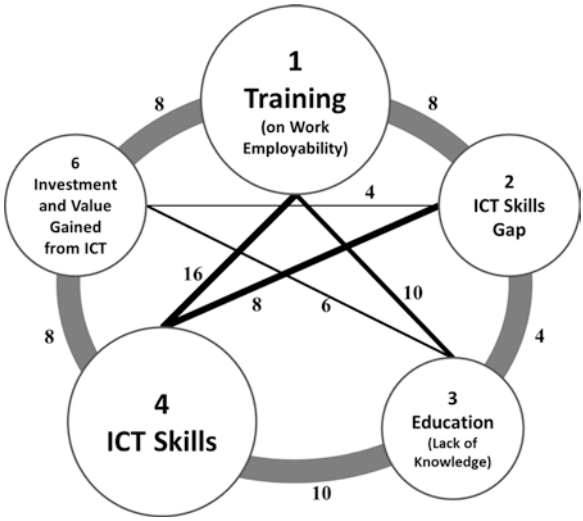

Fig. 5.3 Concept mapping of the top five aspects on the individual level

nologies, combined with a lack of training and education (Vieru et al. 2015). E-skills and systems are important if SMEs are to succeed in the modern marketplace (Vieru et al. 2015). The enterprises should orientate their business as swiftly as possible to this technology (BCG 2013). Without the knowledge of how to benefit from the opportunities offered by E-Commerce, E-Banking, E-Learning and other such things, the SMEs risk experiencing a loss in market share and in the amount of value they can create.

Todd et al. (1995) discuss IS job skills based on advertisements from 1970 to 1990. Their findings showed a significant increase in references to technical skills for both programmers and analysts and a slight increase for managers. Unfortunately, in view of the major technical developments seen since then, the findings of their study are no longer up to date. Nevertheless, their methodological approach is interesting and a replication of the study could help to highlight what skills are currently in demand.

Finally, Fig. 5.3 illustrates the top five research streams on ICT skills and competencies in the field of SMEs. The numbers attached to the lines count the research papers dealing with interconnections between the main issues. Only a small number of businesses are exactly where they want to be regarding their ICT skills sets. Consequently, the majority are seeking a significant improvement on the ICT skills front. With the help of the framework, a structured literature review has been carried out, and this has successfully helped us to map out the research in this under-investigated field of knowledge. For the first time, it has proved possible to provide a comprehensive summary of the specialised research literature on ICT skills for SMEs. The result is at the moment more like a patchwork and undoubtedly requires further investigation. The categories used in the analysis framework are not selective enough and need to be specified more precisely. However, the summary of research can help us to better understand the situation in practice and can serve as a starting point for future research.

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Dr. Franz Lehner is full professor and holds the Chair of Information Systems (Wirtschaftsinformatik) at the University of Passau (Germany). His research interests cover the areas of knowledge and information management, e-learning, mobile applications and cloud computing.

Mathias With Sundby is research scholar in Information Systems. He received his diploma in Business Administration from the University of Passau and is currently continuing his studies at the University Edinburgh. In his research he was focusing on IT skills and capabilities.

Chapter 6
Effects of Digitalized and Flexible Workplaces on Parenthood: New Concepts in Gender Relations or a Return to Traditional Gender Roles?

Anne-Dorothee Warmuth and Ilke Glockentöger

6.1 Introduction

Sociologist Rosa argues that presently "everything has *no* time" (Rosa 2009, p. 33).[1] He describes the problem as follows: All things – meaning whole phases of life and biographical chapters, activities, etc. – are left with a decreasing time of their own ("Eigenzeit"). Rosa sees this phenomenon confirmed specifically in the relationship between family and professional life: "Generally speaking the differentiation in location and time between professional and private areas of life is decreasing. […] From all areas of life, the late modern figures receive calls, messages and information throughout the day. And they themselves become active for these spheres at any possible time of day, resulting in all these spheres of life being present simultaneously" (Rosa 2009, pp. 33–34). Rosa's thesis implies furthermore that nothing has a place anymore. A lifestyle without the overlapping of these areas of life including their inner logic and without the lack of time was guaranteed in Fordism (Rosa 2009, p. 31). Nickel (2015, p. 28) also diagnosed a current crises, particularly in regard to the underlying gender relations.

Both authors refer to a kind of relationship between private and professional life, prominent during the 1970s and 1980s in West Germany and partly other western countries, which is mainly used as a background in the discussions of recent changes: the so-called normal working relationship (Jurczyk et al. 2009; Wimbauer 2012; Kratzer and Sauer 2005; Kirschenbauer 2015, p. 48). This working relationship

[1] German quotes were literally translated into English.

A.-D. Warmuth (✉)
University of Paderborn, Paderborn, Germany
e-mail: awarmuth@mail.upb.de

I. Glockentöger
North Rhine-Westphalia State Institute for Schools and Professional Development, Soest, Germany
e-mail: Ilke.Glockentoeger@qua-lis.nrw.de

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is based on a mostly contractual secured employment relationship. It lasts until retirement, consists of defined working hours creating a distinct separation between private and professional areas of life, and for the most part takes place at a set place of work with the requirement of relatively uniform qualifications (Kratzer and Sauer 2005, p. 94). Realistically, the abovementioned type of employment has always been reserved for the male section of the population. In regard to the division of tasks within the family, this type of employment is referred to as "the breadwinner model", in which the female counterpart is expected to take over the *family* work, unremunerated and also renouncing any kind of employment. Due to the increasing labor participation of women, the dissolution of boundaries and the increasing flexibility within the employment market, the ratio has shifted. Meanwhile, the classic "breadwinner model" is being replaced by the "modernized provider marriage" (Alemann and Oechsle 2015, p. 298), which is the most common way of life of couples in Germany, where woman have, at the least, a part-time job. This has resulted in tensions between private and personal areas, in particularly affecting the gender relations within the family.

By now the German female employment rate has increased to 71.5% (data of 2012, Statistisches Bundesamt 2014). In comparison to men, women mainly still work part-time due to family duties, whereas only a quarter of men who work part-time do this because of family duties (Kirschenbauer 2015, p. 68). In correspondence thereto, women increasingly work under precarious conditions and show discontinuous career patterns due to parental leave (Wimbauer 2012, p. 81; Nickel 2015; Jurczyk et al. 2009, p. 93). In addition, the earnings of women remain at a low level: the Gender Pay Gap 2015 in Germany of more than 21% has remained close to constant over the years (Statistisches Bundesamt 2016). Although difficulties of work-life balance for men are increasingly discussed (Kapella and Rille-Pfeiffer 2011; Schier 2014, p. 261; Bultemeier 2015, pp. 283–285), the concept of "double socialization of women" ("Doppelte Vergesellschaftung") in both career and family life (Regina Becker-Schmidt 2010) continues to apply. Women are therefore encouraged to ensure their equality to men in regard to employment behavior. Nevertheless, most employment relationships and social infrastructures in relation to social care still require a fulltime (female) caregiver for children, the elderly, etc. and housekeeping. More than half of all couples in Germany organize the family work in the way that women do the greater part of the housekeeping (Alemann and Oechsle 2015, p. 299).

At the same time higher paying positions reserved for highly qualified individuals require "around-the-clock" availability and a high flexibility concerning working hours and office location. Alemann and Oechsle diagnosed a very slow moving "culture change within organizations", in fact the "unrestricted availability standards and gender cultures which still gives female employees the main responsibility for care work" (Alemann and Oechsle 2015, p. 315) remain the norm. Wimbauer (2012) also draws attention to the fact that the requirements of the male-dominated labor market (p. 96) cause the workload within private areas, regarding household

responsibilities, to be unevenly distributed between the partners. Women either take on the majority of the work themselves (Wimbauer 2012) or, as frequently done in Eastern Europe, the work is redistributed from women from higher-income countries to women from lower-income countries (Rerrich 2008; Palenga-Möllenbeck 2014). In this regard, Hochschild (2000) coined the phrase "Global Care Chains."

This problem is notably affected by a further development that, in differentiation to the normal working relationship, can be described with terms like "entreployee" (Pongratz and Voß 2004) or the "entrepreneurial self" (Bröckling 2007). It is understood that the normal working relationship in the wake of the processes of dissolution of boundaries, flexibilization, and digitalization is entering a process of dissolution (Kratzer and Sauer 2005; Jurczyk 2010; Schier 2014; Kirschenbauer 2015, p. 48). From employees an appropriate self-organization and self-presentation are expected (Kratzer and Sauer 2005, p. 93; Nickel 2015, p. 33), in which they do not claim free time anymore, are available at any time, and waive claims to boundaries between private and professional areas of life (Wagner 2013). In accordance, Jurczyk refers to the term dissolution of boundaries as influencing and being influenced by both family and gender relations (Jurczyk 2014, pp. 172–173).

For this article the question arises on how individuals will deal with the described processes and how they will cope with the required actions within the various areas of life. We are taking into consideration mainly heterosexual couples with children as we assume that in these relations, the models of masculinity and femininity as described through the "gender characters" ("Geschlechtscharaktere" Hausen 1976) emerge in a particular way.

We are particularly interested whether the dissolution of boundaries – for example, through the digitalization process, which enables working at various locations at flexible times – holds the potential of breaking down the traditional gender relations. Thereafter, we will sketch a discourse on the subject of the dissolution of boundaries, flexibilization, and digitalization, dedicating ourselves to focusing on gender relations. We are taking into consideration mainly occupations in which the dissolution of boundaries has always been constitutive and will intensify in connection with digitalization processes. These occupations are mainly cultural occupations, the IT industry, and the field of science.

6.2 Flexibilization, Digitalization, Labor Market, and Gender Relations

The following chapter introduces two theoretical concepts of employment with dissolved boarders and nowadays changes of workplaces. In particular, it is shown how digitalization influences the described working conditions. Furthermore, the possible effects of these developments on family life and gender relations are examined.

6.2.1 Boundaryless Employment Conditions

In sociology, there has been an ongoing debate about the dissolution of boarders within employment conditions. Here, two theories are pioneering, which attempt to describe the change from the perspective of the employees and the main challenges faced by them. Often discussed (and also criticized) (exemplary Bröckling 2007; Kratzer and Sauer 2005) is the thesis of Pongratz and Voß (2004, p. 9) about the "entreployee" as a new increasing type of employee who simultaneously represents himself as entrepreneurial employer. According to the authors, the entreployee appears in sectors in which more self-responsibility is required, sectors that are identified by a relative small standardization of employment conditions as in IT, consulting, and media sectors. On the other hand, we have the employee working under normal working conditions, who carries out their mainly standardized duties and has stipulated and regulated conditions of employment. The entreployee is defined by characteristics like "self-control," "self-commodification," and "self-rationalization" (Pongratz and Voß 2004, p. 24). At the same time, in spite of the high independent organization and self-responsibility, the performance of the entreployee is evaluated in accordance with clear objectives. Although this ideal type can be particularly found in sectors requiring higher qualifications, the authors specify that generally speaking the entreployee can increasingly be found working under normal working conditions. The renunciation of prescribed workflows and processes (Nickel 2015, p. 35) can create a new sense of freedom, because activities do not have to be carried out at a specified location and within a specified time span. However, promises for autonomy within such dissolution processes lead to increased performance pressures (Pongratz and Voß 2004, p. 22) and are therefore still seen in a negative light. Simultaneously, because of increasing media exposure and digitalization, we can assume that it is becoming more of a challenge for the employee to define boundaries and to claim time with their families, as they can ultimately be reached everywhere. Moosbrugger (2012, p. 143) assumes that as a result thereof, a "prisoner's dilemma" will occur, due to the individual continuously watching others and being watched by others. If colleagues are available when on holiday, it becomes difficult not to apply these standards to yourself (see also Wagner 2013).

Nowadays, considerations and explorations of boundaryless employment conditions increasingly include questions regarding gender issues (see Wimbauer 2012). In their study of employees in different companies, in which the work processes were more project orientated and performed in groups, Pongratz and Voß (2004) could prove the existence of a gender bias. It was evident that particularly women working on projects conform to the ideal type and have a higher flexibility and reflexivity in regard to often contradictory demands from different areas. The authors interpret this as a result of the earlier confrontation with (probably) family needs. Contrary to men, for women it is unavoidable to deal with the question, whether they want a family and how they want to coordinate their family life with their career. As also shown by articles from men's studies (exemplary Meuser 2010, 2012), the majority of men, opposed to women, cling to the idea of normal male

labor, even when this idea has no more bearing. Therefore the changed employment conditions create particular insecurity for men (here Pongratz and Voß 2004, pp. 209–214).

Bröckling (2007) also considered the change of employment conditions in his thesis of the "entrepreneurial self" with focus on the appeal to subjectification. The "entrepreneurial self" represents a "bundle of interpretive schemes with which people measure themselves and their social existence, orientating themselves towards standard requirement and offered roles and regulating their behavior with institutional arrangements, social and self- technology" (Bröckling 2007, p. 7). This means that the individual with the promise of "autonomy, self-realization and non-alienated labor" (Bröckling 2007, p. 58) is increasingly confronted with the requirement of self-reflection to optimize their own occupational actions in a continuous adjustment process. Within this framework the individual carries the responsibility for failure of the self-optimization process. McRobbie (2009) recorded this phenomenon for young women in context of the entanglement of postfeminism and neoliberalism in Great Britain: "Having a well-planned life emerges as a social norm of contemporary femininity. And conversely the absence of such styles of self-organization becomes an indicator of pathology, a signal of failure or a symptom of some other personal difficulties" (p. 77).

Herein the entanglement of gender and employment relations is illustrated in an increased form: According to this logic, the challenge of harmonizing the different aspects of life rests solely on the individual. In correspondence thereto, Rerrich (2008, p. 19) criticizes that public debates give the impression that the interfamily division of tasks is an individual problem of the partners, which can be solved by their negotiation. However, the altered employment relations do not only create the risk of work overload but also the promise of a balanced relationship between work life and personal life, which becomes noticeable in terms such as "work-life-balance" (Kratzer et al. 2015, p. 14; Beneder 2013).

6.2.2 Digitalization in the Professional World and Gender Questions

Digitalization is one of the groundbreaking changes in today's world of work. Digitalization encompasses a number of levels pertaining to either newly created occupations in IT or providing the benefit of shortened business processes as a result of increased digitalization of the formerly standardized processes. New information technologies create the opportunity to work everywhere by being able to communicate with one another over long distance and at any time. Besides the extensive changes in the work processes, knowledge management, and the methods of communication (Funken and Schulz-Schaeffer 2008), according to sociological research, digitalization is also regarded as being responsible for the intensification of work and flexibilization of working relations (Carstensen 2016, p. 14). In popular

scientific literature, digitalization is regarded as one of the essential factors responsible for the change in the professional world (Väth 2016). Digitalization has already reached the area of industrial manufacturing and brought about change in traditional industrial work, termed "Industrie 4.0" (Hirsch-Kreinsen et al. 2015).

The previously mentioned dissolution of boundaries in regard to time and location of working relations only becomes possible through digitalization and the abstinence of permanent presence at the workplace. In 2005 Kleemann has already shown that supporting employees by allowing them to work from home causes a potential increase in working hours which cuts far into private time (pp. 78–79). According to employees, digitalization has an immense effect on the business practice and contains positive and negative aspects (Kirschenbauer 2015, pp. 45–48). Empirical research shows a correlation between being available around the clock, also during the time at work, and the increase in stress and stress-related health issues (Carstensen 2016, p. 178). In her survey regarding the usage of social media in the workplace, Carstensen identifies Cloud- and Crowdwork as new developments. Work tasks are being assigned in small amounts to freelancers via Internet platforms – in Pongratz and Voß' words: to typical entreployees. In this regard, there are possibilities of monitoring the output and behavior of the employees. Also a new form of social inequality and a divide within the professional world rise due to the use and missing use of the World Wide Web and social media as an essential feature of digital development (Carstensen 2016, pp. 177–186).

The digitalization of the professional world is publicly discussed and is part of a political agenda. The government department of education and research and the institute of vocational education examine abilities and skills employees would need to work digitally in the future (BIBB 2016). Also the labor unions are asking the questions regarding how digitalization will influence the labor market and what this will mean for the development of the workforce. Gender questions in relation to digitalization are by all means significant in this regard. As a rule, it can be assumed that digital technology in the workplace contributes to the construction of a bipolar gender concept and to hierarchical gender relations (exemplary Tigges 2008, p. 40). Nevertheless digitalization in the workplace is obviously also associated with providing hope of changes in gender relations. For example, the questions that arose at the conference "Arbeit 4.0 – Blind Spot Gender," hosted by the German Institute for Economic Research and the Friedrich Ebert Foundation, were "which connection exists between new forms of economic activity and gender relations" and "in what way is inequality, like stereotypes, reproduced or dissolved" (DIW 2016).

It is feared that digitalization will lead to the exclusion of women: "We are in danger of creating a new labor market through digitalization where women will not have a place anymore" (Bultemeier and Marrs 2016, p. 27). "The diminishing requirement of attendance as a main power resource in the struggle for career opportunities" (Bultemeier and Marrs 2016, p. 8) can become very difficult for women on their way up the career ladder when focusing on maximum availability of employees as required by the employer. Nevertheless, these predictions remain contradictory: The model of increased availability of executives through digital media may

seem unattractive, especially for women, but at the same time creates opportunities for better reconciliation of family life and work life (Kirschenbauer 2015, pp. 76–78).

6.2.3 *Family, Gender Relations, and Gainful Employment: Entangled Dissolution of Boundaries*

The described dissolution of boundaries does not only influence the professional life but also gender relations and the family in particular. The information set out below differentiates between the dissolution of boundaries within the family and the dissolution of boundaries, caused by the juggle between career and family. Although these dimensions are interdependent, we will be focusing primarily on the boundaryless state of career and family life in regard to location and time. It is assumed that these spheres of life have different requirements and follow a different logic (Wimbauer 2012, p. 163) that frequently stands in conflict with one another.

"Family is not a private matter, although family is situated in the private life. Family is the invisible flip side of the employment system and the welfare system without which the two […] could not manage" (Jurczyk 2014, p. 171). The reproduction and production spheres are therefore inevitably interdependent, as the one is responsible for the existence of the other (also Nickel 2015, p. 42). Although family demands, more than ever before, are challenging organizations and employees to strike a balance between professional and private areas of life, it shows that politics and companies have not yet attuned to these changes. Jurczyk et al. (2009, pp. 57–58) critically classify the modernization as "patriarchal" in the sense that in spite of several adjustments in modern working life, it is still required that one person (mainly women) is still accountable for all family responsibilities on top of the job. Because families can hardly manage the contradictory requirements, Jurczyk (2010) assumes that a crisis regarding the capacity to care for the family will occur, where at the moment, as described by Rosa, not only the *time* but also the *location* is lacking.

Families are increasingly required, of their own accord, to set boundaries between professional and private areas of their lives, creating family time, taking into regard the various demands of all the individuals involved. Jurczyk et al. (2009) termed these roles played by individuals as "Doing Boundary" (p. 62) and "Doing Family" (p. 68). Employees quite emphasize the aspect of autonomy regarding the organization of professional and private areas of life (Kirschenbauer 2015, pp. 55–60). Nevertheless, the attempt to replace or balance the lack of social frameworks leads to an overload of work and family and a lack of self-care (Jurczyk 2014, pp. 54–55; Jurczyk and Szymenderski 2012, p. 102), especially for women.

Women are very often faced with contradictory requirements: Despite their constant commitments, which mothers more than fathers continuously need to prove to their employers, women are required to deal with the reproductive labor within the household and also meet the high demands of being a mother (Wimbauer 2012,

p. 319). At the same time, positions with career opportunities require an increased commitment which is normally incompatible with family care – typical male and female careers with the Gender Pay Gap are continuously reproduced. Hofbauer (2008, pp. 247–249) illustrates the persistence of gender power structures by means of attendance and overtime of male employees: Guided by the assumption that the latter seldom occurs to manage the workload, but instead to show a certain attendance also at unusual working hours, she comes to the conclusion that overtime mainly shows the high level of willingness to perform. Also in the wake of the dissolution of boundaries and digitalization of the workplace, the indication of attendance can, by sending e-mails late at night, show a high level of male willingness to perform and thereby maintain the existing male-dominated power structures (Hofbauer 2008). Considering the previously mentioned "prisoner's dilemma" (Moosbrugger 2012), the question arises whether this behavior is ultimately always driven by the own desire to retain power or rather the need to adapt to colleagues' show of manhood.

However, men are also confronted with diverging requirements arising from the family sphere and work sphere. Based on the project "boundaryless work – boundaryless family," Jurczyk and Szymenderski (2012) highlight that "extensive working hours combined with the pressure of being constantly available and strong work related ambitions, [lead] to a lack of family time" (p. 97) and create for both mother *and* father a feeling of guilt towards family *and* career and do not meet the needs for shared family time.

However, it remains a financial question whether a family can afford a supporting caretaker or childcare, which allows for an earlier reentry by the mother into the labor market or maintaining constant working hours of both parents (Auth et al. 2015, p. 46). This example shows that recent circumstances lead to an adding up of social and gender inequality (see also Jurczyk et al. 2009, p. 26).

In correspondence, research widely demands that working hour models are adjusted to time for family care in a way that working hours are reduced for both partners or that working hours can be aligned with the different caretaking needs (Sorger 2014, pp. 145–148).

6.3 Gender Relations in a State of Upheaval: Consequences of Flexible Working Conditions on Family and Parenthood

The following part is divided into two sections: First, theoretical considerations about the consequences of flexible working conditions on family and parenthood are made. Second, empirical results are introduced on this issue.

6.3.1 Theoretical Considerations

To understand why men, in spite of wanting to be more present in family life, often cling to a traditional breadwinner model (exemplary Jurczyk 2010; Kapella and Rille-Pfeiffer 2011), it is beneficial to consider social models and narratives. These seem to be rather stable, not only in regard to models of masculinity but also to models of femininity.

According to gender studies, particularly men's studies, there is still a conflict between family work like childcare and the accepted ideal of hegemonic masculinity (Connell 1987), which requires a successful integration into the labor market: "Traditionally, fatherhood is determined more by a father's position in the professional sphere rather than his intra-family practice – in contrast to motherhood, which involves mothering as a main feature. The time the father dedicates to his profession is in the specific sense also time for the family, even if it is not spent with the family" (Meuser and Behnke 2012, p. 130). This contradiction manifests itself not only in the practices of the involved parties but also in the social structures on the level of companies, which implicitly or explicitly still require a high degree of availability from men (exemplary Wimbauer 2012, p. 321).

The connotation between females and caretaking – which can be seen in the naturalization of motherly love since the eighteenth century (Badinter 1981; Schütze 1986) – continues to the present day and manifests itself in the previously mentioned conflicting demands made of women: having to be a "good mother" despite a high commitment to work. McRobbie (2009) dealt with the supposed adaptation of feministic issues for the purpose of neoliberalism in relation to Great Britain and stated: "Government is certainly not encouraging women back into the home after having children. The new sexual contract instead offers support and guidance so that the return to employment (often part-time) is facilitated in the form of a work-life balance. There is an implicit trade off, what the working mother wants or needs from her employer is recognition of her dual role, and some degree of accommodation in this respect" (p. 80). At the same time, McRobbie shows how the traditional demands on females remain unchanged on other levels. Therefore Sorger (2014, pp. 139) is critical of the focus on the reconciliation of family and career, because *primarily* women are addressed regarding this matter.

It is still a fundamental problem that caretaking is seen as "dirty work" (Jurczyk 2010, p. 73) rather than as a valuable and crucial foundation for the society. However, a distinctive differentiation between caregivers for children and geriatric caregivers is being made where caregivers for children hold a higher social regard than geriatric caregivers. When focusing on reconciliation, there seems to be a hierarchy between professional and private spheres to the disadvantage of the latter. Therefore associated problems become individualized, and it stays the individual woman's responsibility to choose the right partner to be able to pursue self-optimization in all areas of life (see also McRobbie 2009, p. 19). Consequently, Sorger demands (2014, p. 44) care work not to be individualized and privatized, but to rather be recognized as a task of society. Taking that into account in workplace politics would lead to

structured working hours not being determined by the normal working relationship of men (Sorger 2014, p. 151), but rather to be based on different biographical phases.

6.3.2 Empirical Results

Presented below are empirical results related to some of the questions posed above, namely, whether the illustrated changes in the working sector in the wake of eroding boundaries and digitalization nevertheless carry potential to break down traditional gender roles. To list opportunities and obstacles couples face when committing to work and family life on equal terms, we can take a look at couples who take effort to realize either a dual career or equally split up tasks in spite of both working. In addition, a consideration of occupational fields in which the dissolution of boundaries has always been constitutive.

It is indisputable that couples desire to balance career and family on equal terms. Yet, only every eighth couple realizes this desire (Alemann and Oechsle 2015, p. 297). Only if the upbringing and caretaking of children appear subjectively important to fathers are they willing to defer career ambitions or even decline promotions (Alemann and Oechsle 2015, p. 303). In her study of couples committed to gender equality in their relationship, Rüling (2007, p. 108) detailed the following risks of a return to traditional gender roles: In addition to traditional patterns of interpretation regarding household activities and child rearing, women's professional reentry is often accompanied by financial risks, such as high childcare costs and low earnings. Another risk is that the simultaneous employment of both parents causes an overload.

Schneider (2014, pp. 215–216) illustrates with the example of professional mobility that an increase in male mobility is more likely to go hand in hand with a traditional inner family division of labor, whereas female mobility is more likely to lead to an outsourcing of such activities to third parties. Professionally mobile women are furthermore less likely to have children than their male counterparts. In addition, the research project "Boundaryless work – boundaryless family" which focuses on employees in the retail, film, and TV sectors showed two things: (a) In spite of modernized requirement from mothers and fathers, traditional gender stereotypes lead to a temporary re-traditionalization of task divisions, and (b) structural characteristics which are less family friendly and breadwinner model orientated lead to this re-traditionalization (Jurczyk 2010, pp. 66–67). Although studies show that working hours lacking boundaries can have positive effects and lead to an increasing flexibility, especially the abovementioned appeals to subjectification, "the intensifying of workload and unpredictability thereof" (Jurczyk 2010, p. 67) can also create organizational problems. Within the project, different patterns of familial gender arrangements among informants became apparent (Schier 2014, pp. 256–260): The pattern of traditional gender roles is most common, whereas a more equal balancing of work and caretaking responsibilities between partners is far less common. The authors therefore conclude that the dissolution of boundaries

carries potential for change, but only under certain structural conditions (Schier 2014, p. 262). We also see this confirmed in other sectors such as journalism, editing, translating, graphic, and design, where precarious working conditions, low income, and unpredictable work hours contribute to employees foregoing having children (Betzelt and Gottschall 2007, pp. 127–129). Similarly, Manske (2005, p. 269) identified web workers as a prototype of workers within processes of dissolution of boundaries: Men and women experience having children as incompatible with their careers and therefore opt out of having children.

As a final focus of this paper, we ask whether the potential for modernization lies especially in those forms of employment and sectors where boundaries are already structurally eroded, for instance, in telework, as found in IT jobs and academia. One can assume that new informational technologies and digitalization have intensified these circumstances.

In a study of teleworkers who work from home, Kleemann (2005) highlights the different motivational aspects for employees and employers, especially the motives of employees make for an interesting conclusion regarding the relationship between the digitalization process of the working environment and gender relations. Kleemann (2005, pp. 68–72) distinguishes between family-related, performance-related, and pragmatic motives (you save time not driving to work) and those who concentrate more on self-realization. It is apparent that family-related motives are more prominent among women, whereas performance-related motives are more prominent among men. In correspondence thereto, the strategies also differ from one another: In the first case, the integration of both spheres becomes visible, whereas in the second case, the strategy of segmentation, meaning the traditional task division between the partners, is maintained (Kleemann 2005, pp. 74–78).

Also research results regarding gender arrangements in academic work remain skeptical about the modernizing. Career paths in science have always, through the dissolution of boundaries, characterized a long-term personal commitment with access to subjectification potential as a prerequisite for career success. Irregular working hours in the evenings and on weekends, alternating workplaces, work from home, short-term contract periods, uncertain career prospects, and limited earning potential over a long period of time are not new.

Time and again studies show that there is often no sign of the breaking down of traditional gender models (exemplary Stiehler 2013), but instead an increase in conflict between science and family (Findeisen 2011, p. 139). For example, female professors have considerably fewer children in comparison to male professors, and mothers, contrary to fathers, often reduce their working hours, resulting in them publishing less of their work, etc. (Althaber et al. 2011; Findeisen 2011). Although fathers hope for more time with their families (Althaber et al. 2011), they are, according to Findeisen (2011, p. 186), more than their female counterparts measured by a traditional male example of a successful scientist. This leads to female scientists, in spite of prospects of successful careers, taking parental leave more frequently than their male counterparts, who follow more traditional gender arrangements (Findeisen 2011; Althaber et al. 2011). However, distinct scientific differences are to be seen: In the more male-dominated natural and technical sciences, a

more traditional model is followed; more egalitarian models can be found in the social sciences (Althaber et al. 2011, p. 104; Schreyögg 2013, p. 151), which might benefit in a different way from digitalization as the more workplace-bound, laboratory research-focused sciences.

The resulting scientific work must, by egalitarian arrangements valid for both partners, be relocated to evenings, nights, and weekends (Findeisen 2011, pp. 165, 176), which can be seen in a positive and also a negative light. In this way, fathers who find themselves in egalitarian partnerships emphasize the burdens which result from the lack of segregation of time and location (Findeisen 2011, p. 203), while female scientists can consider this flexibilization and clear-cut digital media as prerequisite for their occupations (Roth-Ebner 2015, pp. 190–191).

6.4 Conclusion

Although the abovementioned evidence gives us hope for a long-term modernization of gender relations though change in the professional life, research seems rather pessimistic in this regard. The prerequisite for a model where different areas of life can coexist would be the renunciation of a traditional male-behavior-orientated work-model. The contradiction between the dissolution of boundaries within work relations, family, and gender relations on the one side and an infrastructure orientated at the male normal work relationships on the other is currently not solved; it is rather declared as individual lifestyle challenge.

The reconciliation of professional and private areas of life and the change of gender concepts are "the result of a two-way process" (Alemann and Oechsle 2015, p. 315). However, it is expected from science, the economy, and politics to develop a model which furthers the transformation of the social task division and the related gender hierarchy. Alemann and Oechsle (2015, p. 314) highlight that the reconciliation difficulties on an individual and organizational level are handled very differently by, for example, fathers and mothers within parental groups than in employee groups.

For further development the essential question can be how long employees are willing to prioritize their professional over their personal lives (Kirschenbauer 2015, p. 53). The reconciliation of career and family seems to be less influenced by technological development like digitalization, but rather driven by the increased work-related output demand. "When the relation between requirements and resources at work are out of balance, then the relation between professional and private life will also be out of balance" (Kratzer et al. 2015, p. 33). The decrease of work intensity would then prevail over the idea of flexibilization and digitalization as regulator for the reconciliation difficulties.

Fundamentally, reconciliation is rather a "model for high-earners" (Jurczyk 2014, p. 180), and the question remains what the connection between the hope for and the realization of a reconciliation of the associated social inequalities is (Alemann and Oechsle 2015, p. 296). We referred to the connection between

financial opportunities and the realization of egalitarian task division between genders in regard to care work. Which additional categories of inequality are significant in this context is to be investigated.

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Anne-Dorothee Warmuth M.A., M. Ed. is a research associate at the University of Paderborn, Germany. She studied Social Sciences and German Studies (Master of Education) and Literary Studies (Master of Arts) at Bielefeld University. Her research interests include gender relations at school, the importance of gender during socialization of children and young people and current issues of Men's Studies. She is currently working at the centre for gender research (Zentrum für Geschlechterstudien/Gender Studies) at the University of Paderborn.

Ilke Glockentöger is currently employed as an expert for gender in school at the North Rhine-Westphalia State Institute for Schools and Professional Development (Qualitäts- und UnterstützungsAgentur – Landesinstitut für Schule NRW). She studied History, Religious Studies and Physical Education at the University of Göttingen, at Emory University in Atlanta (GA) and at the Humboldt-University in Berlin. Furthermore, she taught at different schools and universities. Her research interests include gender in teaching and gender in sports.

Chapter 7
Learning in the Context of Work in a Digital Age: The Use of Digital Media in Informal and Formal Learning Contexts

Sin Sing Ang, Mariana Orozco, David Gijbels, and Piet Van den Bossche

7.1 Introduction

Technology, and specifically digital media, has opened up a wide range of possibilities for working beyond the office and learning beyond the classrooms (Attwell and Hughes 2010), i.e. people have new alternatives to decide what, how and when they work and learn. Concurrently, recent technological developments have also led to the digitalisation of work processes aiming at enhancing any or both collaboration and capacity (Brookshire et al. 2011; Tynjälä et al. 2014). Virtual workplace learning, for instance, has the potential to change the way in which people work individually and collaboratively (Brookshire et al. 2011). Indeed, employees (or 'learners at work') have more flexibility and control over their learning experience, can allocate extra time to more challenging material, find themselves in a safer environment in terms of less pressure than classroom learning, may learn nearly anywhere and anytime and can fairly adapt the materials to their own learning style and needs. The widespread adoption of technology in many facets of modern life has created an increasingly urgency to recognise the importance of adult informal learning, especially within the context of digital media. The term 'digital media', in its broader sense, refers to the format of electronically delivered content (Masters and Nykvist 2006) and includes the idea of diverse hardware, software and technologies to promote communication of all digitalised materials (Weigel et al. 2009). In a recent study on the relationship between employees' learning activities and use of (social) media, it was found that the frequency of social media use had a direct correlation to participation in learning activities (Puijenbroek et al. 2014). These findings suggest that organisations could consider stimulating the use of digital media among employees to support both formal and informal learning at the workplace. In order to have a better understanding of how digital media can support learning in the

S.S. Ang • M. Orozco • D. Gijbels (✉) • P. Van den Bossche
University of Antwerp, Antwerp, Belgium
e-mail: david.gijbels@uantwerpen.be

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workplace, we need to look first at how learners use different devices in different learning and working contexts and at the role digital media play in the activities they engage in.

7.1.1 Adults as Learners at Work

Formal and informal learning processes are crucial within an ageing population as they enable mature students to remain relevant, engaged and empowered. Life expectancy is increasing in almost all countries, and it is predicted that by 2050, there will be more than two billion older persons (21.1 % of the total world population) aged 60 years or older (World Population UN Report 2013). Notably, Europe is experiencing an exponential rise in both life expectancy and falling birth rates (Keese 2006); hence a large number of older persons will be expected to continue contributing in the workforce. According to this, people will be expected to change careers, acquire retraining for new careers or continue to be effective in their current vocations. Although these phenomena may be more challenging for older (knowledge) workers, research aiming at unravelling the role of media in the integration of informal and formal learning processes does not need to be confined to a particular age group.

While most forms of retraining and vocational upgrading involve formal learning, lifelong learning and, in particular, informal learning have been identified as the main factor in improving older people's skills and adaptability (Grundtvig International Network of Course Organisers 2006). Learning is not merely lifelong but 'lifewide', a term used 'to illustrate the versatility of learning situations in all aspects of life, not only during different life phases' (Ala-Mukta 2010, p. 25). Informal learning comprises self-directed, incidental and tacit learning and is often regarded as 'the natural accompaniment to everyday life' (European Commission 2000, p. 8). As such, informal learning has been evidenced as an essential element in adult lifelong learning (Grundtvig International Network of Course Organisers 2006; Hague and Logan 2009; Ala-Mutka et al. 2009; Redecker et al. 2010).

In the particular case of older professionals, research suggests that people prefer informal learning over formal learning and that they are often focused on what, when and how they engage in learning (Fenwick 2012). This group is more likely to obtain retraining in order to upgrade employment status, re-enter a new career or enter a new stage of their lives (van der Heijden 2002). This group is also representative of those who regularly use digital devices for both formal and informal learning. In this chapter, however, we deliberately broaden the focus to adult learners of all ages, and, additionally, the interest goes to those who are working full-time and studying part-time for a tertiary or advanced degree.

We refer to our group of interest not just as 'adult learners' but, moreover, 'at work' to account for the double sense of the expression, i.e. being both active and immersed in a work-based environment.

7.1.2 Learning Through Digital Media

Scholars in a wide variety of disciplines have addressed areas of adult informal learning in an attempt to examine how informal learning takes place. Within the field of adult learning, scores of literature expound the process of informal learning (Hunt 1986; McGivney 1999; Eraut 2000; Billett 2001; Tough 2002; Schugurensky 2004) in different contexts such as the workplace, home and in everyday living (Eraut 2004; Hague and Logan 2009; Puijenbroek et al. 2014). Additionally, studies have explored the use of technology in shaping adult informal learning (Clough et al. 2008; Dabbagh and Kitsantas 2012), and other evaluations have further attempted to explore how informal and formal learning can be bridged (Dabbagh and Kitsantas 2012), experienced (Peeters et al. 2014) or integrated (Tynjälä et al. 2014).

A review of various models dealing with the relationship between formal and informal learning suggests that those models can be ordered according to growing levels of understanding and/or according to their purpose, i.e. models of contexts' transition, interaction, integration or seamless relationship (Orozco and Gijbels 2016). In particular, the seamless learning framework (Looi et al. 2010) emphasises the 'time' and 'space' dimensions making it notably useful to investigate mobile technology as a means of 'pushing the frontier' between formal and informal learning. Indeed, 'seamless learning spaces' represent continuity of the learning experience across different scenarios or contexts and rely on the availability of one mobile device or more per student. The learners are assumed to learn whenever they are curious, and, in doing this, they 'seamlessly switch' both between formal and informal contexts and between individual and social learning (Looi et al. 2010).

Technological tools are expected to operate as mediators in individual and social learning processes as well as in the integration of different forms of knowledge. But, despite this potential to empower workplace learning (and other workplace activities too), digital tools also pose important challenges for both their design and their implementation (Tynjälä et al. 2014). For instance, learning environments which make extensive use of digital tools tend to be loosely structured, what often results in them taking for granted learners' self-regulative knowledge and skills.

A case in point is the study by Clough et al. (2008). They investigated how adults use mobile devices to support intentional informal learning by refining a prior mobile learning functional framework by Patten et al. (2006). Clough et al. (2008) identified seven pedagogical categories (i.e. 'referential', 'location aware', 'reflective', 'administrative', 'constructive' and 'data collection') and, furthermore, introduced two qualifiers (i.e. individual and collaborative). On the one hand, the pedagogical categories reflect the type of learning that learners at work encounter, and, on the other hand, the qualifiers reveal more details about how they learn in terms of individual or collaborative approach. Referential activities are activities learners would engage in to access contents for learning such as accessing e-books, newsfeeds and download information. Location-aware activities are activities that encourage learners to learn more about their environment such as using the

GPS. Reflective activities take place when learners interact or reflect upon materials they have accessed individually or collaboratively such as sites on web blogs or social media. Administrative activities refer to activities that learners do to organise their learning. Constructive activities are those where learners create or construct knowledge individually or collaboratively. Data collection activities are activities that learners do to collect data information in sound, text or visual for learning purposes.

Roschelle et al. (2000, p. 81) state that 'students who participate in computer-connected learning networks display increased motivation, a deeper understanding of concepts and an increased willingness to tackle difficult questions'. Correspondingly, it is not technology that will encourage learners to learn, but rather the activities within the learning environment learners engage in (such as *using* digital media), thus bringing to life individual cognitive and socially distributed learning processes. More precisely, people learn mainly from what they are doing, and they learn more effectively from what they are thinking about what they are doing (Bransford et al. 1999). It is within this context that this study aimed at understanding how learners learn formally and informally in digital media and the activities they engage in while using digital media.

From the above discussions, it follows that learners at work may be seen as unceasingly crossing over various boundaries (albeit often fading boundaries), i.e. from one platform to another (using different digital devices), from one context to another (formal and informal learning) and from one role to another (the worker as learner and as performer). Given the ease with which these learners cross over such boundaries, it becomes necessary to know more than just what they learn, but also how and when they learn. Therefore, the present chapter seeks to answer two related key questions:

1. How do adult learners use digital media in formal curricula?
2. How do adult learners use digital media outside formal curricula?

7.2 Method

7.2.1 Participants

This study targets adult learners of all ages (at least 25 years old) who are working full-time and studying part-time for a tertiary degree and above. An online questionnaire was created and released in March 2015 to students of the Antwerp Management School (AMS) and UniSIM, School of Arts and Social Sciences. A total of 44 adults enrolled in an executive programme participated in the study. Further details about their employment state, age distribution and gender are presented in the result section.

7.2.2 *The Questionnaire*

The questionnaire consists of three main thematic parts, i.e. (a) questions to collect respondents' profile information (nine items), (b) key topic questions (eight items) concerning not only the types and the number of digital devices owned but also the usage of these devices in various contexts and in terms of frequency and time spent, and (c) key topic questions (two items) concerning the activities respondents engage in that are mediated by digital tools. These activities (e.g. record sounds, contribute to web forums, download content, use encyclopaedia and many more) respond to the pedagogical activities and individual/collaborative qualifiers extracted from the theoretical framework.

Examples of general questions are:

- *'Which of the following devices do you own and how many do you own?'* Here estimations of frequency and duration of use are requested. Multiple answers are allowed out of ten provided categories, plus the possibility to add any additional device.
- *'Which of the devices you own is most important to you?'*
- Building on the previous question: *'How important is this device for you?'* The answer format being a five-point Likert scale ranging from 'little important' to 'extremely important'. The options are accompanied by statements about the perception of dependence on the selected device, e.g. from *'I don't need it and I'm not lost without it'* to *'I keep it with me at all times and will feel lost without it'*.

Examples of questions posed for each work, school and leisure context:

- *'Please indicate which electronic tools and apps you use in [context] and the extent to which you use them (daily/weekly/monthly/never).'* Multiple answers are allowed out of 31 provided categories, plus the possibility to add any additional tool or app.
- *'Please indicate the activities you engage in in [context] and the extent to which you use them (daily/weekly/monthly/never).'* Multiple answers are allowed out of 33 provided categories.

7.3 Results and Analysis

Firstly, the results of the findings are organised according to the profile of respondents and the types and number of digital devices owned, frequency of use and the importance accorded for work, school and leisure. Secondly, the results show how adult learners use digital media in formal curricula. Thirdly, the results show how adult learners use digital media outside of formal curricula. This section concludes with an analysis of the presented results.

7.3.1 Profile of Respondents

In total, there were 44 respondents classified into four age categories (i.e. 8 counts 'below 30', 15 counts 'between 30 and 35', 9 counts 'between 36 and 40' and 12 counts 'above 40'). The gender distribution is 57 % females and 43 % males. What the employment state concerns, the majority (65 %) had a full-time payed job at the time of the survey, while the remaining part (35 %) was equally divided into part-time employees and a miscellaneous category. Furthermore, all participants reported that they had Internet access in their places of residence and 90 % were subscribed to an Internet access plan for digital devices.

Of the 44 responses, there were 33 fully completed surveys.

7.3.2 Devices They Own and Frequency of Use (Table 7.1)

According to the participants' reporting: (a) the top three one device owned by participants are smartphones, digital cameras and laptop computers; (b) the top three two devices owned by participants are laptop computers, digital cameras and smartphones; and (c) the top two three devices owned by participants are digital cameras and laptop computers (Table 7.2).

The respondents also stated that the most used devices on a daily basis are the smartphones and laptop computers; on a two to three times a week basis, they are both tablet PCs (iPad) and laptop computers; and digital camera is used more frequently on a weekly and monthly basis (Table 7.3).

Table 7.1 Digital devices owned

Digital devices owned	One digital device	Two digital devices	Three digital devices
Smartphones	36	5	1
Laptop computers	21	8	2
Digital cameras	26	7	2
Game console	12	2	0
Tablet	21	4	1

Table 7.2 Frequency of digital devices used

Frequency of use/digital devices	Daily	2–3 times a week	Once a week	2–3 times a month	Once a month
Smartphones	44	9	0	0	0
Laptop computers	35	8	0	1	0
Digital cameras	1	4	6	13	11
Tablet PC	13	8	1	1	1

Table 7.3 Daily usage of most frequently used digital devices

Time spent on a daily basis/digital devices	3–4 h	>4 h
Smartphones	7	19
Laptop computers	10	28

Table 7.4 Important devices in different contexts

Context	Digital devices	Total
At work	Smartphones	25
	Laptop computers	20
At school	Laptop computers	11
	Tablet PCs	7
At home	Digital cameras	25
	Tablet PCs	21

Table 7.5 Digital devices used in and outside of formal curricula

	Digital devices used in formal curricula		Digital devices used outside of formal curricula	
Digital devices	Daily	2–3 times a week	Daily	2–3 times a week
Laptop computers	19	12	22	8
Smartphones	17	5	31	0
Tablet PCs	4	5	10	8

The top two devices that participants spent more than 4 h daily are smartphones and laptop computers. The top two devices that participants spent between 3 and 4 h daily are laptop computers and smartphones (Table 7.4).

The digital device that is most important at work is the smartphone; at school it is the laptop computer, and at home/leisure, it is the digital camera.

The most cited reasons for choosing the particular device as most important at work are for communication purposes (staying in touch with colleagues and superiors); at school the laptop computer is used for downloading and accessing Blackboard contents; at home it is for leisure.

Following the respondents' claims, the most frequently used digital devices in the programme of study on a daily basis are laptop computers and smartphones. The most frequently used digital devices outside of the programme of study on a daily basis are smartphones and laptop computers. In the case of smartphones used for informal learning purposes, for instance, Table 7.5 shows that the self-reported use is either daily or none. This suggests that there might not be 'occasional smartphone users' and that many people opt for other mobile devices. However, the possibility cannot be excluded that the participants might have misunderstood this particular survey question.

All participants use the Blackboard virtual learning environment in their programme of study.

Table 7.6 Websites and apps used in formal learning programme

Webs and apps	Daily	2–3 times a week	Once a week	2–3 times a month	Once a month
Blackboard content		12	8	7	
Blackboard discussion board				9	8
Google search	23	8			
Google scholar		13		7	
Facebook	10				
Instant messaging	7				
Wikipedia		10	6		7
YouTube			5		
Dropbox					7

It is observed that participants use more frequently their digital devices outside of their formal curriculum.

7.3.3 Websites and Apps Recommended or Used in the Formal Learning Programme (Table 7.6)

Furthermore, the participants report that Blackboard contents and discussion boards are accessed less frequently than the other apps like Google Search, Google Scholar, Facebook, Instant Messaging and Wikipedia. Google Search and Google Scholar are search function that facilitates information search and therefore expected to be used more frequently. Facebook and Instant Messaging facilitate access to community sharing of information and encourage communication with people of similar interests. Wikipedia is likely to be used as a first port of call for quick preview of topic of interest and is seen to be frequently used as well.

7.3.4 Websites and Apps Not Required in the Formal Learning Programme But Have Helped in Learners' Studies (Table 7.7)

Concerning the range of websites and apps reported, it is observed that these are information-seeking sites or apps that participants have found to help them with their formal learning.

When asked if the respondents would like for these websites and apps to be included as part of the formal learning programme, 50 % said 'Yes' and 40 % said 'Maybe' and the rest 'Do not know'.

Table 7.7 Websites and apps not in the formal curriculum but have helped in formal learning

Webs and apps	Daily	2–3 times a week	1 time a week	2–3 times a month	1 time a month
Google search	16	7		5	
Facebook	10				
Newsfeeds	7		12	5	
Google scholar		9		6	
Forums/bulletin boards outside of blackboard				4	
Wikipedia		8	4	5	7
YouTube			5	6	6
Text messaging					8
LinkedIn			4		5

Table 7.8 Websites and apps used outside of formal learning curriculum

Webs and apps	Daily	2–3 times a week	1 time a week	2–3 times a month	1 time a month
Google search	27				
Facebook	15	8			
Newsfeeds	10				
Instant messaging	10				
YouTube	10	10			
Wikipedia		8	5	4	
Forums/bulletin boards outside of blackboard			5	6	
Video conferencing				4	10
Google+					6
Twitter				4	
Link sharing sites					7

7.3.5 Websites and Apps Used Outside of Formal Learning Curriculum (Table 7.8)

Similar to the other contexts, information-seeking websites and apps seem more frequently used on a daily basis. This pattern of reported usage then moves towards a more collaborative and sharing pattern on a weekly and monthly basis. This would seem logical as participants learn on their own and then move to engage with other like-minded people to share and exchange ideas.

7.3.6 Most Frequently Performed Activities Within and Outside of Formal Curriculum

The following table shows the summation of the activities in the main pedagogical categories. For example, 'referential individual activities' consist of accessing newsfeeds, using of course materials, listening to podcasts and downloading content from the Internet. The total number of these activities is summated according to how frequent respondents engaged in them. Other pedagogical categories have been similarly summated.

7.3.7 Activities That Are Most Frequently Used in Formal Learning Programme

'Referential individual' activities are featured prominently in all frequencies. 'Referential collaborative' activities are similarly featured prominently in all frequencies except on a daily basis. Individual and collaborative activities seem to occur more frequently on a daily and weekly basis.

The top three most mentioned activities that have helped in the formal curriculum are 'referential individual', 'constructive collaborative' and 'reflective collaborative'.

Referential individual or collaborative activities are information-seeking or information-sharing activities and thus expected to feature prominently in a formal learning context. Collaborative activities are also featured quite prominently on a daily basis as learners communicate and share their reflections and learn through that exchange.

7.3.8 Activities Not Required in the Formal Learning Programme but Have Helped in Formal Learning

'Referential individual' activities feature prominently across all frequencies. 'Reflective collaborative' activities feature consistently across all frequencies except two to three times a month. 'Constructive collaborative' activities happen more on a daily and monthly frequency basis.

It would seem that information-seeking activities on an individual basis and reflective activities on a collaborative basis are what helped participants bring learning from outside of their curriculum into their formal learning.

7.3.9 Activities Used Outside of Formal Learning Programme

'Referential individual' and 'reflective collaborative' activities feature prominently across all frequencies. 'Constructive collaborative' features consistently across all frequencies except on a two to three times a week. It would seem that outside of formal curriculum, learners engage in activities across more different pedagogical categories. Individually, participants seek out information and then participate collaboratively to exchange through reflective activities such as read and post to web blogs and social media sites.

It would seem too that more collaborative activities take place outside of formal curriculum. And on a daily basis, more activities are taking place outside of formal learning.

7.4 Conclusion

This study has adopted the perspective that it is the perception learners at work have on their technology-mediated activities what encourages and promotes their learning (be it individual or collaborative), rather than the technology itself. In the light of this framework, this study aimed at understanding how learners learn formally and informally using digital media by looking at the mediated activities they engage in.

The two research questions raised earlier in this chapter imply a comparison between the use of digital media by adult learners at work either within or beyond a formal curriculum. In short, the results of the present investigation suggest that learners engage more frequently in activities belonging to wider pedagogical categories when they are part of work-related contexts (predominantly informal) than it is the case in more formal contexts.

In order to find an answer to the research questions, this study proceeded by focusing on what digital devices learners owned, the frequency of use and amount of time spent on these devices at work, at school and at home/leisure, which websites and apps, as well as the types of activities, 'learners at work' engage in, within and outside of formal curriculum.

The profile of working adults going back to formal learning on a part-time basis shows that the most owned digital devices are the smartphones and the laptop computers. Usage of these devices often goes beyond 4 h on a daily basis. Digital cameras and games consoles are more often used for leisure, and some even owned more than one of such devices. Given the powerful capabilities of the smartphones, they often double up as functional device to access emails and accessing the Internet. However, the laptop computers remain as the main device of choice for computing purposes in work and school. Tablet PCs are used mainly for leisure for surfing the Internet. It is observed that participants use more frequently their digital devices outside of their formal curriculum.

Within the formal curriculum, the most frequently cited websites and apps are information-seeking websites and apps such as Blackboard content – a virtual learning environment – Google Search, Google Scholar and Wikipedia (cfr. Table 7.6). Referential or information-seeking activities are most frequently engaged in either on an individual or collaborative basis and followed by reflective individual activities such as reviewing downloaded contents from the Internet. This seems to suggest that learners in formal learning context first seek out information on their own and then reflect upon it before reconstructing it collaboratively through information sharing. This strategy of learning seems to bear up with the types of devices used in formal learning context where the smartphones and the laptop computers, two highly frequently used devices on a daily basis (cfr. Table 7.5), provide the platforms from which referential individual and collaborative activities could take place. This seems to also line up with participants' perceptions of the top three activities that have helped them most in their formal learning: 'referential individual', 'constructive collaborative' and 'reflective collaborative'.

Outside of the formal curriculum, the most frequently cited websites and apps that are not required in the formal learning programme but have helped in learners' studies are information-seeking websites and apps such as Google Search, Google Scholar, Facebook and newsfeeds. Half of all the participants in this survey would like to have these websites and apps included in their formal learning programme, while about slightly less than half of them were ambivalent. One possible reason for this ambivalence could be that they are uncertain about how these websites and apps could directly help them in their formal learning. It is noteworthy that in this context, the reported top two most performed activities are similar to those in a formal learning context, i.e. 'referential individual' and 'reflective collaborative'.

The top three activities perceived by participants to have contributed most to their formal learning are similar to the three most engaged activities outside of formal learning, i.e. 'referential individual', 'constructive collaborative' and 'reflective collaborative'. It is also observed that outside of formal learning, activities performed are spread over a wider range of pedagogical categories and in higher frequencies (Table 7.9).

In sum, this study intended to find out how adult learners use digital media in and outside of formal curriculum. From the initial data collected, we see a pattern of how learners cross over from informal to formal learning contexts through first engaging in information activities on their own (referential individual) and then either through information-sharing activities (referential collaborative) or reading and posting activities (reflective collaborative) to build on their existing knowledge. We see these activities repeated in both formal and informal learning contexts. These three activities were not only more frequently engaged in informal learning context; they are also perceived by participants to have contributed the most to their formal learning.

This study is limited by the small data set collected. Future works could direct at different age group learners to see if similar learning patterns are also observed. Despite the limitations, some practical implications already arising from this study may be mentioned: first, to consider how to leverage and complement informal

Table 7.9 The most frequently performed activities within and outside of formal curriculum

Context	Activities	Daily	2–3 times a week	Once a week	2–3 times a month	Once a month
In formal curriculum	Referential individual	23	53	16	10	22
	Referential collaborative		13	11	10	14
	Constructive collaborative	14		8	11	
	Reflective collaborative	18				
Outside of formal curriculum but helped in formal learning	Referential individual	13	14	6	11	15
	Reflective collaborative	12	12	6		9
Outside of formal curriculum	Referential individual	24	18	5	4	12
	Reflective collaborative	22	15	4	7	7
	Constructive collaborative	28		4	5	6

activities with formal learning; second, to highlight how certain websites and apps though not used in formal learning could help learners at work in their learning process; third, to encourage referential activities from an individual level and subsequently extend them collaboratively through referential, reflective and constructive activities; and, at last, to encourage learning outside of formal curricula.

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Sin Sing Ang is a PhD student at the University of Antwerp, Belgium in the Department of Education & Information Sciences. She is also an Associate Faculty at SIM University, Singapore and was awarded the Associate Faculty Champion in 2014.

Mariana Orozco is a PhD student at the University of Antwerp, Belgium in the Faculty of Social Sciences. She is also active member of the CeMIS research group at the same university, focusing her research particularly on (vocational) education.

Dr. David Gijbels is Professor of Learning and Instruction at Edubron research group at the University of Antwerp, Belgium, Faculty of Social Sciences, Department of Training and Education Sciences. His research focuses on student learning and assessment in (higher) education and at the workplace.

Dr. Piet Van den Bossche is Associate Professor 'Learning in Organisations' at the Edubron research group, University of Antwerp, Belgium, Faculty of Social Sciences, Department of Training and Education Sciences and at Maastricht University, School of Business & Economics, The Netherlands.

Chapter 8
Integrated Digitised Video Recordings in Postflight-Simulator Training: A Matter of Reflection

Yoriko Kikkawa and Timothy J. Mavin

8.1 Introduction

Over the last decade, the airline industry has been required to respond to an urgent need for delivering effective training methods for pilots of all experience levels: initial pilot training through to airline pilots. This situation has been due to an increased global demand for low-cost carriers. In addition, a lack of pilot supply has contributed to the situation. A recent report predicted a potential global shortage of 160,000 pilots over the next 20 years (Elamiri 2013). Consequently, this shortfall has created situations where less experienced pilots are taking on the responsibility of airline captain in many regions of the world.

A modern airliner such as a jet or large propeller-driven aircraft requires two pilots. The first pilot, or pilot-in-command, is always referred to as a captain and occupies the left seat of the flight deck. The captain is ultimately responsible for the safety of the aircraft, passengers, and crew. The second in command is commonly referred to as a first officer (FO), although some airlines around the world continue to refer to them as a copilot. The FO will fly the aircraft from the right seat, via instruments duplicated and identical to the ones in front of the captain.

One of the quality assurance programmes adopted by every airline around the world is a regular assessment of the competence of each airline pilot. In most cases, pilots undergo at least 4 days of training and assessment each year. Unlike in a majority of professions, an airline pilot must be able to continually – throughout their entire career – demonstrate an acceptable level of performance. Failure to achieve a required standard will end in dismissal in most cases. During the annual quality assurance programme, a senior pilot called a flight examiner will be tasked with conducting the assessment of each pilot within an airline. The position of flight

Y. Kikkawa • T.J. Mavin (✉)
Griffith University, Nathan, QLD, Australia
e-mail: y.kikkawa@griffith.edu.au; t.mavin@griffith.edu.au

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examiner is not only approved by an airline but, in most cases, also requires regulatory approval from an aviation regulator of the country. The flight examiner who already holds the position of captain needs to be trained to (a) conduct briefings and debriefings, (b) make final assessment of a pilot's performance, and (c) operate a high-fidelity simulator.

Digitalisation has become a critical part of recent transformation for airline pilot training. Today, the high-fidelity simulators are used extensively to assess an airline pilot's performance (Kearns et al. 2016). The International Civil Aviation Organization (ICAO) defines a flight simulator as follows:

> A full-size replica of a specific type or make, model and series of aeroplane flight deck, including the assemblage of equipment and computer programmes necessary to represent the aeroplane in ground and flight operations, a visual system providing an out-of-the-flight-deck view and a force cueing motion system. It is in compliance with the minimum standards for flight simulator qualification. (ICAO 2003, pp. 1–2)

One of the greatest strengths of simulator training is that it allows an airline to safely replicate all manner of possible malfunctions and critical flight manoeuvres. These critical malfunctions and manoeuvres range from common occurrences through to rare encounters that pilots must be able to practise but are unable to safely practise in the real aircraft. For example, while pilots regularly rehearse the rare engine failure immediately after takeoff in the simulator, it is not taught in the real aircraft due to the number of incidents and accidents that have occurred in practicing such events. In a report into a near accident of a 30-seat commercial aircraft, for instance, the branch of accident investigation outlined that the pilots involved in the incident had not been provided adequate crew (two pilots) training to deal with an emergency (Australian Transport Safety Bureau 2009). The report revealed that, as the airline was only using the company's aircraft for training, the capacity of the training was limited to around 13 malfunctions, in contrast to the 225 malfunctions that are able to be rehearsed using a simulator. The importance for simulator training for airline pilots is clearly underlined in the report.

Figure 8.1a depicts a typical modern example of an airliner high-fidelity simulator used by an airline that we have worked for over 7 years. As can be seen in Fig. 8.1b, the entire simulator is on hydraulic jacks, suggesting that the simulator is able to create a virtual reality with flight sensations of turbulence, deceleration, and acceleration.

The central advantage of the flight simulator is its capacity to create an exact replication of the aircraft flight deck. For high-fidelity classification, all switches, dials, and instruments must be identical to the real aircraft. Another advance is the visual system. Via wrap-around visual monitors, pilots are able to look out the front and side flight-deck windows and see other aircraft, runways, mountains, weather (e.g. clouds, rain, and snow), and day or night conditions (see Fig. 8.2a). The visual system over the last decade has made great advancements in its fidelity. It has made an experience in the simulator almost identical to the aircraft. In fact, most modern airline simulators are referred to as zero-time. That is, pilots learning to fly a particular aircraft (e.g. Boeing 737) will not be required to fly the actual aircraft prior to carrying passengers (Kearns et al. 2016). One area of great importance is the

Fig. 8.1 (**a**) The modern flight simulator is a large device that houses an exact mock-up of the aircraft but also contains an advanced visual system that is wrapped around the front of the simulator. (**b**) The high-fidelity simulator is on jacks allowing true sensation of turbulence, acceleration, and deceleration to be transferred to the pilots

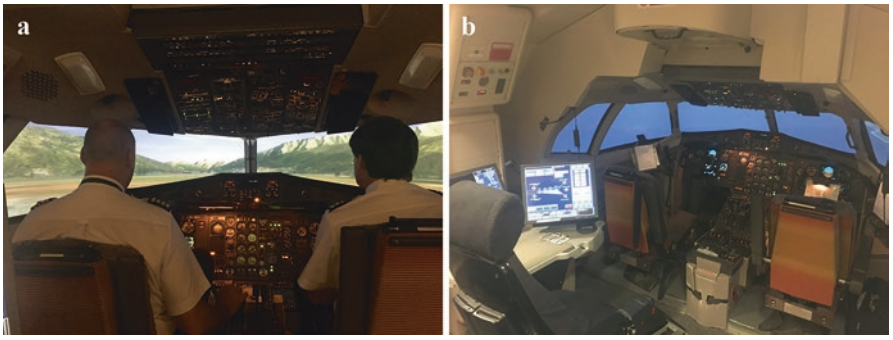

Fig. 8.2 (**a**) Cockpit snapshot of a high-fidelity simulator presenting the accurate and realistic visual representation outside. A captain occupies the left seat, and a FO flies from the right seat. (**b**) An instructor is able to sit behind the pilots and communicate with them via aircraft radios or directly to them for direct instructions during a simulator session. They are also able to operate numerous malfunctions and flight conditions from a control panel

crew-to-instructor interface. The flight examiner, who sits in the rear of the simulator, is able to interact with the pilots and to create a learning experience by acting as a stakeholder (e.g. air traffic controller, cabin crew) or by actioning malfunction usually at the most inconvenient time for the pilots (see Fig. 8.2b).

One of the final advancements in flight simulation is the ability to record the actual simulator scenarios on video- or audio-cassette recorders after video home system (VHS) became available (Sethi 2013). During the late 1980s and 1990s, videocassette recorders were mounted above and to the rear of the pilots. Using a VHS, the flight examiner would record the training event, retrieve the videotape from the simulator on completion of training, and replay selected events on a television in the debriefing room. After the debriefing, the videotape would be erased by using

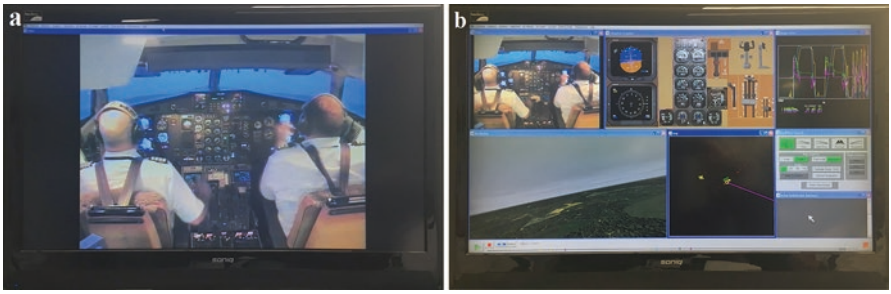

Fig. 8.3 Two possible views available to a flight examiner with the "debriefing tool". (**a**) Full screen video/audio recording of the flight deck: This view is typically used by the flight examiner to demonstrate pilot interaction and specific behaviours such as decision-making and management. (**b**) More comprehensive view: This view provides, in addition to the flight deck, an integration of recorded information on flight, engine, and system instruments that are used for pilots to demonstrate flying manoeuvres during the simulator session. It enables the status of instruments during an emergency exercise to be replayed

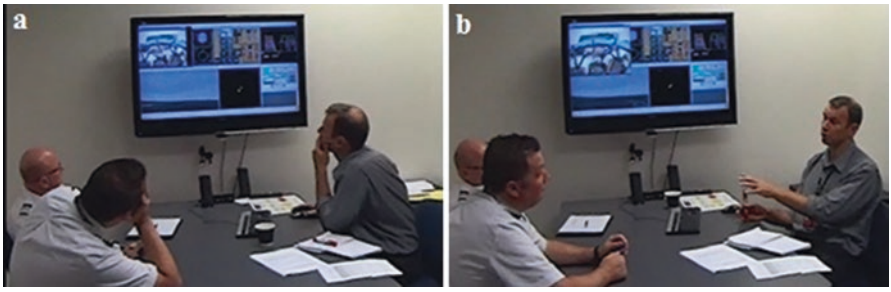

Fig. 8.4 (**a**) A flight examiner replays the video segment that he was referring to, which the crew are not able to recall. (**b**) The crew now discuss their reasons behind their decision-making at the specific moment presented in the video segment

a large electromagnet. A rapid advance in recording system from the VHS to a more high-definition digital recording system offered better visual and audio recordings, as well as a faster process of transferring the recorded data. For instance, the modern aviation simulators integrated electronic recording devices (e.g. MP3, MP4) feed recorded data directly into the television monitors in the debriefing room (Fig. 8.3a). Further, as presented in Fig. 8.3b, the simulator also records the entire flight with relevant information that the pilots observed during the simulator sessions (e.g. engine status and system instruments). It also provides pilots with a back-shot view of cockpit and "out-the-aircraft" views. This integrated system is more complex than a simple video or audio recording of trainees' interactions and behaviours; therefore, we will refer to the digitised recording system as a "debriefing tool" for the remainder of this chapter.

During the debriefing, the flight examiner will then use the debriefing tool to assist in the post-simulator debriefing. For example, in Fig. 8.4a, a crew reviews a video seg-

ment after they were unable to recall the moment at which the flight examiner asked about their decision-making process. After being presented with a clear picture of the moment, the crew started talking with the flight examiner about what they were doing and why they were doing it as well as possible improvement of their strategies.

Understanding how pilots use video examples of their own performance as a reflection tool would assist further improvement of debriefing practice. However, there are mixed findings to the effectiveness of video-assisted debriefing across different disciplines (Kikkawa and Mavin 2017). This led to a simple question, "Is such digitalization of work necessary for pilot training?". This chapter, therefore, aims to understand how the debriefing tool facilitates learning for pilots, both captain and FO, and to figure out the importance of the advanced, digitalised system of debriefing in pilot training.

8.2 The Use of Video-Assisted Debriefing (VAD)

The use of high-fidelity simulation has gained an increasing interest in the broader literature of high-risk professions including healthcare, the military, and aviation (Hyland and Hawkins 2009). To make further improvements to the learning experiences in high-fidelity simulators, video recordings of learners' performance have increasingly been used in post-simulator debriefing across the professions (Kikkawa and Mavin 2017). There are a number of studies that investigated the effects of video reviews in debriefing (e.g. Chronister and Brown 2012; Savoldelli et al. 2006; Sawyer et al. 2012), explored the variables influencing the effect of video-assisted debriefing (e.g. Bingham et al. 2015; Boet et al. 2011, 2013; Jankouskas et al. 2011), evaluated simulation debriefing programme using video review (e.g. Cantrell et al. 2008; Gordon and Buckley 2009; Shortridge et al. 2014), compared the effects between video-assisted debriefing and other multimedia aids (e.g. O'Meara et al. 2015; Welke et al. 2009), reviewed the existing studies systematically to evaluate the use of video review in debriefing (e.g. Cheng et al. 2014; Levett-Jones and Lapkin 2014; Tannenbaum and Cerasoli 2013), and explored perceptions of learners towards use of video review in debriefing (e.g. Arthur et al. 2011; Beaubien and Baker 2003). In aviation, as discussed earlier, the method has been used to enable individual pilots, and teams of pilots, to reflect on their actions and behaviours, evaluate their decision-making processes, and improve overall performance. This method has been regularly applied also for other professionals as an ideal format. However, there were inconsistent findings regarding the benefits of video review in debriefing (e.g. Fernandez 2015; Levett-Jones and Lapkin 2014).

A literature search was conducted as a part of a broad systematic review of the existing debriefing studies (Kikkawa and Mavin 2017). Out of 493 articles selected for full-text review for the systematic review, Kikkawa and Mavin first reviewed the existing systematic reviews of debriefing studies ($N = 10$) and identified 19 important elements that influence the effectiveness of debriefing across five foci based on the framework of Raemer et al. (2011; 5Ws hereafter): who (who is debriefing and

Table 8.1 Important elements identified as influencing debriefing effectiveness in the systematic literature review

5Ws	Theme	Theme descriptions
Who	Instructor level of involvement	The debriefing is/isn't facilitated by instructor/s
	Instructor characteristics	Instructor's past experience (debriefing, professional practice), training, skills, and attitudes
	Participant characteristics	Participants' age, past experience (simulation debriefing, professional practice), and/or levels of competence
What	Debriefing structure	Levels of the debriefing structure[a]
	Use of scripted questions	Debriefing is guided by scripted questions (debriefing technique)
	Application of specific debriefing models	The type/s of debriefing structures
	Debriefing topics	The topic/s focused on during a debriefing session
	Alignment of learning objectives	The learning objectives are consistent among participants (individuals or group), debriefing focus and intent, and level of measurement
	Practical implication to work	Skills and knowledge directly applicable to practice
	Use of video	Use of video recordings of simulator sessions during a debriefing session
	Use of other multimedia aids	Use of other multimedia aids during a debriefing session
	Type of resource/artefacts	The guiding tools or evaluation instruments used for assessing the debriefing effectiveness
	Use of reflection	Participant reflection is facilitated during a debriefing session (debriefing technique)
	Provision of constructive feedback	Constructive feedback of simulator sessions is given to the participants (debriefing technique)
When	Debriefing timing and sequence	The debriefing is conducted during or after a simulation
	Debriefing thoroughness and depth	Process of debriefing is not interrupted and completed
	Debriefing duration and length	The length of the debriefing session
Where	Safe situation	The psychological condition of the debriefing
Why	Theory or theoretical underpinning	The theoretical framework supporting the debriefing

Kikkawa and Mavin (2017)
[a]Based on Tannenbaum and Carasoli (2013)

who is being debriefed), what (what is the content/method of debriefing), when (the timing and duration of the debriefing), where (what is the location of the environment and the situation of the debriefing), and why (what is the theoretical framework supporting the debriefing). Table 8.1 lists these elements. Kikkawa and Mavin highlighted the interrelatedness among these elements, which made it difficult to conduct experimental studies of debriefing, and suggested that the complexity of workplace activities involved variables that may be unknown.

Out of ten systematic reviews, seven studies investigated or discussed the use of video review for debriefing. Four of those concluded no added effect of using video review to debrief (Cheng et al. 2014; Dufrene and Young 2014; Garden et al. 2015; Tannenbaum and Cerasoli 2013), while two highlighted inconsistent results with regard to an additional benefit of video review for debriefing (Fernandez 2015; Levett-Jones and Lapkin 2014). Besides, insufficient details of how their nominated studies used video review in debriefing were reported in these reviews. It suggests that further studies are required to refine their findings.

In addition to these reviews, a reference-checking procedure (i.e. examining the references listed for the selected studies) found one systematic review of using video technology as a pedagogical tool for training nurses. The authors suggested:

> The multimedia technologies can be integrated into a teaching program as a topic, a communication mode or as a pedagogic tool. It is important to note that using them does not in itself guarantee learning. They must carry an adequate pedagogic content. Multimedia can facilitate the collaboration between students and teachers as well as stimulate reflection and problem resolution. (Vigeant et al. 2008, pp. 15–16)

This notion implies that a simple experiment may not be sufficient to draw a conclusion of effect of video aids for debriefing. In order to explore this notion, the 493 articles that Kikkawa and Mavin (2017) had screened for debriefing studies were examined in regard to effectiveness of video review for simulator debriefing interventions and programmes, particularly from aviation perspectives.

8.2.1 Transferability of Mixed Findings

Out of 493 articles selected for full-text review, eight studies applied a quasi-experimental study design (seven for random control and one for non-random) to compare video-assisted debriefing (VAD) and oral debriefing groups. All of these studies were conducted with healthcare students or clinicians (i.e. nurse, medicine, or anaesthesia). Table 8.2 presents the summary of these comparative studies.

Out of those, four studies reported the participants' perceptions of benefits of, or preference for, reviewing own performance, in contrast to oral debriefing only (Dusaj 2014; Grant et al. 2010, 2014; Reed et al. 2013). Some of the studies found that the participants perceived more positive effect of, or preference for, using video review in debriefing. It indicates that VAD may support learning processes of the participants. In fact, these studies reported that the participants reported more learning satisfaction with VAD (Dusaj 2014; Grant et al. 2010, 2014). This finding was consistent with a number of descriptive studies evaluating a simulation debriefing programme, which reported that their participants valued video review (e.g. Allan et al. 2010; Gordon and Buckley 2009; Nilsen and Baerheim 2005). Furthermore, Reed et al. (2013) suggested that VAD facilitated theory-practice link, made self-reflection deeper, and assisted the participants' concentration on their own performance.

Table 8.2 Summary of eight studies comparing between VAD and oral debriefing

Study/profession	Subjects/DB timeline	VAD effect
Byrne et al. (2002)[a]/ healthcare (anaesthesia)	32 anaesthetists (16 for VAD and 16 for oral debriefing)/no detail for timeline	Non-significant (VAD vs oral debriefing – time to solve and chart error)
Chronister and Brown (2012)[a]/ healthcare (nurse)	37 undergraduate nursing students (not specified the number for VAD and oral debriefing)/15 min for simulator, 30 min for debriefing	Non-significant (VAD vs oral debriefing – overall); significant (knowledge retention in oral debriefing group; faster times for three CPR operation skills in VAD group)
Dusaj (2014)[a]/ healthcare (nurse)	74 nursing students (37 for VAD and 37 for oral debriefing)/15 min for simulator, 30 min for debriefing	Participant positive view (clinical judgement, learning satisfaction)
Grant et al. (2010)[a]/ healthcare (nurse)	40 nursing students (20 for VAD and 20 for oral debriefing)/no details for timeline	Significant (VAD vs oral debriefing – desired behaviour); non-significant (VAD vs oral debriefing, performance); participant positive view (self-satisfaction)
Grant et al. (2014)[a]/ healthcare (nurse)	48 nursing students (24 for VAD and 24 for oral debriefing)/no details for timeline	Non-significant (VAD vs oral debriefing – behaviour); participant positive view (learning satisfaction)
Reed et al. (2013)[b]/ healthcare (nurse)	64 nursing students (32 for VAD and 32 for oral debriefing)/60 min for simulation of four scenarios, 25 min for debriefing	Participant positive view (theory-practice link, depth of self-reflection); participant similar view (VAD vs oral debriefing)
Savoldelli et al. (2006)[a]/healthcare (anaesthesia)	42 anaesthesia residents (VAD, oral debriefing, no debriefing)/8 min for simulator, no time control for debriefing	Significant (VAD vs no debriefing – nontechnical skills); non-significant but less improvement (VAD vs oral debriefing, nontechnical skills)
Sawyer et al. (2012)[a]/ healthcare (medicine)	15 teams of 2 residents (8 teams for VAD and 7 teams for oral debriefing)/10 min maximum for simulator, 20 min for debriefing	Significant (pre/post-test for VAD only – performance); non-significant (VAD vs oral debriefing, performance); authors' positive comment

[a]Random control study
[b]Quasi-experimental study

On the other hand, six studies compared the effect of VAD with one of oral debriefing by using objective measurements. The summary of these findings suggests that studies using objective measurements tended to report the non-significant effect of VAD in contrast to oral debriefing. One study did, however, report significant change in performance behaviours in VAD groups (Grant et al. 2010), and another presented faster responses of CPR skills in VAD groups (Chronister and Brown 2012). A further inspection into these studies on their timeline and measurements suggested potential reasons for the negligible effects between VAD and oral debriefing.

Tannenbaum and Cerasoli (2013), who identified insufficient evidence to support use of video aids as an effective method of debriefing through a meta-analysis of 46 study samples (2136 subjects), still highlighted the importance of involving video aids. They believed that the debriefing itself might be effective already so adding video might not produce any extra benefit. In fact, out of the eight comparative studies, no study actually took into account the ceiling effect or the limit of possible improvement for higher scoring participants, for using their objective measurements when reporting the negligible effect of VAD. More specifically, these studies showed overall significant improvements of either VAD or oral debriefing group from pre- and post-test of their targeted performance areas. It indicates that the improvement space between oral debriefing and VAD could be insufficient to show significant effect, even though VAD improves performance. For example, when a 1–5 scale measurement was used for evaluating performance skills and oral debriefing improved from two to four of the performance, the room for further improvement is only between 4 and 5 (highest score). Similarly, Byrne et al. (2002) claimed the deficiencies used in performance measurements as potential barriers to experimental studies.

Moreover, Sawyer et al. (2012) assumed that the fresh memories of events were sufficient for the participants to review the events without video review. Few descriptive studies of evaluating simulation programmes with VAD assisted this assumption (Cantrell 2008; Cantrell et al. 2008). Their participating nursing students reported that they perceived timing of debriefing (viz., immediately after simulator session) more critical than medium of debriefing (viz., video) as they were still presently engaged in the learning activity with a fresh memory of the simulator experience.

In addition, our reflection on one field experience provided the assumption that the length of simulator session prior to debriefing may be another potential reason for the insignificant effect of VAD. We had a chance to observe a day-long simulation programme for clinicians at an Australian hospital. The programme contained five different scenarios (or simulator exercises) with instructor-led oral debriefing immediately following each scenario. Each scenario has one focused event (around 10 min) and is much shorter than an aviation simulator session (4 h). On our initial impression, participants were able to remember the events or what happened during the short scenario at the debriefing session without video review occurring immediately after one scenario.

To test this assumption, we looked closely at timing and length of debriefing used in the comparative studies between VAD and oral debriefing. Table 8.1 shows the simulator debriefing timelines for these comparative studies. The range of simulator length was between 8 and 15 min, while the range of debriefing length was between 20 and 30 min. All of these studies conducted debriefing immediately after a simulator session (or scenario). Similarly, a cross-sectional survey with 24 faculty members from Australian schools of nursing reported that 50% of participants used video recordings of the simulator session as a part of the debriefing which lasted for between 10 and 60 min (Arthur et al. 2011). This inspection may verify our assump-

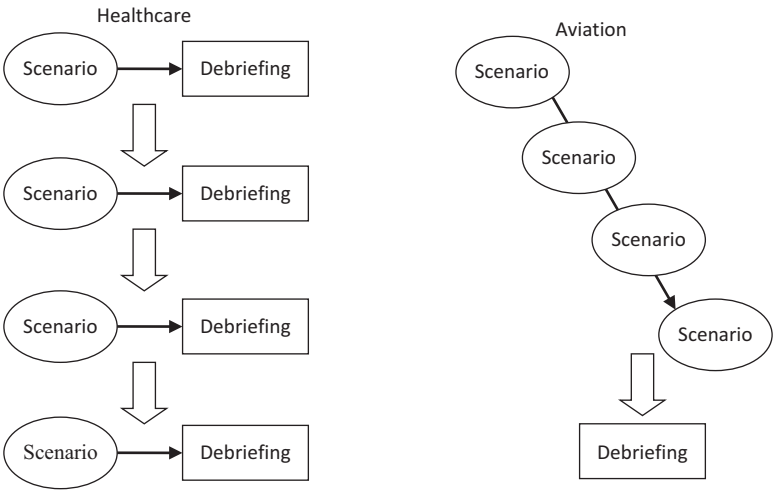

Fig. 8.5 Different modes of simulation debriefing programme typically used in healthcare and aviation

tion that since the scenario was short and focused, the participating clinicians were able to reflect on and discuss their performance without video reviews.

Figure 8.5 demonstrates the difference between the simulation debriefing programmes in healthcare and aviation. The simulator session is relatively shorter in healthcare training as they conduct a short scenario followed by a debriefing session only on the scenario and then repeat the cycle. In contrast, the simulator session is usually longer in aviation (4 h in our partner airlines), involving multiple exercises (scenarios), followed by a 1-h debriefing to review the entire session. The intensive and lengthy debriefing was found to cause the crew members difficulty in recalling what happened during the simulator session at the debriefing session (Mavin 2016; Roth 2015a). For the purpose of assisting the crew members to reflect on targeted performance, video review may be more beneficial in aviation in contrast to other professions.

Moreover, these comparative studies tended to use the same length of debriefing for VAD and oral debriefing except for one study that did not set the time control for each debriefing type (Savoldelli et al. 2006). Chronister and Brown (2012), for example, used the same length for VAD and oral debriefing groups and found insignificant difference between these groups. They suggested that the VAD group may require more time to review the video in order to ensure that VAD groups have the same amount of instructor feedback in addition to playing the video. On the other hand, Savoldelli et al. (2006) examined the effect of VAD with three groups of anaesthesia residents (VAD, oral debriefing, no debriefing). In their experiment, time control was not determined for debriefing of two experimental groups (VAD and oral debriefing). They found a surprising result of lower improvement in VAD groups in contrast to oral debriefing groups and argued that watching videos may

make participants pay less attention to the instructor's constructive feedback. To refine the assumption, they proposed to monitor the actual time spent on instructor talk and watching the video when evaluating the effect of video aids.

In addition to these studies comparing the effects of VAD and oral debriefing, three studies were found to experiment with VAD in two different formats: self-/team-led versus instructor-led debriefing (Boet et al. 2011, 2013; Sukalich et al. 2014). These random control quasi-experimental studies showed that the outcomes of each group (self-/team-led or instructor-led debriefing group) were significant but the difference between the groups was insignificant. Based on their findings, Boet et al. (2011) argued that video-assisted self-assessment may be effective even when instructors are not available. However, another study of evaluating a simulation debriefing programme argued that video review in conjunction with a guided reflection helped the participants to engage in quality reflection (Shortridge et al. 2014).

The inconsistent findings among the existing studies suggested that researchers should be careful when interpreting findings of studies conducted in different disciplines. In addition, other elements of effective debriefing (Kikkawa and Mavin 2017) should be considered. For example, individual characteristics of the participants may influence the effect of the debriefing intervention. From our past research, we observed that less experienced pilots tended to prefer instructor-led debriefing, while more experienced pilots tended to value video review of their own performance (Mavin et al. in review n.d.). A systematic review of video use for educational purposes (Vigeant et al. 2008) argued that different learning models of participants (i.e. diverging, or assimilating versus convergent, or accommodating) would determine their preference for, or benefits from, different learning approaches (i.e. reflective observation tool versus active experiment).

Moreover, cross-bordering issues (Akkerman and Bakker 2011) have been highlighted in a process of literature review for debriefing (Kikkawa and Mavin 2017) as research findings were not simply transferable across different professional contexts. Clearly, the findings of research conducted outside of aviation must be carefully examined in order to direct future practice and research in debriefing pilots. Over a decade, the second author has led university–industry projects involving airlines producing rich data around simulator–debriefing training experiences of pilots (Mavin 2016). In the following sections, these data will be used to explore the pilot perceptions of involving not only video review but also the more advanced recording system in debriefing sessions and explore practical implications for the issues emerging from a broad review of the existing debriefing literature.

8.2.2 Pilot Perception of the Debriefing Tool

The debriefing tool used in our partner airlines became a platform enabling crews to discuss performance clearly with their flight examiner. In this section, we explore data sets that we have progressively collected from airlines in order to identify pilot

perceptions of the debriefing tool. For instance, the following comment was stated by a captain in one of our partner airlines underlining how concrete video recordings of his performance helped him come back to his "frame of mind" or what he was thinking at the time of event.

> You know it's a long session, it's four hours. When you get to the end of it and try to talk about what happened at the start, and you can't remember …. The debriefing tool … definitely helps because you can zone back in to that particular event because you've got a picture. You can get back to that position and that frame of mind when it was happening. (Crew-2, Captain)

The use of video for debriefing also helps pilots become receptive of flight examiner's critical but constructive feedback, which assists the pilots to improve their practice. For example, one FO (Crew-2) agreed that the video recordings changed his perception of what actually happened during the simulator session. In this example, with video confirmation, the pilot was able to concentrate on what the flight examiner said about the performance rather than defending himself about what he believed he did.

> There was a point there where I said the wrong thing [during the debriefing]. I was thinking one thing but I said something else in relation to the flap…. [For example] if you'd asked me, I would have said "No, I didn't say that"; but yep, I did and you can just see I said it [in the video]. That's pretty indisputable.

A previous study emerging from our progressive project highlighted the impact of crew's "objective sense" on their performance and reported how each of the crew saw the same video segments differently and, therefore, referred to different facts (Roth 2015b). It indicates that VAD itself may be insufficient for an effective debriefing approach and may require expert refinement for reflecting on a particular learning objective. It appears to be consistent with the notion of Vigeant et al. (2008), which highlighted the integration of video review as a pedagogical tool.

One flight examiner who was undergoing his personal performance assessment – flight examiners are still captains requiring annual performance assessment – talked about his difficulties recalling all the details of his simulator session. Although he was able to remember most of the details that the other flight examiner had raised, he required some clarification. He highlighted "the power of debriefing tool" when he realised his mistake of interpreting his flight instruments during reviewing the video. This example also emphasised the benefit of the debriefing tool replaying surrounding information recorded in the new advanced flight-simulator video-recording system.

> You're busy flying. Once the scenario's over you're sort of trying to get your head into the next event. It just highlights to me how the crews are not able to pick up all the events…but also shows the power of debriefing tool. I hadn't realised that the engine hadn't untrimmed [until] you looked at it there and replayed it. It's so powerful to see it. (Crew-7, FE)

One of the studies from our projects illustrated what the debriefing tool offered flight examiners during the instruction of pilots. For example, there have been many studies outlining important skills for airline pilots including situational awareness, decision-making, aircraft tolerances, knowledge, management, and communica-

tion. These skills are often identified as the root cause of serious aircraft accidents (Flin et al. 2008). Further, it has been suggested that situational awareness is one of the most critical skills (Mavin and Dall'Alba 2010; Mavin and Roth 2014). In our studies, Roth and Jornet (2015) reported an instructional effect using the debriefing tool to enable a crew and flight examiner to communicate well with the broad process of situational awareness. More specifically, the flight examiner can ask an individual pilot or pair to describe what happened and what they thought of "it" (i.e. the whole process) by referring to what they just saw in the replayed video (i.e. "it"). At the same time, quality refinement of the factual matters through using the debriefing tool found that it contributed to the quality of assessment that the flight examiner made to the crew. It indicates that debriefing with both methods of video assisting and instructor facilitation can assist effective conversation and reflection on a targeted performance aspect.

In addition to the benefits for crews, the debriefing tool has also offered a practical advantage to flight examiners. The previous study reported the regular use of a documentary method of interpretation or construction of storytelling for pilots' overall performance by 23 flight examiners from our 5 partner airlines (Roth 2015b). In this method, the instructors gathered observations as evidence for an underlying reality. At the same time, the instructors utilised this reality as a resource for clarifying the observation. In the same study, these flight examiners were found to be aware of the limitations in their use of documentary evidence that they obtained (e.g. missing a critical moment while taking notes). Our progressive data collection provided evidence for the instructors in modifying their debriefing delivery associated with the recording system. The following comment was obtained from post-simulation interview with one experienced flight examiner after the new recording system was introduced to his airline. According to his reflection, the video-recording system allows him to deliver the debriefing according to learning aspects that he needs to address, rather than in chronological order.

> I can keep track of everything if I'm the flight examiner, it makes me think that sticking to events and debriefing each event is better [for video-assisted debriefing] because you can get the crew's mind refocused with that and on it. Whereas [for oral only debriefing] to generally say, procedural knowledge for the whole session [by asking the crews] "how was it" is just too broad. [For the oral only debriefing] you've got to [go] back to those specific events and doing it in a chronological order. (Crew-7, FE)

8.2.3 Practical Implication for Debriefing with the Debriefing Tool

Exploring the available data from our projects highlighted the benefits of integrating multimedia technology (the debriefing tool) from the perspectives of pilots and flight examiners. In this section, we consider effective ways of using the technology in order to deliver better post-simulator debriefing. A model that simplified the process of using the information effectively will be introduced.

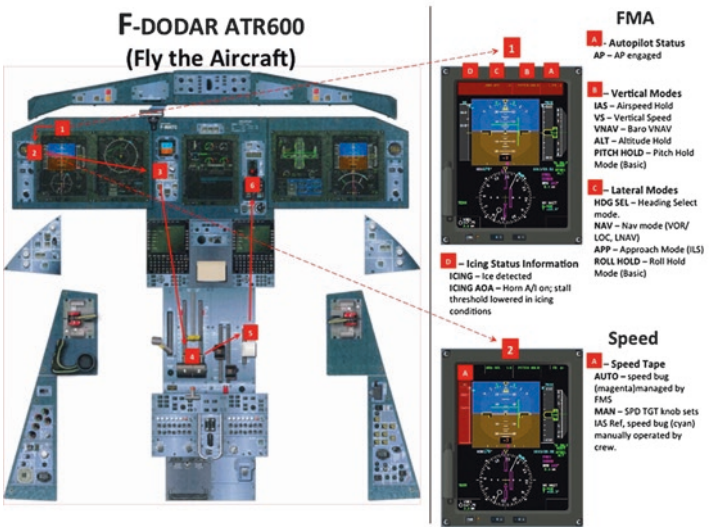

Fig. 8.6 F-DODAR: this model was presented by Munro and Mavin (2012) at the 10th International Symposium of the Australian Aviation Psychology Association. A permission was granted from the airline

The previous sections illustrated the complex nature of flying an aircraft because the crew are required to process various and large volumes of information during the workplace activity. This is particularly true during a simulated emergency event like an engine fire. In the event, the crew is required to manage a great number of tasks: fly the aircraft, diagnose the malfunction, secure and extinguish the fire, climb to a safe altitude, determine a new airport, brief cabin crew and passengers, and prepare for an engine-out landing, just to name a few. The process of handling the problem has been modelled by our partner airline into a particular action model (Munro and Mavin 2012). Figure 8.6 shows the F-DODAR model that illustrates the ordering steps of handling an emergency situation. With the model, pilots are able to practise a step-by-step procedure of complex performance (e.g. decision-making, management), which is closely aligned with the learning development of a pilot (Roth et al. 2015).

With F-DODAR, Roth et al. (2015) demonstrated how pilots applied a "kinetic melody" procedure to solve an important problem and to successfully cope with such a complex scenario. Because there are many switches, dials, and procedures, pilots may find it difficult to pick out the correct switch, dial, or procedure in the right order in which it should be carried out. The authors argued, "if kinetic melodies establish themselves, then the right presentations are picked out of an array and the right switches are thrown" (p. 296). It indicates that establishment of the problem-solving process or kinetic melodies (Roth 2015c; Roth et al. 2015) is an essential skill for a pilot. The F-DODAR model – argued to be an action model – illustrates a set of steps that form a kinetic melody for an emergency encounter and,

therefore, is a powerful tool for the partner airlines to educate and train their pilots. A flight examiner valued the model because "it gives people a process and a starting point" (Crew-3, FO).

In some cases, the different perspectives between a crew member and flight examiner about what happened during a simulator session should be considered by the flight examiner when they deliver a debriefing in order to avoid mismatching the aspect in the interest during the discussion (Roth 2015b). Training flight examiners especially for utilising the debriefing tool is required in addition to instructive techniques to facilitate self-reflection of crews. The previous study from our project team, for example, reported that the instructor (i.e. flight examiner) tended to spend more time on their talk rather than allowing the crew members to talk during debriefing (Roth 2015a). Introduction of a new reflection model with video review helped the instructors to let the crew members talk about their self-reflection on own performance (Mavin 2016). In addition, the actual time spent for video review and instructor was highlighted in our literature review of VAD as one of the variables influencing the effect of VAD. Researchers should take consideration of time spent among pilots, instructor, and video review into their analysis.

8.3 Conclusion

This chapter highlighted the importance and usefulness of digitalisation of work for pilot training. Mixed findings about integration of video playback into debriefing have been reported repeatedly. That is, adding video playback to debriefing showed non-significant effects in comparison with debriefing without video playback but was preferred by trainees. However, revisiting these debriefing studies highlighted cross-bordering issues of transferring findings from one profession to another. For example, the measurements used in the existing studies may not be sensitive enough to confirm the effect of video review in debriefing. A possible experimental study would be to compare pre- and post-test of simulation debriefing programmes (pre-test is conducted as baseline and post-test is conducted a week after the simulation debriefing programme) with two groups of aviation students (one debriefed without video and another debriefed with video). The tests should not be only based on simple scores but also qualitative examination asking them what they remember from their debriefing sessions.

Moreover, a qualitative inspection into the experience of pilots using the advanced flight-simulator video-assisted recording system, or debriefing tool, highlighted these pilots' preference for using the digitalised multimedia aid. The data showed that video playback assists pilots to recall the critical events that flight examiners refer to during the debriefing session, resulting in less effort for recalling what the examiner refers to and more concentration on actual reflection on their performance. In fact, the participating pilots expressed their difficulties in recalling the targeted events during the debriefing session as they were too tired after a long debriefing session or as they had too many events (episodes) in their mind.

The advantages of using such digitalisation of work in aviation contexts were seen as offering flexible opportunities for rare event encounters, reducing the demands placed on a crew and instructor during the debriefing, and improving instructive interactions between them. Video recording offers pilots multiple reviewing opportunities to rewind and pause the image, and more advanced systems allow flight examiners to collect evidence for their quality of assessment. To allow effective debriefing practice, using digitalisation of work must carry an adequate pedagogic content (Vigeant et al. 2008). It is clear that research is required to develop our understanding of how the digitised technology could be integrated into a flight examiner's debriefing process.

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Dr. Yoriko Kikkawa (PhD) is Research Fellow at Griffith University where she is a qualitative research methodologist. Her research interests involve learning and development for adults across professional domains including aviation and health.

Dr. Timothy J. Mavin (EdD) is Associate Professor of Aviation and Vocational Education at Griffith University. He has 10,000 hr of flight experience, including 7000 hr of jet time. He continues to conduct type-rating endorsements on the Boeing 737. His research interests include skills assessment and learning.

Part III
Educational Challenges on Organizational Level

Chapter 9
IT Capabilities for SMEs: An Analysis at the Organisational Level

Franz Lehner and Mathias With Sundby

9.1 Introduction

In the book *The Deepening Divide: Inequality in the Information Society*, Van Dijk (2005) discusses the digital divide and how it has changed over the years. It started with shortcomings in accessing technology in the 1990s and early 2000s, but has now evolved into a gap between the demand for and supply of skills. A closer look shows that the divide is actually not a simple divide, but a rather complex digital issue comprising several gaps. There is a tremendous shortage of IT professionals, and this is more and more seen as a huge disadvantage for SMEs. While the need for IT skills at the individual and employee level has been quite well examined, relatively few studies can be found dealing with the organisational level. The organisational level is different, comprising as it does the core competencies of an enterprise or organisation. These two levels comprise different standpoints of the enterprise, where the *organisational level* refers to the *capabilities* enabled by ICT as a whole, while the *individual or employee level* refers to the individual abilities and knowledge of the employees (also known as the *human resources*).

In the case of IT, the relevant literature speaks of IT capabilities. The literature in this area has not so far been gathered or analysed systematically with regard to the IT capabilities boasted by SMEs. As IT represents the backbone of modern organisations, the goal of this article will be to present a systematic analysis of the relevant literature in order to summarise and integrate the existing knowledge on IT capability in the context of SMEs. Because the terms "skills", "competencies" and "capabilities" and a number of other terms are used synonymously or interchangeably, the next chapter explains the semantics used here and comes up with a capability model that has served as the underlying research framework.

F. Lehner (✉) • M.W. Sundby
Faculty of Economics, University of Passau, Innstraße, 43, 94032 Passau, Bavaria, Germany
e-mail: Franz.Lehner@uni-passau.de

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9.2 Definitions and Capability Model

The organisational level relates to the core competencies or organisational competencies of an enterprise, often termed *capabilities*. A summary of definitions, together with a critical discussion of this concept, can be found in Schreyögg and Eberl (2015). They describe a firm's capabilities to manage, organise or coordinate specific sets of activities which are developed over time through complex interactions. They enable firms to perform coordinated tasks in order to achieve particular results. By contrast, the individual level (also known as the employee level) involves the firm's employees and their individual abilities, often treated as *skills* and *competencies* (see Fig. 9.1). It is important to distinguish between the employee level, which is also known as the individual level, and the organisational level, as each of them comprises both management and operational tasks. If value and turnover are to be boosted in SMEs, then ICT is an important component of both levels, and this is why it is considered to be relevant to further research (Bernaert et al. 2014).

ICT is present at both levels of the enterprise, along with the knowledge and information of the technology and information systems within the enterprise. Both levels depend on each other and influence the final *business success* or *value to be gained* (market opportunities) from the commercial activities and from the use of ICT with a view to achieving this. The actors are different at the two levels – *individuals* (possessing skills and competencies as to *how* and *why* to use the ICT) and the *organisation* (consisting of the systems and organisational structures defining the business process).

Sometimes the term "knowledge" is used instead of core competencies, but knowledge is a term that is difficult to define, and is apparent at both the individual and the organisational level, which thus creates different and distinctive meanings of the same term. As described in Kogut and Zander (1992), knowledge can be held not only by individuals at the employee level, as one might at first think. Firms would in this case change simply as a consequence of staff turnover. "Because we know that hiring new workers is not equivalent to changing the capabilities of a firm, an analysis of what firms can do must understand knowledge as embedded in the organizing principles by which people cooperate within organizations" (Kogut and Zander 1992, 383). Therefore, *knowledge* is considered to be a general term comprising the denotation of both levels, either yielding *information* as systemised or organised capabilities (at the organisational level) or as technical know-how, skills and competencies (at the individual level).

Several approaches to categorising the knowledge possessed by the firm have been developed. Thus, Nelson (1982), for example, approached the objective by separating the "techno" from "logy", with the former belonging to the firm and its structures, while the latter belonged to the public arena (workforce and individuals). In this regime, the knowledge, skills and competencies are held by individuals and communicated through the systems, regularities, networks and organisations within a firm in which the individuals cooperate in social societies. "Growth occurs by building on the social relationship that currently exists in a firm" (Kogut and Zander

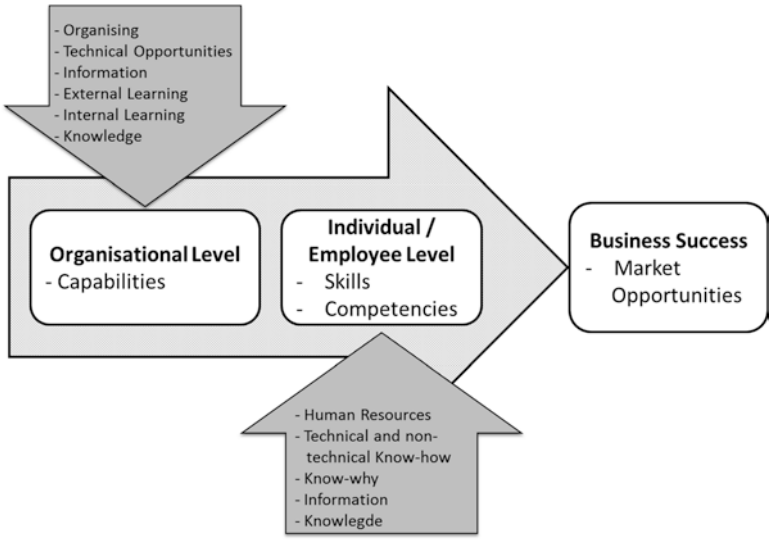

Fig. 9.1 Differences between individual and organisational level

1992, 284), but in addition to this human resources-based view, the organisational change has to be taken into consideration, too.

Bresnahan et al. (1999) discuss the central role played by ICT in the context of organisational change within firms. The view from the organisational level helps us to determine the role played, and the overall contribution made, by ICT at a macro-level. The goal is to make a better utilisation of the ICT and to align it better with business objectives. Kogut and Zander (1992, 383) also suggest that "…firms learn new skills by recombining their current capabilities", and go on to argue that the organisations (the firm at large) know more than all their employees know together.

In order to identify the relevant studies, a research into the literature was conducted along the guidelines laid down in Webster and Watson (2002). To this end, the literature databases Google Scholar, IEEE Xplore, ACM Digital Library, Springer Link and Emerald Insight were searched, using the keywords "skills", "competencies", "capabilities" and "SME" and combinations of these terms with "IT" or "ICT", and the same thing was done with the German equivalents of these words. This search was restricted to academic contributions. The abstracts of the publications were first screened to examine their relevance and academic soundness. To ensure that relevant literature was not overlooked, the bibliographies appended to selected publications were examined (in a backwards search). The final list of papers has been classified by the topics discussed in the papers. This procedure resulted in a framework model addressing all the relevant aspects discussed in the literature so far. The following 13 categories (partially consisting of subcategories) have been identified as being relevant in the context of an SME's ICT capabilities:

- Training (on-the-job employability): this topic embraces the themes training, employability and the changing nature of employment, together with assessment and development plans (career management).
- ICT skills gaps: this topic is directly or even indirectly discussed in most of the studies, but not registered by the keywords in any of the subjects, be it the ICT skills development barrier, closing the digital divide or the lack of government strategies, and it is therefore discussed as a separate category.
- Education (lack of knowledge): the education takes place either within the enterprise, in which case it is linked to the first topic (training/on work employability), or at educational institutions, such as universities.
- ICT skills: they are seen from different points of view, namely, the skills boasted by the ICT managers, ICT skills challenges, identifying critical skills, skills sets change and development and basic ICT skills. These are themes that might also be considered to be part of the ICT skills gap topic, but they have instead been considered to be part of a positive view on skills instead of being treated as an orientation towards shortcomings.
- Adoption: the topic is discussed in this context with a focus on the skills, competencies and capabilities that are needed to adopt new technologies.
- Investment and value gained from ICT: as with adoption, we find research on productivity, growth and other phenomena that can be seen in relation to ICT skills, competencies and capabilities as an instrument to promote overall business success.
- E-skills and their assessment: they are mostly referred to as skills relevant to new age businesses applying the Internet as a source of business in order to gain value through E-business or similar activities.
- ICT competence: in this category, papers discuss the subject using a general approach to how the enterprises as a whole can enhance upon the right use of technology.
- Demand for, and supply of, skills: in this category, both the educational system and the job market will be addressed.
- ICT workforce: ICT workforce, ICT specialists and non-ICT knowledge or expertise are the themes of this category, with the focus resting on who the workers are and how they work.
- ICT in organisations: this topic includes IT in organisations, organisational change and business IT challenges.
- Globalisation of ICT: this topic is related, among other things, to ICT outsourcing and offshoring issues. With the increasing use of cloud services, its importance could well grow.
- Capabilities: the term is mostly used to describe ICT knowledge or complex ICT-related abilities as a whole at either a nonpersonal or an abstract level.

The categories to some extent overlap and represent the different topic areas and denote research streams related to IT capabilities that it has been possible to identify so far in the SME context. The framework model, which can be applied both at the organisational and the individual level, has been used to analyse the relevant

literature from an organisational perspective in order to highlight the current state of knowledge. It can serve as a basis for further research and refinement in the future.

9.3 Results from Analysis at the Organisational Level

9.3.1 Training (on Work Employability)

In the context of this topic, the following issues were discussed at the organisational level: *Training, Employability and Assessment and Development Plans (Career Management*), except for the *Changing Nature of Employment.* These subjects are cited in a total of 87.5% of the sources at the organisational level in SMEs. Its essence is excellently described in Goh et al. (2008, 361): "Training is seen as an essential and effective way to help SMEs to cope with skill shortages", which explains the connection both to the *ICT skills gap* and to the *education*, *ICT skills* and *demand for and supply of skills* topics. This view is displayed in several of the studies on the issue (e.g. Wielicki 2007; Scholarios et al. 2008; Wielicki and Arendt 2010), which shows us how intricate the system of topics is. The topic *training* is very often connected to the fact that there is a shortage of ICT skills, the so-called ICT skills gap, competencies and capabilities in SMEs and, equally, insufficient access to, or funds devoted to, technology (Wielicki 2007). Wielicki (2007) goes on to show how the three principal barriers to the implementation of IT are cited as being, first, the *lack of IS plans*, then the *lack of knowledge and skills* and, lastly, the *lack of funds*, as the question of funding is always an issue for enterprises, irrespective of their size.

Most of the sources discussed *training* as being attributable to the need for skills and more as a solution to the skills shortages (Goh et al. 2008; Wielicki 2007; Scholarios et al. 2008; Wielicki and Arendt 2010; Zambarloukos and Constantelou 2002). Other sources tried to answer the question as to *how* the training should be made accessible to the ICT experts. A common issue was the focus on employability (Maryska and Doucek 2013; Scholarios et al. 2008; Caldeira and Ward 2003; Zambarloukos and Constantelou 2002), focus could be found on assessment and development plans (Scholarios et al. 2008; Zambarloukos and Constantelou 2002).

Training is mentioned as an issue when employability is discussed in the SMEs, as a solution to the existing gap, "… the education system and training policies should try to fill this gap. This could be achieved by combining formal education in ICTs with more hands-on experience, which is currently lacking among those that are being employed for the first time" (Zambarloukos and Constantelou 2002, 250–251), which puts the focus firmly on the educational perspective as the solution to the same problem.

All the sources at this level consistently define on-the-job employability and the need for training as a result of the skills shortage, which, in turn, shows how the fields of study *ICT skills, competencies and capabilities in SMEs* are connected and

constitutes a highly intricate concern. A tacit assumption made here is that the ICT skills gap or the skills shortage in SMEs (and enterprises overall) is an issue in most of the studies on this theme. As a result of the pace of technological change, the development of knowledge in the form of skills, competencies and capabilities is just as fast – which creates a skills shortage in the enterprises. This shortage (ICT skills gap) needs to be filled either by workers' education or with the aid of organisational investments in *work employability.*

This hypothesis is confirmed by the most relevant topics at both organisational and employee level. *Training (on work employability)*, *ICT skills gaps*, *ICT skills*, *education (lack of knowledge)* and *investment and value gained from ICT* are throughout the most important topics in the studies focusing on *ICT skills*, *competencies and capabilities in SMEs* across the different levels. This coherence is probably no coincidence, and further research could be done to look into similarities and parities.

Wielicki and Arendt (2010, 172) present the findings that: "… the more knowledge-driven a given economy is, the more likely it is that managers and owners of SMEs in that economy will shift their attention from short-term ICT barriers, like lack of funds, to more long-term barriers, like lack of knowledge and of an information system plan", which is confirmed by Scholarios et al. (2008), who present a thorough analysis of the employment and psychological contract in the European ICT sector SMEs by analysing over 100 interviews with managers in SMEs in seven different countries. The analysis showed that actual policy for enhancing ICT skills tends to lag behind despite "… the existence of skill shortages in the more developed ICT sectors and a generally expressed need for more generalists, and a socially skilled, adaptable technical workforce" (Scholarios et al. 2008, 1052).

9.3.2 ICT Skills Gap

The framework clearly presents this topic as one of the most important in the context of *ICT skills*, *competencies and capabilities in SMEs* at the organisational level, with a close link to the other topics: *training (on work employability)* and *education*, as most of the sources that discuss *the ICT skills gaps* (Goh et al. 2008; Wielicki 2007; Wielicki and Arendt 2010; Zambarloukos and Constantelou 2002) and also discuss these issues at the organisational level.

The ICT skills gaps are not always explicitly expressed in the sources; Goh et al. (2008) describe the ICT development barrier in SMEs as being the main problem to the ICT skills challenges faced by SMEs today. One of the key findings in Goh et al. (2008) pointed to SMEs' need to update their current and latest ICT solutions and to the benefits of ICT training opportunities. Other papers discussing the same problem refer to it as involving a *closing of the digital divide* (Wielicki 2007; Wielicki and Arendt 2010), which is still a statement that points to the skills shortage in SMEs. In addition, Wielicki and Arendt (2010), together with Zambarloukos and

Constantelou (2002), see a need for more action to be taken at governmental level and ask where the governmental strategies to solve the skills shortages cited by the enterprises are.

Wielicki and Arendt are two well-known names in the research, having elaborated several theories and studies on *ICT skills gaps*. Their articles are all of considerable relevance and interest, and the same is true of the subject *ICT skills, competence and capabilities in SMEs*. It should be mentioned that several of their studies could be considered relevant here, but only the most accurate ones have been chosen. They describe *the digital divide* as a multidimensional phenomenon emerging from the concept of an information society embracing several disciplines, such as sociology, political science and economics, business and information systems – therefore the term should perhaps be *digital divides* (Wielicki and Arendt 2010).

Van Dijk (2005) reiterates this way of seeing the digital divide, albeit from a different perspective than the *skills perspective* – which embraces the perception of the complex intricate relations between the topics. "… the perception of key barriers to implementation of ICT-based solutions is shifting from those factors associated with lack of access to funds and technology to those associated with lack of knowledge, education and know-how" (Wielicki and Arendt 2010, 165). Thus, along with these barriers to ICT adoption and perception gaps, the rapid growth of ICT presents both perpetual opportunities and challenges to SMEs (Goh et al. 2008, 360). The general approach, seen from an organisational point of view, is stressed in these papers – namely, the objective of how SMEs (on a regular basis) can be enlightened in order to solve the problems.

9.3.3 Education (Lack of Knowledge)

As described in the former topic on *the ICT skills gaps*, these two subjects are closely related. Wielicki and Arendt (2010, 173) conclude that in order to eliminate the business digital divide (between SMEs and larger corporations) the solutions should "… not evolve around merely providing SMEs with more access to technology, but rather concentrate on providing access to training, education and creation of organizational knowledge among SMEs". This is connected to the quotation in the first topic of Wielicki and Arendt (2010), which describes how this should be the focus in both more highly developed and less-developed economies.

The studies on e*ducation (lack of knowledge)* all see education closely related with the need for training (topic 9.3.1). This comes as a result of the lack of knowledge cited by the enterprises (Wielicki 2007; Wielicki and Arendt 2010; Zambarloukos and Constantelou 2002).

Goh et al. (2008) confirm this link, defining *Training* and *Education* as the solution to dealing with the skills gap and to coping with the rapid changes in technology, although education is not even one of the main subjects of this study. Even the European Commission urges the introduction of policy initiatives to enhance ICT

training at all educational levels, with a view to meeting market needs and closing the ongoing skills gap (EC 2014).

As a matter of fact, ICT skills quickly become obsolete so that "… institutions of lifelong learning that will ensure the continuous re-skilling of the labour force need to be established … " (Zambarloukos and Constantelou 2002, 251) along with programmes between educational institutions and the job market that would enhance a relevant education, as it is "… important for educational institutions to achieve a balance between teaching specialised skills and more generic skills, which will enable employees to quickly learn new skills" (Zambarloukos and Constantelou 2002, 251). This issue is thus also closely linked to the topic of the *demand for, and supply of, skills.*

9.3.4 ICT Skills

ICT skills, from an organisational point of view, refer to the SMEs' needs for ICT skills to be offered to them by their workforce in the area of ICT. This subject is one of the five most discussed issues at the organisational level in SMEs and is especially closely connected with the issues of *training* and *investment and value gained from ICT* according to the framework. The skills are seen to be both part of the management and the workforce level. Caldeira and Ward (2003) mention the firm's managerial IS/IT skills as a determinant for the overall organisational competence in IS/IT; when resources are allocated for investment in ICT, the IS/IT provides the basis for the firm's distinctive business capability.

This issue is considered at different levels. Zambarloukos and Constantelou (2002) go on to consider the *skills shortage* and *ICT skills challenges*, as in topics 9.3.2 and 9.3.3. This perspective on the skills shortages is shared by other publications on the subject, even though Maryska and Doucek (2013) and Caldeira and Ward (2003) choose to focus on the skills boasted by the ICT managers as being the key to solving the skills shortage in the enterprise overall. This includes the *use* of IS and technology (Caldeira and Ward 2003).

It is important that the skills aspect of an SME be seen from both the technical and the non-technical perspectives (Maryska and Doucek 2013). The authors also emphasise the importance of the managers' knowledge and skills, which "… should include knowledge outside the field of ICT, known as the 'non-ICT' knowledge", so as to ensure that the macroeconomic aspects of the business' daily life and complexities are understood. These statements are confirmed by Zambarloukos and Constantelou (2002, 250–251), as they accentuate the importance of finding a *balance* between technical and more generic skills – and not just in ICT SMEs. The training and education perspectives are thus connected, too, in order to reduce the shortage of those skills needed by SMEs, irrespective of whether these be ICT or non-ICT skills.

9.3.5 Adoption

Adoption is a subject considered more at the organisational level, than at the employee level in the publications dealing with SMEs. The subject on this scale is linked to the effective and successful adoption and management of critical capabilities at the organisational level with a view to gaining value from ICT (Doherty et al. 2013; Wielicki and Arendt 2010; Caldeira and Ward 2003).

In order to understand the successful adoption and use of IS/IT in SMEs, the model in Caldeira and Ward (2003, 1166) focusses on the importance of there being a top management that understands and supports the development of IS/IT capabilities and its needs and importance to the business. This definitely describes the connection between *adoption*, *capabilities* and *investment and value gained from ICT.* Doherty et al. (2013) explain the importance of organising the IT capabilities in order to succeed in the adoption of ICT, as a framework of skills, competencies and capabilities providing an overview of the actual situation in the enterprise. The perception gap of *what skills are needed* is confirmed by Wielicki and Arendt (2010, 172), who also suggest that there is a need for more information as to *what* knowledge is necessary to the enterprise.

9.3.6 Investment and Value Gained from ICT

This issue is one of the five most important topics at both the organisational level and the employee level. Value gained from ICT is probably of considerable relevance to SMEs, as the opportunity to raise productivity is closely connected with ICT. Maryska and Doucek (2013, 373) point to the importance of the innovation process in SMEs as an "… essential part of successful business" and use it to explain the connection between the innovation, investment and value gained.

This issue is viewed from different positions, albeit sharing the same goal – to boost value in the SME. Doherty et al. (2013) consider precisely this, i.e. they look at how value can be gained from mapping critical capabilities, which is one of the central questions they ask. Wielicki and Arendt (2010) explain the value gained as a result of higher productivity, and they are supported in this by Maryska and Doucek (2013), who add the competitive advantages provided by ICT through the use of innovations as a means to achieving the goal of gaining value and boosting turnover.

Doherty et al. (2013, 7) develop a capability-centric framework "… designed to enhance the business value gained from the IT investment of the SME". The ICT skills challenges are linked up by Wielicki and Arendt (2010), as investments in training and education, in turn, bring value gained from ICT workers in SMEs. Investment should therefore be divided into material and human resources (HR) investments.

9.3.7 E-Skills and Their Assessment

As this topic was not found to be significant in the papers discussing ICT in SMEs at the organisational level, it is left out of this discussion. Anyway, it overlaps with ICT skills.

9.3.8 ICT Competence

As with E-skills, this topic is not considered to be significant in the literature discussing ICT in SMEs at the organisational level. It is therefore left out of the discussion and also overlaps with ICT skills.

9.3.9 Demand for and Supply of Skills

This topic is mentioned by only one study at the organisational level. The focus is concentrated more around supply and demand at the individual level, when the SME's situation is discussed. The issue seems to be addressed more often in studies on larger enterprises. This may suggest that there is indeed a problem relating to the research at SME level, as the importance of the demand for, and supply of, skills should be discussed for these firms, too.

Zambarloukos and Constantelou (2002) are the only authors who consider this issue at the SME level. During their interviews, they found that ICT knowledge was to a considerable extent outsourced and that there was therefore less demand for ICT skills, along with a sufficient supply of skilled labour, which explains the small number of skilled professionals hired. "Only about half of firm representatives interviewed stated that their department/firm had hired or looked for a person with ICT-related skills during the past two years" (Zambarloukos and Constantelou 2002, 244), although it has to be stressed that this study was looking at Greek SMEs or enterprises in peripheral Europe, and the results could deviate from highly industrialised cities in the rest of Europe.

9.3.10 ICT Workforce

The topic is discussed only in one publication, *Non IT Knowledge*, by Maryska and Doucek (2013), and the main focus is on managers of SMEs and their employability, where ICT knowledge is seen as a factor in enhancing value gained from ICT at the business level. There is a good reason to believe that the focus on the *ICT workforce* should be considered only when there really is a *workforce.* At SME level,

there is rarely any *workforce* worth mentioning, as most of the SMEs are enterprises that employ fewer than 50 employees.

9.3.11 ICT in Organisations

Also this issue is discussed only once, namely, in the work on *Business IT Challenges*, by Doherty et al. (2013). As already mentioned, this source discusses the critical capabilities in SMEs from a business process management (BPM) point of view – in particular, with a view to how the execution of an organisation's processes is intended to work. The paper seeks to examine the key business challenges faced by SMEs around their ICT in a fast-changing technological society (Doherty et al. 2013). Still, is this a relatively barren field of research when it comes to SMEs, as the *organisations* considered are mostly larger enterprises?

9.3.12 Globalisation of ICT

This issue is mentioned by Zambarloukos and Constantelou (2002, 244) in terms of their focus on the demand for and supply of skills – as a reason for the lower demand for skills at SME level. Still, this is not one of the key terms of this paper and was not considered to be very relevant. Basically, it is well-known that SMEs often outsource ICT skills in order to solve their skills shortage problems in the short term (e.g. Zambarloukos and Constantelou 2002; Bernaert et al. 2014; Mauch and Wildemann 2004).

9.3.13 Capabilities

The concept of capabilities is mostly used to describe ICT knowledge at the organisational level. In their discussion of the IT capability, Doherty et al. (2013) use a maturity framework in order to figure out the critical capabilities (CC) and IT areas for SMEs – before it is cross-checked with the key IT business challenges and finally listed as overall critical capabilities. This approach to viewing capabilities looks at the problem from a decidedly organisational point of view. It is supposed to propose a general framework for SMEs at the organisational level, describing how the enterprise should be structured so as to achieve the highest possible revenues (Doherty et al. 2013).

9.4 Conclusion

In the course of considering the underlying research papers at the different levels (organisational and employee level), it has become clear that the different issues addressed in the framework model have distinct goals and objectives at the two different levels. At all events, the framework allows a coherent assessment of the core issues to be undertaken, albeit while underlining the need for further research.

Articles at the organisational level discuss the skills gap more often from a managerial point of view. They argue in favour of a change in attention – from a focus on short-term shortcomings, like access to funds and technology, to the more long-term barriers, like the lack of skills. This argues in favour of a need for change in the systems and ways of thinking found in SMEs.

At the organisational level, we found general approaches from an organisational solution-related perspective as to how systems or cooperation structures (*capabilities)* in SMEs can be changed and improved on a regular basis. Their goal mostly is to enhance the flexibility of training and education – in order to close the ICT skills gap. Frameworks for skills assessments can help in detecting *which* skills will be needed in order to train or hire the workforce so as to compensate for existing skills shortages.

Articles at the organisational level, furthermore, display a greater interest in *governmental strategies* and approaches to solving the skills shortage; these sources deploy general approaches to the educational perspective – proposing a closer relationship between academia and the job market, overseen by the government. This subject at the organisational level is also connected to the individual level perspective on education, where the issue is divided into an *academic* (educational curricula discussions) and a *business* perspective (considering work *employability*, to be understood as involving *training* and vocational strategies).

What is interesting is the inconsistency with which the term *ICT skills* is used. As stated in the introduction, this term should be utilised mainly at the individual or employee level, as a term discussing the applied knowledge boasted by the ICT workforce. Nevertheless, the framework elaborated here showed that this term can be found at the organisational level, too, which is sometimes confusing for the reader and leads to misunderstandings.

Figure 9.2 comprises the top five subjects of research on *ICT capabilities in SMEs. The numbers assigned to the lines count the papers dealing with the interconnections between the main topics. Investment and value gained from ICT* is the last topic among the top five research subjects. All enterprises, irrespective of their size, strive for the highest possible turnover. ICT is cited as being one of the most important tools to promote innovation, which again is considered to be a main factor in helping businesses to generate a higher turnover or foster growth (e.g. Antlova et al. 2011; Maryska and Doucek 2013; Doherty et al. 2013; Dorner 2009). The subject, by the way, is discussed at both levels. What is consistently true is that this issue is considered to be important in any general approach to achieving the goals to which SMEs aspire.

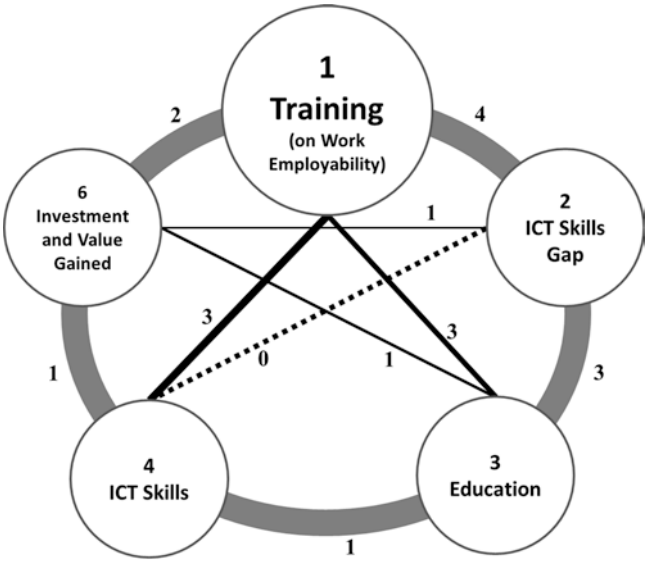

Fig. 9.2 Concept mapping of the top five aspects

A clear understanding of the capacities possessed by ICT for SMEs is considered to lead to their gaining a competitive advantage with the help of enhancements to their performance, productivity and growth, these things always being linked to managerial factors (e.g. Dibrell et al. 2008; Vieru et al. 2015; Southern and Tilley 2000). Matthews (2007) also points out the importance of ICT as a factor in supporting the expansion and growth of SMEs and states: "The SME support needs to fill in the gaps left by policies that only provide equipment or incentives without boosting knowledge and the ability to adapt to new ways of working" (Matthews 2007, 818). The need for ICT to be dealt with in an insightful way so as to turn it into a tool to gain value is a prevalent subject, one that is discussed and associated with a beneficial impact on revenues – and thus one of considerable importance to the SMEs.

From a macroeconomic perspective, consolidation (i.e. mergers and amalgamations with other benchmarked enterprises) is an important result of ICT usage. On the other hand, the adoption of ICT and the employment of ICT staff foster the exploitation of technology and leads to SMEs boosting their profitability and increasing their outreach (Matthews 2007; Dibrell et al. 2008). Along with the focus on the adoption, training and use of ICT in SMEs, academia is an important factor and should be considered to be more relevant in the future (e.g. Bernaert et al. 2014; Petrova and Medlin 2009).

Generally speaking one can state that today SMEs suffer from handicaps in acquiring up-to-date skills and expertise on new technologies, combined with a lack of adequate training and education. Both factors hinder the enterprises from adopting the opportunities brought by new technologies (Vieru et al. 2015). With the help

of the framework, a structured literature review has been carried out, and the research in this under-investigated field of knowledge has been successfully mapped out. For the first time, a comprehensive summary of the specialised research literature in this field has been provided. The state-of-the-art presentation in this paper can help firms not only to take the right measures in practice but also to build a basis for further research that is commensurate with the importance of the role played by SMEs in global business.

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Dr. Franz Lehner is full professor and holds the Chair of Information Systems (Wirtschaftsinformatik) at the University of Passau (Germany). His research interests cover the areas of knowledge and information management, e-learning, mobile applications and cloud computing.

Mathias With Sundby is research scholar in information systems. He received his diploma in business administration from the University of Passau and is currently continuing his studies at the University Edinburgh. In his research, he was focusing on IT skills and capabilities.

Chapter 10
Supporting the Change to Digitalized Production Environments Through Learning Organization Development

Christoph Fischer and Alexander Pöhler

10.1 Introduction

The digitalization of society and all industries is a continuous process. The ongoing penetration of computer technologies has had a major effect on personal as well as working life. Nowadays, nearly every job includes operating a computer or working with a computer-operated machine. This penetration has already greatly changed working environments and led to a transformation of workplaces and corporate functions. Even in production, the majority of working hours is used for operating of or communicating with computers or computer-controlled machines (e.g., logging in new orders, reporting quality defects, and documenting on process changes). Until now, computers in industrial companies were mainly used as supporting tools or automation for repetitive tasks. Current research in artificial intelligence, cyber-physical systems, and advanced robotics will lead to a change in the roles of computer technologies, making them not just tools or devices but participants in the industrial environment itself (Gronau 2013). This transformation process is embodied in areas such as self-controlling production systems and autonomously working machines, showing the automatization of decision-making and the subsequent execution of business processes in industrial companies. Current national and international research programs and topics such as the industrial Internet, factories of the future, smart factories, Industry 4.0, and cyber-physical production systems address this change to digitalized products and processes (Manzei et al. 2016). This change of the role of computer technology in industrial companies will likely also entail changes in working environments and the role of employees in production.

The term *digitalized production environment* describes the final state of the alteration process through the implementation of modern computer technologies. This

C. Fischer (✉) • A. Pöhler
Institute of Educational Science, University of Paderborn,
Warburger Str., 100, 33098 Paderborn, Germany
e-mail: chr.fischer@upb.de

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alteration process includes the penetration of computer technologies into all aspects and a change in the use of computers from being tools to being active parts in the production. This change will lead, inter alia, to a self-executing production control system. The interconnection among the systems plays a crucial role in this production scenario. For a computer system to be able to make a decision regarding its task, it needs to obtain holistic information about that task. Therefore, localized information needs to be used in order to gather all information required for the decision-making process. A cyber-physical production system (CPPS) addresses this problem and enhances production systems with the needed information-gathering and processing tools and communication devices. A CPPS consists of linked, collaborating cyber-physical production device (CPPD). A CPPD is an embedded system that has an additional networking interface to communicate with other CPPDs. Its task is to control or observe physical production processes through sensors and actors (Bettenhausen and Kowalewski 2013). Through the connection of multiple CPPDs, the data exchange among them and connections to superordinate collaboration platforms, CPPSs can gain holistic information on their given tasks. This improved information processing also enables localized improvement of processes, such as an implementation of embedded cognition and artificial intelligence. CPPS offer a higher flexibility of the production system due to the possibility of implementing self-x abilities and using them for control-decision processes (Acatech 2012).

The automatic decision-making and execution of tasks through computer technologies has a significant impact on the working environment. Nowadays these decisions are made and executed by human employees. The role of human employees is going to change if in future computers can assume such tasks. Besides assuming tasks, modern computer technologies can also be used to support employees more intensively than before. Human-machine collaboration, data analytics, and information visualization can improve human working and decision processes. The elaboration of the change and the consequences for working environments is yet uncertain. In the literature, two scenarios, called the automation scenario and the tooling scenario, describe two opposing manifestations of this change (Botthof and Hartmann 2015).

In the automation scenario, the computer technology is used to replace employees (even in complex processes) with automated computer technologies, whereas in the tooling scenario these technologies are used for improving current working situations.

The tooling scenario assumes that the new technologies are used to support human working environments by providing additional information and assuming hazardous and harmful tasks such as lifting heavy objects. Decisions, however, are still made by responsible employees and not by the computer system itself. Collaborating machines enable process-integrated assistance. This scenario leads to a higher appreciation of human work and human decisions. Their knowledge is still the key success factor for an efficient production process. In addition, the operation of the computer technologies introduced demands certain abilities of the assigned employees.

In contrast, the automation scenario focuses on replacing the human workforce by machines and modern computer technologies. The employees in this scenario mainly perform the tasks given by the computer system. Through transferring these tasks to computers, their own scope of action becomes limited. The knowledge of the process and the machines is digitalized and transferred into a knowledge basis and superordinate data management tools, which are needed for the decision-making process.

These scenarios describe the connection of the virtual representation of the industrial production with the physical production environment on the machine side. Despite the elaboration of the change, the introduction of CPPSs in a human-centric environment demands also a connection between human and CPPS. This connection requires adaption processes on both sides. The elaboration of these adaption processes depends on company-specific circumstances. A broad perspective on this matter will allow insights into different implementation plans. Section 10.2 shows specific implementation examples. Changes in the workplace (Sect. 10.2.1) and in the working environment (e.g., order assignment and workflows; Sect. 10.2.2) are also depicted. Section 10.3 describes factors crucial for a successful transformation process. Subsequently, the learning culture as one crucial success factor for the commitment to change is discussed in Sect. 10.4. The final section, Sect. 10.5, includes a brief summary.

10.2 Digitalization

The digitalization of the workplace can lead to many changes in working life. The introduction of modern information and communication technologies changes the way people interact with each other, with machines, and with the information itself. The omnipresence of information can be used for a faster dissemination of information and thereby a flexibilization of planning and execution. Specific examples of the introduction of modern technologies and the digitalization expressed thereby are illustrated in the following Sects. 10.2.1 and 10.2.2.

As mentioned in Sect. 10.1, the elaboration of the digitalization depends mostly on company-based influencing factors. The technologies themselves can be used in many different ways. For example, industrial robots can be utilized to support human workers by moving heavy objects, but they can also replace human workers by assuming all of their tasks. The appreciation of employees plays a key role in this elaboration. In the following, possible changes to the workplace and the working environment are described by illustrating different scenarios. Section 10.2.1 deals with direct influences on the workplace through the implementation of new technologies such as human-machine collaboration, augmented reality, and improved information processing. The direct workplace is mostly changed through the introduction of digital technologies and not the digitalization of processes. The implementation of augmented reality (AR) in assembly stations and the digitalization of

a mobile phone-based personnel planning system are explained in detail as examples of different elaborations.

In Sect. 10.2.2, the influences of modern information and communication technologies on the working environment are discussed. In particular, an automation of production planning and control is examined, and consequential transformations are estimated.

10.2.1 Digitalized Workplace

The digitalization of the workplace has many facets. The most visible changes stem from the implementation of new technologies such as using mobile devices for information management, using new ways of human-machine collaboration, and using new tools for information processing and visualization. In the following, digitalization is examined by evaluating pilot applications of the implementation of digital technologies in the workplace.

Bauer et al. (2016) described the implementation of wearable sensors to support employees in production environments. The sensors were able to detect working capability factors such as stress, physical strain, and effort by measuring external forces and endogenous indicators such as heartbeat, sweat production, and blood pressure. Measuring this data enabled automatic human-centric personnel planning with a consideration of automatically derived personal demands. For example, a working schedule can be adapted to consider performance capacity and the previous personal physical strain of every employee, thereby reaching a harmonization of efforts and improvement of physical and mental performance (Paelke et al. 2015). Another example of implementing measurement devices into the workplace is the usage of cameras to determine the mental state of an employee (Sarode and Bhatia 2010). Mental states (e.g., stress, anger, and boredom) can be classified by extracting facial characteristics and evaluating facial expressions. Similar to the data derived from body sensors, this data can be used to measure working performance indicators such as stress level. Another research field is the investigation of new ways of interactions between humans and machines. Collaborative robotics is a key research field that enables robots to work together with humans without additional barriers and interfaces and also makes it possible to program robotic workflows for non-technicians. Collaborative work helps both the machine and the employee to fulfill tasks that neither could have accomplished alone. For example, a robot is able to support employees by lifting heavy parts. This collaborative characteristic also enables a human workforce to be implemented in completely automated production stations. In this way, tasks that are normally difficult for machines, such as producing a great variety of products or handling parts, can be assumed by the employee and repetitive tasks can be done by the machine.

New technologies open up possibilities regarding the improvement of the working situation and opportunities for novel workplace design, but they also entail great hazards for employees. Sensors that collect personal performance indicators could

be easily used for permanently monitoring and evaluating. The ongoing development of robots can lead to an assumption of simple tasks and thereby displacement of human labor. By making their procedures more flexible, robots will be able to execute even complicated operations (Bezak et al. 2014). The following two examples show specific applications of digitalized technologies and their effects on employees.

The first example shows how modern technology (in this case, AR) can be used to simplify current working tasks. The implementation of AR in assembly processes shows how technology can replace the necessity of employee knowledge and certain skills. Through AR, virtual objects are projected into a real environment. The virtual projection is normally done by a visualizing device (e.g., AR glasses) and an enrichment of the real world with additional virtual objects. AR is, for example, tested in production environments to display additional information such as assembly guidance, working plans, and assembly documentation. The augmented assembly information can also be used for assembly task-training purposes, as shown in Boud et al. (1999). Assembly visualization in augmented environments can be used in several types of assembly applications to increase productivity and reduce human error (Wang et al. 2016). Some experiments have been conducted to evaluate the potentials of AR, e.g., Westerfield et al. (2015) and Webel et al. (2013). The experiments showed that the implementation of AR could reduce mistakes and shorten the training period significantly. After the training period finished, operators still made fewer mistakes using AR-based methods. The process execution time, however, was longer than without the implementation of AR. Combined with a pick-by-light system and visual representation of the assembly documentation, no prior long-term training was needed to operate an assembly station (Hořejší 2015). Through video surveillance and the pick-by-light system, operation mistakes could be identified during task execution, and the quality assurance could thereby proceed automatically. By demonstrating every working step and installing restrictions such as specifying from which box the worker needs to grab parts in this process step, the worker only needs to execute the orders given by the system. The assembly of a great variety of products normally takes a lot of experience with the product as well as the assembly process. The delivery of all needed information paired with the installation of restriction (e.g., pick-by-light system) led to a downgrade of needed skills and therefore a devaluation of the assembly job. Knowledge of process and product is no longer needed by the process executor in order to operate the assembly station. The knowledge only needs to be available from a superordinate information system. The variety of the job and the intellectual claim are withdrawn from the competencies of the employee and stored into the information system. Promising results such as improved error susceptibility do not display possible negative consequences (e.g., devaluation) for employees. This example shows that the availability of information can lead not only to better execution of the job but also to paternalism treatment of human workers.

AR can also be used to improve familiarization with new environments and support employees mastering difficult working tasks. Gavish et al. (2015) described the usage of AR to support employees and train them on the job to exceed their actual

working scope. AR opens up the possibility of training in an added virtual environment in the actual real working space. AR makes it possible to learn new skills and operate new devices on the job. Employees are thereby empowered through the technology to improve their skills and learn completely new skills on their own. This example shows that technology can be used in either way. AR can grind down or suppress the acquisition of skills but can also be used as a learning tool. Attached restrictions or a downgrade of competencies is company driven and does not depend on the technology itself.

10.2.2 Digitalization of the Working Environment

The main potential of Industry 4.0 is the connection or integration of systems and services. Two types of integration are thereby distinguished: vertical integration of the company and horizontal integration across enterprise boundaries. Vertical integration allows each unit (e.g., software services, machinery, equipment, workpieces, and storage and transport systems) to collaborate in an enterprise network with other participants. Horizontal integration is used for networking of systems and services across the value chain, including those of customers and suppliers. This networking and thus the constant availability of information offer considerable potential in the production process itself. Through this interconnection, new possibilities regarding information processing, automation, and process improvement can be exploited. The following are the main changes that result from the implementation of Industry 4.0 (Bettenhausen and Kowalewski 2013):

- A multidisciplinary, integrated information exchange, e.g., to product/process and production status of all participants in the value chain
- The immediate, automatic optimization of processes and systems, for example, machine learning
- The flexible configuration and self-organization of the production processes for faster adaptation to new market conditions and product variants
- The adaptation of processes and systems during runtime (plug and produce)
- The self-diagnosis of the components (e.g., predictive maintenance)

Nowadays, workflow management software and product data management software already simplify the storage, usage, and processing of information. New computer technologies will have a great effect on the automation of such processes and their interaction with information. Examples of the effects of the change of interaction with information were described in the previous subsection. The diffusion and further development of process automation will include processes such as decision-making and planning processes. This means that employees will need to execute decisions and plans that were made and created by computer systems and not a human supervisor.

The roles of employees in such an environment can differ substantially. To illustrate possible consequences, two examples are introduced in the following. The first

example shows an application of computer systems that completely assume production system tasks that were under human control. The second elaboration shows the usage of a modern information system as a supportive tool for employees to improve decision-making processes in the production system. Both examples show the production planning process in different elaborations. Nowadays, production planning is usually executed by production planners, who create production plans for every machine by considering, for example, contracts, available capacity, and stored material. This production plan serves as a basis for the upcoming working tasks of each production system. With fully integrated systems such as manufacturing execution systems (MES) combined with production data acquisition facilities, a consistency of plans and data can be reached today. Either machines receive the production plan automatically and simultaneously report order and machine status or employees in the production system are informed about changes and consistently need to report order and machine status. With systems such as this, there is no need for a direct interchange between the production planer and the executing employee in the production system. Changes are implemented immediately, and the situation in the production system is permanently observed. The major difference of Industry 4.0 will likely be a complete replacement of the production planner by a computer system. This means that major decisions involving, for example, working processes and direct commands for human employees are created by a computer system and not another human employee. The elaboration of this change and the involvement of employees can differ substantially. Possible elaborations can be explained with the aid of an assignment to the automation and tooling scenarios presented in Sect. 10.1.

In the automation scenario, computer technology would be used to replace human employees to save expenses. Production control and planning would be executed automatically by the planning software, and employees in the production would receive production plans and working tasks from the software system. Nowadays, an MES is partially capable of automatically creating a production plan and determining tasks. The technical allocation of orders and employees to the production system is executed via computer algorithms. Kiener (2012) described a collaboration with human employees from a technical perspective. The study focused on the correct usage of machine and production data collection and the visualization of production plans and working tasks. The difference between a human- and a machine-made decision was not considered in this technical perspective. The production plan creation was based only on technical key figures and personal experience. Production employees did not feel changes through an automation of this kind of planning process. Technically, the production employee received the same technical information regardless of whether the plan or working task was created by a software system or by another human employee. However, psychologically this process can differ. An examination by Töniges et al. (2017) showed that there was a difference in perception depending whether the decision was made by a human or a software system.

Another way to use computer technology in the production planning process was studied by Bauer et al. (2014). In this scenario, the employees collaboratively

decided how working tasks were assigned. Employees were able to decide on their own working hours and their workload and were able to choose production orders independently or as a collaborative group decision. In order to select appropriate orders, all needed information for making the decision was displayed at the workplace. Working groups or employees who were responsible for a single production system organized themselves. This organizational form, where employees in a production system are organized in working groups and decide about their own production plan, is very common. This scenario can be expanded by replacing the prescreening process of a production planner with a computer system, which lets the employees in the production system make the final decisions about their working tasks and their production plans. The computer technology can also be used for providing and gathering additional information for an improved decision-making process. In this scenario, the employees decide and the computer systems are used as a tool for the employees in the production system.

The immediate visible changes of this enlargement of the usage of computer systems in the automation scenario for production planning appear less significant than they really are. Employees still need to execute the orders that appear on their monitors. Through automation, the task assignment process as one supervising process is taken over by the computer system. This changes the role of both the employee and computer system. In this scenario, the computer system generates direct orders for human employees. In the other scenario, the changes are also significant. The superordinate decision-maker is replaced by a computer system. Therefore, there is no superordinate contact person and the decision scope of the employees is widened.

10.2.3 Conclusion

Section 10.2 illustrates possible changes for production personnel through the digitalization of industrial companies. Digitalization will change how employees work and the superordinate processes that they are part of. The interaction with computer technology will in any case increase; therefore, reliance on the competent use of technology is a key to the change. These changes in the role of human employees are also accompanied by a change in skillset. The elaboration of the change, however, can differ substantially. Novel technologies can, for example, be used to replace employees and decrease the working area or as a tool to improve human decisions and enhance their decision-making scope. How a change is implemented depends mostly on company-based factors. Companies' currently existing systems, organizational forms, and hierarchies play important factors in the elaboration of this change. Often the technical implementation is just an enhancement of the existing system. For example, if a company already has a restrictive policy, it is unlikely that production personnel will assume production planning tasks. This section shows that there are significant changes either way and that these changes have a great effect on the workplace, the working environment, and the working situation

of production employees. Therefore, these changes must be managed, and factors for a successful implementation must be considered.

The following section illustrates factors that play a key role in the commitment of employees to change regarding a more digitalized workplace and working environment.

10.3 Change

Both of the ways of introducing new technologies into the workplace described in Sect. 10.2 represent organizational change processes. To most organizations, this introduction is a major change process that changes the very nature of work and jobs (Wolter et al. 2015, 2016). Therefore, the change process cannot easily be implemented on the fly but requires deliberate management. Additionally, this change is not based on imminent danger but on the evolution of technology. Thus it is time to plan this change process to achieve a smooth transition to the new work environment.

Besides the technical and organizational issues that accompany this change process, the human factor must also be taken into consideration. Humans will work at the digitalized workplaces either as machine supervisors or as machine-supporting workers. Since humans will in neither scenario vanish completely from the workplace, they are crucial to the change success. If humans are not willing to support the change process and work in the new environment, the change will fail (Mazmanian and Mazmanian 1999). In order to ensure success in the change process, in addition to the technological challenges, the change must be managed in a way that considers how to foster change-supporting behavior in employees.

10.3.1 Commitment to Change

Change processes rely on the active support and participation of employees. Because change is a long process and employees cannot be under constant supervision or instruction, it is necessary that employees show self-initiated change-supportive behavior. Change management has thus to rely on the employee's intention to support this change.

Because the introduction of new technologies in the workplace is a process with a long timespan, employees have to show a kind of long-term motivation toward the change goal: the digitalization of the workplace. Furthermore, the change to a digitalized production environment generates huge development requirements for the employees.

Both the necessity of learning skills to handle the new technologies and the introduction of a digitalized production environment changing the way technologies and human resources are used in the production cycle change the roles of employees.

These changes are not easily mastered and require support of those who have to implement the changes over a long period. One way to predict the continuing support of the workers to change processes is to assess their commitment to the change.

The construct of commitment to change stems from the previous construct of organizational commitment (Herscovitch and Meyer 2002). A large body of literature deals with the employees' commitment to organizations in order to research the relationship between individuals and organization. Organizational commitment was described by Meyer and Allen (1991) as "a psychological state that (a) characterizes the employee's relationship with the organization, and (b) has implications for the decision to continue or discontinue membership in the organization" (p. 67). The common understanding of commitment in the research literature is that commitment "(a) is a stabilizing or obliging force that (b) gives direction to behavior" (Meyer and Herscovitch 2001, p. 301). Following this common understanding, commitment has a long-term effect on behavior toward a certain goal. Initial research on commitment focused on employees' behavior toward the organization. Meyer and Herscovitch (2001) pointed out that there is also a commitment toward different subjects and on that basis developed a general model of commitment. They defined commitment as "a force that binds an individual to a course of action of relevance to one or more targets" (Meyer and Herscovitch 2001, p. 301). This course of action often includes times of hard work or unpleasant situations. For example, commitment to gain a college degree involves times of hard studying and even unpleasant examination situations. But if one is committed to getting the degree, one accepts the unpleasantness and work that this course of action requires and engages in a behavior to reach that goal.

Meyer and Allen (1991) conceptualized commitment as a multidimensional construct. They stated that the reasons for being committed (to the organization at that time) are not only determined by the individual's attitude toward the organization but also by the cost of leaving the organization and the sense of obligation toward the organization. Following this three-dimensional construct, Meyer and Herscovitch (2001) defined commitment in general as a mindset consisting of an affective attitude toward the commitment target, the perceived cost of not continuing the action toward or not reaching the target, and the felt obligation to continue or pursue actions toward the commitment target. These three dimensions are thus called affective, continuance, and normative commitment (Meyer and Allen 1991; Meyer and Herscovitch 2001).

In the case of change management, the commitment target is the planned change process. So the goal of change management is to ensure the employees' commitment to the change.

10.3.2 Antecedents and Inhibitors of Commitment to Change

The reasons employees do or do not support change processes may be diverse and even ambivalent (Piderit 2000). Therefore, to understand commitment to change, a differentiated view of the subject is necessary. The change management literature outlines then following influences on commitment to change: (a) the change content, (b) the change process, (c) individual attitudes, and (d) the context change is happening in (Choi 2011).

The change content in the case of digitalization of the workplace, as depicted in Sect. 10.2, varies greatly. Whether a scenario is favorable and appropriate and therefore yields a high commitment to the change is dependent on the situation of the organization.

The organization of the change process is also an issue on its own, consisting among other things of participation, fairness, and communication in the change process (Bernerth et al. 2007). Even though these components are also part of organizational culture, their impact on the commitment to change is scenario specific.

Individual attitudes and characteristics are an important predictor for commitment to change. Change self-efficacy may play a role as may competence or job satisfaction (Herold et al. 2007). However, the organizational influence on individual attitudes is limited. Organizational development will therefore not aim directly at individual attitudes.

Organizational development will rather focus on the organizational context the change is happening in, since this is a field where organizational development has direct influence.

Organizational culture and leadership promise a positive impact on the employee's commitment to change (Ahma and Gelaidan 2011; Choi 2011; Michaelis et al. 2010).

The opposite of commitment to change is resistance to change. Oreg (2003) described resistance to change as the "individual's dispositional inclination to resist changes" (p. 680). Therefore, resistance to change is not only a lack of commitment but behavior that is the exact opposite of commitment. It aims at preventing change and therefore opposes change-supporting behavior. The sources of resistance to change can therefore be seen as inhibitors of commitment to change. According to Oreg (2003), resistance to change is based on (a) routine seeking, (b) emotional reactions to imposed change, (c) short-term focus, and (d) cognitive rigidity.

In the case of digitalization of workplaces, several main issues criticizing the process of digitalization have been mentioned that can be associated with the resistance to change dimensions.

These are (1) the need for new skills and knowledge (Kagermann 2015; Bochum 2015), (2) the loss of jobs (Frey and Osborne 2013), and (3) the issue of privacy (Roth and Siepmann 2016):

1. The need for new skills and knowledge that accompanies the introduction of new technologies in the workplace requires at least new work routines or, in the case of highly flexible production environments, does not allow routines at work. This

requires a flexible mind that can adapt to ever-changing production situations. The change to a more digitalized working environment may cause resistance to this change in individuals that seek routines and show high cognitive rigidity.
2. The digitalization of working environments changes workplaces. This change transfers the digitalized tasks to the CPPS and thus affects the jobs at the workplace. Sometimes the change is extensive enough that the job at the workplace is completely replaced. In the long term, tasks are transferred to the CPPS and thus do not need to be performed by humans, but there will be new tasks that cannot be digitalized or that arise through the digitalization of the workplace. These of course require new skills and knowledge. Employees with a short-term focus and, as above, employees with high cognitive rigidity will therefore resist this change, since they will not see job opportunities in the labor market that will value their current skills.
3. The digitalization of workplace and especially the introduction of CPPS in the working environment raise the issue of privacy. The installation of all kinds of sensors through the introduction of CPPS at the workplace allows status updates on all installed cyber-physical devices (CPD). This allows constant monitoring of the machines. Through the introduction of sensors that allow the automatic adjustment of the machines to the operator, the CPPS allows direct monitoring of the operator. Through system status monitoring, indirect monitoring of the operator is also possible. This direct and indirect monitoring is essential to the goals of the CPPS but can cause strong emotional reactions against the change.

The goal of change management should be to act on these issues to counteract change-resistance behavior. Since the roots of the change-resistance behavior lie in the change itself, fighting the roots is not possible. In fact, it is more plausible to change not the reasons for these issues but rather the environment to the issues in order to reduce their negative impact.

The introduction of digital production environments represents a huge challenge for the changing organization. Naturally, the implementation of the new technologies has to be mastered, but this section has also shown that the support of the employees working in these new environments also plays an essential part. Their support ensures the success of the change process. One main predictor of change-support behavior and thus of change success is the employee's commitment to change. A high commitment to the digitalization of the work environment is therefore desirable. To ensure the required commitment, this work focuses on the organizational context that influences the commitment to change.

Therefore, change management should provide the required environment to support the employees' commitment to the change.

10.4 Learning Culture

From an external viewpoint, organizational culture is a certain way of doing things in an organization. It is how an organization works. Therefore it comes to mind first when thinking about organizational change. It is thus often proposed organizational change be supported with improvements in the organizational culture (Ahma and Gelaidan 2011). However, organizational changes also change how the organization works and therefore imply a change of culture. So the introduction of new technologies, which change how the organization works, also calls for a cultural change. The adaption of new ways of working and their integration into the organizational culture based on the necessities of the change can be called organizational learning (Watkins and Marsick 1993; Hendry 1996). Along with the aforementioned commitment to change, this raises the questions: (1) What is organizational culture? (2) Is there an organizational culture that supports organizational learning? (3) Can it also foster commitment to change?

10.4.1 Organizational Culture

As mentioned above, the way of doing things in an organization depicts its culture. Schein's (2004) theory is that organizational culture consists of three layers. (1) The basis and the bottom layer of organizational culture are the organizational members' shared beliefs and assumptions. (2) The second layer of organizational culture is strategies and goals. (3) The third and top layer consists of artifacts:

1. The basis of every action is a general belief about how the world works. In the organizational context, every strategy or every process started is based on beliefs or assumptions of what is the right way to handle the problem at hand. Since beliefs and assumptions are bound to humans, organizations cannot have beliefs or assumptions. To achieve a consistent way of handling problems, these beliefs and assumptions have to be shared. Naturally, one cannot give away beliefs and assumptions; therefore, everybody has to build up their own assumptions. According to Schein (2004), one can acquire beliefs and assumptions by solving problems together with other organizational members or by enculturation through feedback.
2. Based on shared assumptions and beliefs, strategies are made. These strategies can only be interpreted with the lower layer of beliefs in mind. Every strategy of how to handle problems is based on assumptions about the method of tackling the problem. Different assumptions will produce different strategies. On the other hand, a strategy only seems reasonable in the light of suitable assumptions.
3. The strategies result, if carried out, in processes, organizational structures, or workplace conditions called artifacts. The existence of artifacts can easily be observed, but the reason for their existence can only be interpreted in the light of

the strategies for their implementation and the assumptions on which the strategies are based.

The way problems are handled in an organization is based on the assumptions that every organizational member has about how to handle these kinds of problems, then on the strategies that are therefore deemed suitable for these problems, and finally on the handling of the problem itself.

In the context of organizational change and the introduction of new production environments, the focus on the culture is highly relevant. This more sophisticated view of organizational culture shows that the installation of new tools or work processes in the organization alone does not change the way the organization works. For a successful introduction of these new production environments, it is necessary that the employees working there see them as a good way to solve the problems at hand. This also requires new shared beliefs about the prospect of success these new production environments offer.

A change in culture requires new beliefs, new strategies, and new artifacts. So to use the new production environments, both the organization and its members have to learn them. On the organization's side, learning happens through the sharing of the beliefs and the introduction of new strategies that are based on these new beliefs. On the other side are the individuals that have to acquire new skills and know-how in order to work in these new production environments.

Usually didactically enhanced settings are used to support learning processes. In change processes this is also often the case. In a setting where production environments are designed to change often, however, organizing dedicated trainings may not be the method of choice. It seems more promising to create an environment that supports learning on all levels, thus fostering a culture of learning (Watkins and Marsick 1993).

10.4.2 Organizational Culture for Learning

Schein's general theory of organizational culture can be applied to different aspects of organizational culture. In fact, Schein (2004) specifically recommended focusing on a certain aspect of culture, since it is not possible to capture all shared beliefs, even in a small group. Since the acquisition of new skills and knowledge for individuals and organizations is one of the major factors that influence the success of an organizational change, the aspect of learning in an organization is of high interest. The concept of organizational learning culture tries to cover all aspects of learning in organizations and focuses on all explicit and implicit beliefs about learning. Following cultural theory, the shared beliefs concerning learning in an organization shape the organization's strategies and behavior toward learning, resulting in organizational structures. Depending on the shared beliefs, the structures can be more or less supportive for learning. Learning culture is therefore the value that is attributed to learning in an organization (Sonntag et al. 2004).

This appreciation of learning as good and necessary manifests itself in organizational conditions that support learning. This appreciation not only surfaces in formal trainings that are offered in organizations but also in a much bigger way as informal learning in the workplace. It spans from learning that supports coworkers over supervisors to proactive knowledge exchange with entities outside of the organization (Sonntag et al. 2005; Marsick and Watkins 2003). This positive view on learning in the whole organization leads to the perception of learning as an everyday routine, in contrast to learning as a solitary activity in a student-teacher situation.

Beliefs about learning, however, not only shape the organization's HR development concept but also have an impact on an employee's daily work life. One significant part is the handling of errors. Errors can be seen as a crucial part of the learning process or as something best to avoid. Therefore, the handling of errors can either support or inhibit learning. The error-handling culture of an organization can therefore be seen as a part of the learning culture that affects learning indirectly. Nevertheless, the error culture plays an important part in learning in the organization.

10.4.3 Organizational Learning Culture and Commitment to Change

The introduction of smart production environments present a change that depends on the support of all employees that work there. Since this change process is considered crucial for the future of industrial production, investment in staff training is recommended (Ganschar et al. 2013). The nature of training, however, is to focus on one theme or issue, and the introduction of smart production environments consists of a multitude of different small changes. So an investment not only in training but in the development of the organizational learning culture appears to be favorable.

Additionally, an organizational culture that supports learning can address the points that create resistance to change mentioned in Sect. 10.3.2:

1. Resistance to change that is based on the necessity of learning new skills could be lowered in a learning-supporting culture. This can be explained in two ways. (a) In a learning-supporting culture, learning is a kind of routine. Thus, the necessity of learning new skills is not a change but part of a routine. Since this is not a change, there can be no resistance to the change. (b) In a culture that fosters learning, learning is an everyday process and the employees are used to having a flexible mind. So there is less likelihood of cognitive rigidity that leads to resistance to change.
2. The resistance to the change because of the feeling of being left behind may be lower in a learning-supporting culture. In an organization that fosters learning from every angle and has a strong learning culture, the employees get the support they need to acquire new skills. Also, it is unlikely that they will feel that they are becoming obsolete. Since there is a culture in which constant acquisition of

knowledge is normal, it is also normal that knowledge becomes obsolete after some time. If in this culture someone feels left behind, this feeling stems not from the change but from other reasons.

3. The introduction of CPPS in the workplace can cause resistance to change because of privacy issues. Cyber-physical machines register the actions by the employees and communicate them to the other connected machines. This is not good or bad per se. However, it gets very complicated if errors occur. Since machines cannot "grasp" the situation that led to the error and can only report what the sensors measured, automatic error reporting by the CPDs may lead to serious misinterpretation. So workers may be afraid of using CPDs because they cannot explain their views on errors if they have already been reported by the CPD. They may be afraid of losing their sovereignty over what happened at the workplace. In the case of errors at the workplace, this can be counteracted with a good error culture. If there is a common understanding that errors happen and are used to learn from, employees are not afraid of them. If the employees are not afraid of errors, it is much easier to use the advantages of a CPPS to handle errors.

A learning-supporting culture may help to increase support for change processes in different ways. In general, change presents the need for new knowledge and skills. Since learning is change, a culture that favors learning means that change is nothing strange or to be afraid of. Additionally, a good learning culture makes learning simpler and therefore less of a hassle. And, finally, in a culture where everybody is encouraged and supported to gather new knowledge, nobody feels left behind if change requires new knowledge.

In the special case of the introduction of digital production environments, a good error culture, as a part of learning culture, can help to reduce fear from this change. The errors that every change includes and the widened reach of the digital production environment pose less of a threat if errors are considered a learning opportunity instead of a failure. In summary, investments not only in staff training but in learning culture development may indeed be a good way to ensure change support.

10.5 Conclusion

The digitalization of industry has a huge effect on human work and workplaces. Through the introduction of cyber-physical production systems, more tasks can be transferred to machines. Depending on the scenario or implementation strategy, this either replaces human jobs, forcing them to search for new jobs, or expands their job duties due to the relief the digitalization provides. Both scenarios represent theoretically extreme positions where human labor is still an issue. The actual introduction of digital production environments in organizations will be somewhere between these two extreme positions. In either case, the introduction of digital production

environments on a larger scale is a change process that requires the support of the employees working in this environment.

Since the introduction of CPPDs in industrial production is considered inevitable, an associated change is certain. To ensure a transition to the new production environment with minimal difficulty and stress, change management requires planning ahead. This work proposes supporting this change by fostering the employees' commitment to the change through an organizational learning culture. Commitment to the change process is a good predictor for change support by employees. A learning-oriented culture can foster the commitment to change through providing learning opportunities and thus creating the skills necessary for handling of future production machines and devices. This eases usage of new technologies in the workplace and thus fosters the change process.

Furthermore, a learning-oriented culture can lower the fears that are associated with digital change in the workplace and thus lower the resistance to change. In a learning-oriented culture, the need for new skills poses no threat that could lead to resistance to the change. Furthermore, a culture that sees errors as learning opportunities may serve to reduce fear of the introduction of machines that report errors throughout the organization. Fewer reasons to resist change make the decision to support the change process more likely.

This work proposes a good learning culture to support the change to a digital production environment in an industrial setting. Working on organizational culture however is a long-term task. It is necessary to embed new ideas and beliefs in the organizational culture and create a shared understanding of these new values. This is not a short-term intervention to ensure a near or already started change process. This is a means to support change processes that still lie (far) ahead. This may seem unsuitable, since changes to occur far in the future are not specific, no precise efforts can support them. However, establishing a learning-oriented culture in the organization creates a foundation for a variety of changes and thus supports the required organizational development as a preparatory measure.

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Christoph Fischer, M.A., is a research assistant at the working group on educational management and research in further education at the University of Paderborn (Germany). His research interests comprise workplace learning, knowledge management and organizational learning culture.

Alexander Pöhler, M.Sc., is a research assistant at the Heinz Nixdorf Institute at the University of Paderborn (Germany). He works on topics concerning the practical implementation of Industry 4.0, especially decentralized production control systems and their influence on the workplace.

Chapter 11
Agency and Learning in the Work of Software Professionals

Katja Vähäsantanen and Anneli Eteläpelto

11.1 Introduction

Digitalization challenges old work practices, patterns, and services, creating a need to generate new ways of working, collaborating, and leading in a wide range of professional contexts (Alasoini 2015; Bosch 2017; Edwards and Fenwick 2016; Haapakorpi 2012). Furthermore, novel technology shapes professional identities, roles, and boundaries (e.g., Eriksson-Zetterquist et al. 2009). Digitalization also affects the content and context of the work done by professionals who creatively design digital tools, applications, and services (as opposed to transferring them mechanically to digital form). So far, the digitalization of work has mostly been addressed from the perspective of employees who utilize digital products, rather than that of the professionals who design and produce digital services and environments.

This chapter considers software professionals' agency and learning in their work. Professional agency – generally understood as exerting an influence and making a difference in a professional context – appears to be necessary in a work that requires innovative learning, creative working, and the fluent renewal of work practices (Vähäsantanen et al. 2017b; Ylén 2017). This applies to information technology, in which there is an urgent need for creativity (Collin et al. 2017; Ulrich and Mengiste 2014) and the continuous development of expertise (Edwards 2010; Edwards and Fenwick 2016; Ha 2015). According to Edwards (2010), a crucial aspect in developing a piece of computer software is also the enactment of relational agency. This involves recognizing how others interpret problems, and aligning one's own suggestions with theirs, in order to produce enriched practices. This kind of agency is needed insofar as professionals need to solve complex problems through collaboration

K. Vähäsantanen (✉) • A. Eteläpelto
Department of Education, University of Jyväskylä, P.O. Box 35, 40014 Jyväskylä, Finland
e-mail: katja.vahasantanen@jyu.fi; anneli.etelapelto@jyu.fi

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with others (Edwards 2010). Although there are many expectations regarding software professionals, it remains uncertain to what extent there are real opportunities for their agency and learning at work.

To gain a fuller understanding of software professionals' agency and learning, we conducted an empirical investigation in a medium-sized Finnish company which produces (among other things) digital business applications. Below, after presenting some theoretical considerations on professional agency and learning, we elaborate our methodological commitments. We then present our findings on the opportunities for being an agentive actor and for learning in software work. Finally, we set out some theoretical and practical conclusions, including how to promote professional agency and learning in work organizations.

11.2 Professional Agency in Work Contexts

There is considerable discussion on agency in working life (see Eteläpelto et al. 2013). On the one hand, professional agency is conceptualized as capacities and dispositions which enable to make choices and initiate actions based on those choices in relation to one's work practices and career (Goller and Billett 2014; Harteis and Goller 2014). On the other hand, professional agency refers to a more action-based notion, according to which professionals' agency is manifested via influencing, making decisions, and engaging in negotiations regarding work-related matters, such as professional identity and work practices (Toom et al. 2015; Vähäsantanen 2015). In this chapter, we take up the latter theoretical notion; hence, we understand professional agency as involving influential activities and decisions that are related to one's work and shared work practices.

In the field of information technology, Ylén (2017) similarly conceptualizes professional agency in terms of influencing and participating in decision-making in the work community; however, she sees it as especially related to the moral dimension of work (e.g., professional virtues, goods, and ideas). Working in the same field, Collin et al. (2017) have investigated professional agency in relation to creativity. They found that in matters of problem solving, agentic activities included the selection of tools and work methods, the prioritization of work phases, exploration, and obtaining and exchanging information. In the development of working methods, agency was manifested as determination of the best working methods, experimentation, and the sharing of practices (Collin et al. 2017).

Although professional agency is often seen as resourced by individual backgrounds and characteristics, it should be noted that agency emerges within specific times, conditions, and relationships in the workplace. The subject-centered sociocultural approach in particular emphasizes the role of both social contributions (e.g., work cultures, material circumstances) and individual contributions (e.g., professional identity, competencies) to professional agency (Eteläpelto et al. 2013). Recently, leadership practices have also been emphasized as both resourcing and

constraining professional agency in a variety of work contexts (Hökkä and Vähäsantanen 2014; Ylén 2017).

11.3 Learning at Work: Professional Agency and Social Conditions

The recent discussion has emphasized the crucial significance of professional agency for individual and organizational learning in working life (Billett 2011; Harteis and Goller 2014; Philpott and Oates 2017; Tynjälä 2013; Vähäsantanen et al. 2017a). In other words, individuals' active actions and decisions are understood as a prerequisite for learning. According to Goller and Billett (2014), professionals can deliberately influence their professional development, for example, by seeking additional work experiences and deliberating information and feedback and new learning opportunities (see also Harteis and Goller 2014). Similarly, Pyhältö et al. (2015) suggest an interdependence between professional agency (e.g., the ability to transform work practices and actively seek help) and learning.

A similar interdependence was found in a study by Ylén (2017). This revealed four practices that enable agency and promote learning in software developers' professional work. These include (1) the practice of *democracy*, i.e., a set of procedures built on ideals of openness and equality, enabling software developers' agency in the work community's decision-making; (2) the practice of *experimentation*, related to goals of flexibility and constant improvement in the organization, enabling professional agency in relation to the development of work procedures and methods; (3) the practice of *self-directed development*, making possible developmental-oriented and passion-based professional agency concerning one's own career; and (4) the practice of *independent project teams*, enabling agency in relation to one's work. Despite such supportive practices for software developers' agency, Ylén (2017) also observed that they have no choice or decision-making power in all situations of the customer projects.

In this chapter, learning is understood notably as the development of individual and collective work practices, but also as the development of employees' professional skills and knowledge. According to Ha (2015), the professional expertise of IT professionals includes programming languages and software development tools. Their expertise further encompasses skills to deliver technical support to users and to maintain the IT systems of companies. The development of this kind of expertise occurs, for example, via self-directed learning (e.g., reading professional literature), but especially though participation in communities and through working on projects (Edwards 2010; Ha 2015). Generally speaking, learning occurs also through trying new things, collaborating and solving problems with others, and learning from errors (Eraut 2011; Harteis and Bauer 2014; Shepherd et al. 2011; Tynjälä 2013; Vähäsantanen et al. 2017b). In line with these notions, and with other authors (Harteis and Goller 2014; Kira 2010; Philpott and Oates 2017; Vähäsantanen et al. 2017a),

we understand learning at work as embedded in the social context and in relationships, although the enactment of professional agency is viewed as driving both individual development and organizational development.

11.4 The Aim of the Study

This study aimed to explore professional agency and learning in the work of software professionals within one private sector organization. Thus, the research questions were as follows:

1. What kinds of opportunities for professional agency are perceived in the work of software professionals?
2. How is professional learning related to software professionals' professional agency and the social conditions of their work?

Bearing in the mind the notions outlined above, professional agency is here considered via two lenses. As regards the first question, professional agency is viewed as a matter of exerting influence at work. As regards the second question, professional agency is considered as a phenomenon encompassing development-oriented efforts and activities, touching on both individual and shared work practices.

11.5 Methods

11.5.1 Data Collection

The study presented here applied a mixed-method approach to data collection, including interviews and quantitative questionnaire data. In the first place, the data were derived from three focus group interviews with professionals who were working in a medium-sized Finnish company producing (among other things) digital commerce applications. These interviews were gathered from three professional groups in 2015. The groups consisted of (1) software developers ($n = 4$), (2) installation experts ($n = 4$), and (3) program testers ($n = 5$).

Most of the 13 interviewees were male ($n = 9$) and highly educated; thus, 12 of the participants had at least a bachelor's degree or a polytechnic degree. Their age varied from 29 to 63 years (average 39 years), their working experience in the current job varied from 1 month to 11.5 years (average 4 years), and their working experience in the field varied from 1 to 35 years (average 12 years). The software developers interviewed mostly worked as experts in developing software and services. Their work was mainly project based, including also responsibilities in the management of the projects. The installation experts notably addressed and solved problems relative to data systems, but they also designed data systems and the moni-

toring of web stores, and engaged in various services. The work of the program testers included the design of testing tasks relative to the projects and implementation of the required testing designs; by this means, information was gained on the functionality of the software and web services used.

The interviews addressed the software professionals' current and future work, their learning at work, their professional agency, and the work organization plus its leadership practices. Within the interviews, the questions were asked flexibly in relation to these themes (Kvale and Brinkmann 2009). The aim was to encourage the interviewees to talk about the issues with each other, rather than to have each participant answer questions in turn. In this sense, the interviews refer primarily to informal discussions (Wilkinson 2016).

In conjunction with the interviews, the participants completed an individual questionnaire on professional agency. To gain data on professional agency, in terms of exerting influence at work, participants were asked to what extent they could influence a range of matters related to their work. Altogether, 13 aspects (such as ways of working, customer projects, and changes in the work community) were listed. A five-point response scale was used (1, not at all; 3, enough; 5, very much).

11.5.2 The Data Analysis

To analyze the focus group interviews (which amounted to 115 pages, Calibri font, 1.5 spacing), we applied qualitative content analysis, the aim being to produce a relatively comprehensive summary of the data as a whole (Wilkinson 2016). The analysis was data driven (Saldaña 2013), but we also utilized current conceptualizations in order to identify expressions regarding professional agency.

For the first research question, the interviews were read in order to locate and extract the expressions concerning professional agency (in terms of exerting influence at work). Following this, the majority of the expressions could be listed and grouped under two categories; this was appropriate in terms of the variation between the perceived opportunities for professional agency. Thus, the bulk of the categories could be viewed as manifesting either (i) *ample* or (ii) *limited* opportunities for influence at work. To some extent, these categories illustrate how far the organization created opportunities for people to affect work-related matters. It was further found that the opportunities to exert influence were connected to the professionals' individual and collective activities. Hence, a third theme was identified; this was named as *negotiated opportunities to exert influence at work*.

To answer the first research question, we also utilized questionnaire data concerning opportunities to influence a variety of work-related matters. Means and standard deviations were calculated for all the items presented in the questionnaire.

Concerning the second research question, all expressions pertaining to the software professionals' learning were identified and extracted from the interviews. These expressions also reflected organizational learning and the kinds of agentic

activities and/or sociocultural conditions that were related to the professionals' learning at work. Overall, six themes were found to cover this question. We also found an additional theme which encompassed suggestions for supporting the development of the individuals concerned and the organization. The next two sections illustrate our main findings regarding professional agency and learning in software work.

11.6 Professional Agency in Software Work

The current discussion (e.g., Toom et al. 2015; Vähäsantanen 2015; Ylén 2017) conceptualizes professional agency as primarily a matter of exerting influence on work-related matters. The subsections below present the opportunities available for influencing matters in software work. These findings are presented in the form of a blend (condensed) of both the interview and the questionnaire data.

11.6.1 Ample Opportunities to Exert Influence at Work

The findings of the questionnaire (see Fig. 11.1) showed that the software professionals had rich opportunities to influence especially their working hours (mean = 3.92), the order in which they carried out their work tasks (mean = 3.83), the ways in which they carried out their tasks (mean = 3.77), and the selection of working tools (mean = 3.77).

In a similar manner to the questionnaire, the interviews indicated that the software professionals were mostly able to prioritize their work tasks and to determine their working hours. Their work also included a good many opportunities for seeking out the most suitable ways of working. As one software developer said, "I am able to affect how I do things, and along with that I can develop other things." Another software developer went even further: "Speaking for myself I can affect everything at work… And I think that's a good thing."

Within the interviews, the possibilities to have influence were experienced broadly as important and as a basis for individual learning and meaningful work. In part, agentic opportunities were viewed as connected with a change toward self-directedness in the organization. At the same time, it was criticized in terms of leaving people without any supportive structures. It was nevertheless hoped that new control mechanisms would not be introduced in the future: such mechanisms were seen as harmful in work which includes continuous changes and requires great flexibility.

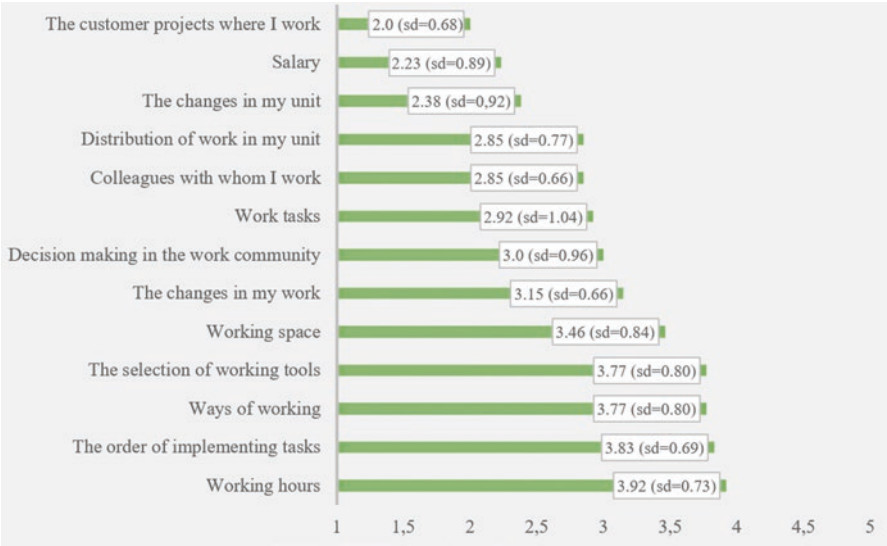

Fig. 11.1 Opportunities to influence work-related matters, presented as means with standard deviations (scale: 1, not at all; 3, enough; 5, very much)

11.6.2 Limited Opportunities to Exert Influence at Work

The questionnaire (Fig. 11.1) indicated that the professionals had actually limited possibilities to influence some work-related matters, particularly regarding the customer projects that were taken on (mean = 2.0), their salary (mean = 2.23), and the changes in the work unit (mean = 2.38).

Similarly, the interviews revealed that the professionals had only some opportunities to choose which customer projects they could be involved in. The interviews also illustrated that the projects and their different stages determined a large proportion of the work tasks. Furthermore, it was not always possible to determine one's working time: people could be forced to do overtime. This was in part due to the strict timetables for projects. There was also mention of difficulty in influencing matters (e.g., customer contracts) that had a strong bearing on their work. As one installation expert emphasized:

> *I can do my own work as I like; I think nobody actually wants to interfere with that. The main thing is that the work gets done. But the area in which you can make decisions yourself is quite small. So a worker has no power to make the kind of significant decisions that could substantially change the way things are done. For example, we can't change customer contracts in such a way that we could proceed to do the work some other way. We, the people who do the main job, have no power to affect that… So self-direction occurs within that space, even if, in order to get things to work better, we ought to have the power to influence matters that are outside that space.*

From the point of view of agency, the project leaders were also seen as significant actors. They were able to resource or constrain other professionals' possibilities to affect the work.

Although generally speaking the professionals' agency was fairly constrained in customer projects, the perceptions of their agency varied. On the one hand, the customer was seen as a boss, someone who decided what to do and the timetable for doing it. On the other hand, the professionals also saw themselves as active actors in collaboration with the customers, for example, in terms of suggesting to customers workable practices, alternatives, and ways of executing the project.

The professionals also reported weak opportunities to affect organizational practices, decisions, or strategies. They hoped for changes in the goals and strategies of their organization (e.g., the aims regarding short-term efficiency and economic productivity), but did not see real opportunities to influence these. It was possible to make developmental suggestions, but the perception was that nobody truly listened and that the suggestions seldom resulted in any real changes.

11.6.3 Negotiated Opportunities to Make a Difference in the Work Organization

Despite the difficulties in influencing significant matters in the work organization, it seemed possible to have an influence on smaller matters through being active, either individually or with colleagues. Some professionals saw possibilities to change organizational practices (e.g., in how testing practices were included into the projects) when they convincingly presented their opinions. The significance of activeness for changing contracts was described by one software developer as follows:

> *Participation is one way to influence matters. I participate in shared events. You just have to speak up in conversations, saying like, hey, from now on let's not do it like this or have these kinds of contracts. You can change the model of acting, when you go with and participate in the forming of contracts and such like.*

Some software professionals further said that it was easier to put forward successful developmental suggestions, or to take actions, if one did so with colleagues rather than alone; also, one could be more influential if one knew the right people to fight the case.

11.7 Learning at the Heart of Individual Activities and Social Conditions

The software professionals were eager to develop the practices in their own work and more generally in the work environment. Based on the interviews, we illustrate below how professionals' learning at work and organizational development occurred and how it was related to professional agency and social conditions in the work.

11.7.1 Complex Problems Enabling Agentic Activities for Individual Learning

Previous studies, including those in the context of information technology (Collin et al. 2017; Goller and Billett 2014; Ylén 2017), have suggested that professional agency includes experimenting and solving problems. Our findings showed that challenging work facilitated professionals' agentic activities. These included finding errors, addressing challenging and long-term problems, experimenting, and finding solutions to the problems. These manifestations of professional agency around complex problems were seen as an important element in meaningful work. They also created a foundation for learning at work. As one software developer emphasized:

> *Meaningful and effective learning occurs when you have the possibility and ability to do some experiments, and from that get new ideas.*

That is, individuals' knowledge and skills were developed through challenging work that involved seeking solutions to problems. However, from the perspective of shared learning, the challenge was that these activities tended to be done on an individual basis, even if shared experimentation, and problem solving with colleagues, did sometimes occur. The individualistic way of working promoted the personal learning of those concerned, but not organizational development, as one installation expert emphasized:

> *In my opinion, when there's problem-based learning, it means that each employee studies the same things, and in such a way that the individual learns, but the organization doesn't really learn.*

To sum up, one can say that individual learning – but only rarely organizational learning – emerged when challenging work tasks brought with them agentic activities related to complex problems.

11.7.2 Routinized and Hectic Work as a Threat to Innovativeness

The software work was not purely an arena for addressing complex or long-term problems, since it included many routine tasks. These tasks did not facilitate learning through problem solving, nor did they bring about much joy in the work. As the installation experts put it in their discussion:

> *Interviewee 5: In my case it brings joy when a challenging problem is solved. The thing is, some problems are quite irrelevant, for example when a customer is worried because something is the wrong color somewhere, or stuff like that. But then there are those real problems, like if something is broken and we try to figure out how to fix it. Those situations can be challenging, but it's rewarding when we can solve them. But there isn't much of that sort of thing. In relation to the number of tasks, routine work dominates.*

Interviewee 6: Well it's pretty much the same for me. The nicest thing is when you can solve a long-term problem.

Interviewee 7: It's also nice when you learn something while working – this happens usually when there is some challenging problem. Learning seldom arises from the basic work.

In a similar manner to routine work, hectic work was seen as an obstacle to learning and innovative working, as a software developer indicated:

In my opinion knowledge work requires enough time, if we really want innovations and development… If you have too many things to do all the time, you never reach the right frame of mind to think and do things innovatively.

As compared to innovative and regenerative working, amid hectic work, the professionals relied on current ways of working, doing their tasks in familiar routinized ways. As pointed by a program tester: "When there is a rush with the projects, you have no chance to think about and develop these things or of approaches to the work." The main reason for rushing was that the projects were designed with tight timetables, in order thus to gain maximum efficiency and economic profit. Overall, work that was routine or hectic did not create an optimal arena for experimenting or trying out new ways of working, nor was there innovative development through such activities.

11.7.3 Outdated Technologies Hindering Learning at the Individual and Organization Levels

The developers discussed technologies as they affected learning. The technologies used were described as somewhat outdated and complex, thus leading to hurry and stress. Although these technologies hindered working, they continued to be used; this was seen as due to the fact that the organization did not want to engage in technological development. The managers did not want to put new technologies into operation, since the current technologies still produced good financial results. This was emphasized in the discussion as follows:

Interviewee 1: The logics and models of business support the use of this old technology, and at the moment we are achieving good financial results. Since the numbers look really good, it's difficult to aim for changes in that direction.

Interviewee 2: The problem is that decision makers don't experience technology the same way as we do, the developers and the people dealing with it. Decision makers can't understand how oppressive it can be to use old and inferior technology.

The outdated technologies did not merely bring about annoyance and stress; having to use them was experienced as an obstacle to learning. If the interviewees wanted to learn new technologies, they had to do this in their free time:

Technology changes rapidly, and that requires continuous learning. It means that you should be able to do more with the newest technology. The main challenge is that we have a large technological debt in this company; we have only out-of-date technology. One thing that particularly bothers me is that we should be more radical in adopting new technology, but learning is our own responsibility. We can't use working time for learning, so we have to use our own time for that.

All in all, the failure to use the most advanced technologies meant more haste and difficulties in the work. It also created constraints on individual learning and organizational development. A need was seen for more resources and more time to implement advanced technologies. This was required for the sake of innovative individual learning, but also for the future success of the company as a producer of high-quality software applications.

11.7.4 Learning Framed by Variable Practices for Seeking and Giving Help and Feedback

According to scholars (e.g., Goller and Billett 2014), professional agency encompasses activities such as seeking help, feedback, and knowledge. The software professionals were active in seeking help and information in order to develop their work. They further reported that the culture of their work organization generally encouraged people to seek feedback and novel tools for their work. Despite this kind of supportive culture, haste at work created obstacles to gaining help from others or for sharing knowledge. A program tester noted that people were unwilling to disturb colleagues who were busy:

> *We have good dialogical connections. But learning is highly restricted by the rush. When developers have a terrible workload, even if I would like to know more about something, I prefer not to interrupt them. Interruption always breaks their flow and it takes a lot of time to get back into productive work.*

The professionals further emphasized that feedback on one's work is important for professional development. Although some practices existed for giving and gaining feedback, it was quite rare for feedback to be given, especially the kind of feedback that promoted one's own learning. Getting feedback depended mainly on how active the professionals were themselves (i.e., in asking for feedback) and on the personal enthusiasm of leaders and colleagues. Overall, it seemed that the enactment of professional agency could support professionals' learning. However, the rush and the lack of feedback practices tended to weaken the foundation for agentic activities and learning in the work.

11.7.5 (Non-)learning in and Across Professional Groups and Projects

Collaboration was emphasized as important of learning. According to the accounts given, a basic element in learning and feeling joy in the work consisted of the possibilities to share with others new experiences, tools, and practices. As one installation expert told:

It brings joy at work when you develop or find the new ways of acting or more advanced ways of doing things. And then you can share them with others and they are utilized in practice. It is amazing.

These kinds of agentic activities (e.g., sharing experiences and practices) emerged in particular with colleagues who were carrying out similar tasks or working on the same project, even if there were, in addition, some orchestrated arenas for sharing knowledge and experiences on matters of common interest.

It was also emphasized that experiences were rarely shared, other than within professional groups and projects. Therefore, new knowledge and practices did not transfer across the boundaries of the professional groups and projects. This was seen as hindering individual learning and organizational development; however, it was also seen as related to the broader organizational strategy, as one software developer indicated:

All this is related to our strategy that customer projects are done separately, and really, hardly anybody shares anything like information or the code base. Everybody more or less need to start with a clean sheet in each project. This is also influenced by the strategy, in the sense that the aim is to achieve as much billable work as possible.

Overall, the sharing of experiences, knowledge, and tools was seen as rewarding and as aiding learning. However, the enactment of such agentic activities was more feasible within projects and professional groups than across them. The boundaries between projects did not support individuals' collaboration or shared development.

11.7.6 Short-Term Efficiency: Freezing Development?

According to those interviewed, the main principles of the organization were short-term efficiency and economic growth. As mentioned above, these principles were also intertwined with other aspects of the work (the rush, the use of outdated technologies, and bridges between customer projects) and learning at work. This was also pointed out by an installation expert:

The primary emphasis at management level is for the company to make a profit. Decisions are based on that strategy, and that's why, for example, developing and testing new operations and ways of working has been given a low priority, and doesn't move forward.

The main concern of the interviewees seemed to be that the guiding principle of short-term efficiency and economic profit did not support genuine innovativeness or development in the organization – this despite the fact that official organizational discourse highlighted the importance of development. The interviewees saw the goal of short-term productivity as inconsistent with long-term development at individual and organizational levels. An installation expert viewed the issue in the following terms:

There's a conflict that I would like to point out. That our company's values have included growth, cost-effectiveness, and development in recent years. In my opinion the first two of these have been achieved, but the third hasn't. So learning, development, and increasing

competence are important, according to what company management says. But in practice they have a very low priority.

The general view seemed to be that the management's business orientation did not offer enough time, resources, or support for the kind of learning that would promote the development of the organization.

According to the interviewees, the principles of maximizing profit and efficiency also created an atmosphere that did not encourage people to truly try out new things, or take risks, since all possible failures had to be minimized. Overall, it seemed that the case here could be one of short-term efficiency at the heart of the organization, with long-term learning and development (both individual and organizational) suffering as a consequence.

11.7.7 Toward Novel Thinking and Practices: Unlearning and Learning Something New

The findings illustrate opportunities and constraints for professionals' agentic activities and development, both at the individual and organizational level. The interviews also revealed ideas for promoting more comprehensive learning and development within the organization. These ideas are presented below. To some extent, they indicate means to address the challenges to learning and development described previously.

A Lower Priority for the Principle of Efficiency According to the interviewees, a lower priority could be given to the short-term focus on efficiency and economic growth. Although these goals are always present in any business, there should also be room for new ways of acting and thinking to support learning. For example, it was hoped to be more opportunities for shared problem solving, collaboration, and practices across customer projects, possibilities to use new technologies, and more time to learn (as opposed to merely carrying out tasks mechanically). This could lead to better services and applications, to individual and collective learning, and to an even higher reputation for the organization in the future.

The (Un)learning of Individuals While there was a scope for transformation in organizational practices, it was also noted that individuals, too, could learn new ways of thinking and acting. There also seemed to be a need for *unlearning*; in other words, individuals should withdraw from familiar routine ways of working, and experiment more creatively at work, in order to learn. There was also a need for a culture that would support experiment and risk-taking without fear of failure. As pointed out by a software developer:

You must have the opportunity to try and to fail, because that's how learning happens. We should have a more permissive organizational climate so that we would not be pressurized into sticking to old, safe ways of doing things. People should understand that it they are allowed to make mistakes, so that you can let go of old habits.

Controlled Self-Directedness The move toward self-directedness in the organization was not seen as truly successful. For example, opportunities to affect certain work-related matters, such as projects, were still seen as limited. In addition to having more agentic opportunities, the professionals hoped for a clear organizational vision, with social affordances for them to frame their self-directed activities. In the absence of these, the work was experienced as extremely challenging. The professionals were further concerned that they were not doing enough work together or learning together. As one software developer pointed out, one of the main challenges of self-directedness was that individuals would learn, but not the organization: "It's simply not enough that individuals learn; rather, the whole organization should learn more, in a controlled way."

Orchestrated Feedback and Training Practices Although current feedback practices were in part workable, there was a wish for more systematic and constructive feedback for the sake of continuous personal development. Furthermore, there was a need for regular processes and collective practices for discussing, for evaluating, or for giving/receiving feedback. This would enable to identify which shared matters were workable and which matters needed to be developed – together with ways of furthering that development. Furthermore, the interviewees wished for more arenas (formal and informal) for sharing knowledge, practices, and tools. These could involve orchestrated training and discussion around relevant topics, whether within or outside the organization.

11.8 Discussion

As regards the *first research question*, we found that the professionals were able to influence, in particular, their working hours and the order in which they approached their tasks. On the other hand, there were fewer opportunities to influence customer projects or their own salary. There were also challenges in making a difference in shared matters or on practices within the organization (involving, e.g., the failure to adopt the most advanced technologies and the company's orientation to short-term efficiency). Overall, the organizational and leadership practices appeared to be closely connected to the professionals' agency, creating both opportunities for and limitations to agency in the professional context in question (see also Hökkä and Vähäsantanen 2014; Ylén 2017).

At the same time, it must be noted that some professionals indicated that it was possible to affect some organizational matters (e.g., project practices) through their own activities and collaboration with colleagues. In line with previous notions (Eteläpelto et al. 2013; Harteis and Goller 2014), this illustrates the point that the structures and conditions of work organizations do not comprehensively or exclusively determine professionals' agency; agency is also embedded with professionals' own individual and social resources.

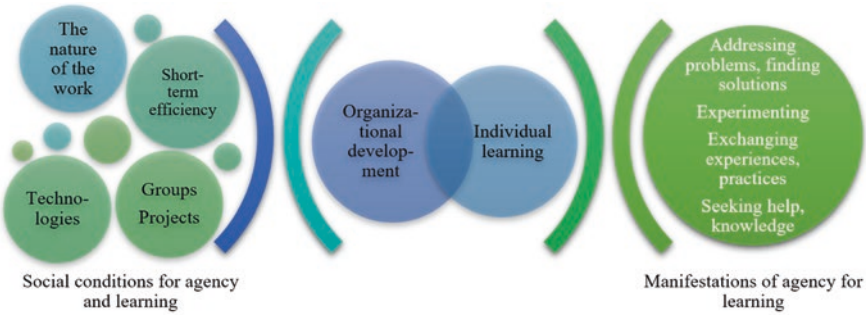

Fig. 11.2 Social conditions and manifestations of professional agency connecting to learning in software professionals' work

Overall, in the present study, the software professionals had variable opportunities to enact professional agency at their work. In this sense, our study did not paint as optimistic a picture of software professionals' agency as the study of Ylén (2017); this indicated that a Finnish information technology company offered almost only ample arenas for software developers' agency. As always, one must bear in mind the context: our study was conducted at a specific time and within a single organization.

The findings relative to *the second research question* are summarized in Fig. 11.2. Professional agency was manifested via a range of agentic activities (such as finding solutions to complex problems, asking for help, and sharing knowledge). These were at the heart of learning at work. Without such activities, it can be suggested that individual and organizational development cannot occur in any sustainable way. However, the findings also underlined the notion that learning is not separate from the sociocultural circumstances of the work and the organization. In particular, the nature of the work (in terms of being, to a considerable degree, challenging, hectic, and routine) both resourced and constrained agency and learning at work. Sharing practices and knowledge with colleagues promoted learning, but the boundaries between the projects and the professional groups, plus unavailability of the most advanced technologies, hindered both individual and organizational development. In this sense, relational agency and expertise (Edwards 2010) emerged here more within the projects than across project boundaries.

The study also indicated that the organizational aim to achieve economic growth and short-term efficiency was an obstacle to individual and organizational development. This aim was connected to the hectic pace of the work on the one hand and to the use of outdated technologies and routines on the other. In similar manner, a study by Haapakorpi (2012) indicated that opportunities for creative work and learning diminish with decreasing resources and new project management patterns, conjoined with a profit-making orientation.

In line with previous discussions (Harteis and Goller 2014; Philpott and Oates 2017; Vähäsantanen 2015), we found professional agency to be embedded with development and learning in the workplace. Individuals' agentic activities worked as a means for learning at work, although the sociocultural conditions of the work also

framed learning, through either supporting or hindering the emergence of individuals' actions. The study also confirms previous notions of the pivotal role of other people and of exchanging experiences (Collin et al. 2017; Ha 2015; Tynjälä 2013) and solving problems (e.g., Eraut 2011) for employees' learning and creativity and underlines the importance of professional boundaries – and the crossing of them – for individual and organizational development (Fuller and Unwin 2011; Kira 2010).

11.9 Theoretical and Practical Conclusions

The findings suggest that learning at work should be understood as intertwined with the enactment of professional agency and embedded with the social conditions of workplaces. This kind of thinking resembles the notion of learning at work as negotiated phenomena, operating between (1) individuals' preferences and activities and (2) the sociocultural environment of the workplace (Billett 2011; Vähäsantanen et al. 2017a, b). Since professional agency and learning can be seen as intertwined, we suggest that the most applicable phrase would be *agentic learning at work.* This means that learning at work will occur via the enactment of professional agency in the sociocultural context of the workplace. The findings also support the notion that it is the opportunities to be an active actor and learn that make work meaningful and joyful (Kira and Balkin 2014; Vähäsantanen 2015).

To enhance the bloom of digitalization in working life (see also Bosch 2017), there is a need to discuss how software professionals' agency and learning can be supported in work organizations. It is possible to promote professional agency via agency-promoting leadership practices in the daily work of professionals (Hökkä and Vähäsantanen 2014; Ylén 2017). This means that professionals need sufficient opportunities to influence their work and to share matters in the work organizations. In line with the opinions of the professionals interviewed for this study, we would also advocate specific structures and a shared vision for working and acting. This will make it much more feasible to collaborate in working toward common targets.

This study showed how learning and development at the individual and collective levels appeared to be embedded in organizational aims and strategies. The professionals in the study hoped for the kind of changes in organizational practices that would promote both individual learning and development. The view taken among the professionals was that the aim should not merely be higher productivity in the short term but sustainable, long-term development in work organizations (see also Ramstad 2009). As they saw it, there was a need for more resources and more time for experimentation at work, in addition to the adoption of advanced technical tools; all this would help in promoting innovative individual learning and in maintaining the success of the company as a producer of high-quality software applications.

All in all, one can say that in seeking to support learning at the individual and collective levels, it is important to have an organizational culture that allows people to address problems and experiment collectively. The culture should be one that allows people to make mistakes and learn from their errors, without being afraid of

failure (see also Harteis and Bauer 2014; Shepherd et al. 2011). It is also important to encourage the crossing of boundaries between different groups and projects, as other scholars have also suggested (Fuller and Unwin 2011; Kira 2010). Even if there is a need to create agentic arenas for daily work and learning, not all responsibilities should be placed on the shoulders of the leaders. Professionals, too, need to take responsibility for their learning, to be ready to be active and creative, and to abandon old ways of thinking, even if these are experienced as safe. In particular, agency in its creative and relational forms is needed in the field of information technology, which includes development-oriented collaboration, since it is seldom possible to create innovative solutions for the digitalizing working life and solve difficult problems by oneself (Collin et al. 2017; Edwards 2010).

The study addressed software professionals' agency and learning and revealed some optimal sociocultural conditions for them. As described above, previous studies have supported quite similar notions of learning and/or agency in different professional domains. Our study also showed that it is not self-evident that work organizations enhance employees' agency and learning, even if their emergence is pivotal for the employees themselves and the success of the organization. Haapakorpi (2012) has also found that even the media industry, which requires innovative working and high-quality competencies of employees, does not create optimal conditions for the employees' creativity and learning when new management and business-like management are adopted. In this sense, our findings might be quite transferable to other work contexts. Simultaneously, one could say that compared to the other professional domains, the digitalization processes in working life apply more pressure on software professionals and the organizations in which they work. They must provide high-quality software products and services to the clients at a fast pace, in which case there are not necessarily time and optimal circumstances for creative experiments and long-term development. The goals of achieving economic growth and short-term efficiency might also be more pronounced in private sector organizations in the field of information technology than in other domains and public sector organizations.

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Katja Vähäsantanen, Ph.D. (adult education), is a senior researcher in the Department of Education at the University of Jyväskylä (Finland). She is currently working on the REAL research project, which investigates emotions in agentic learning at work. Her current research and teaching interests lie in the areas of professional identity, agency, learning and emotions in work organizations.

Anneli Eteläpelto, Ph.D. (psychology), is a full professor of adult education in the Faculty of Education and Psychology, University of Jyväskylä (Finland). She has led several research projects, funded by the Academy of Finland, on professional learning, identities and agency. Currently, she is leading the Finnish Academy-funded project REAL, which explores the role of emotions in agentic learning at work.

Part IV
Educational Challenges on Societal Level

Chapter 12
Information Privacy in a Digitalized World: Private Issue or Public Matter?

Franz Lehner and Aleksandra Dzepina

12.1 Introduction and Problem Description

The discussion on information privacy (also called informational privacy) found its origin in Europe with the concept of information self-determination, at a time where the automated processing of personal data was growing. This was before the breakthrough of personal and laptop computers, the Internet, mobile technologies, etc. Nevertheless, from the beginning, it was necessary to regulate the transfer and use of person-related data by firms to avoid misuse. This was originally more a legal issue than a technical or social challenge. The general goal was to define the field of operation and clarify from a legal perspective what is allowed. The situation was characterized by the fact that the use of computers was more or less restricted to firms and governmental institutions. In addition, computing capacities were much lower than today and were rather restricted. German and European data protection laws tried to impede abuse and to protect fundamental rights. The private use of computers was the exception until the end of the twentieth century, and the legal arrangements seemed to be sufficient.

At this point, it should be mentioned that the legal concepts differed between Europe and the United States from the beginning. In the United States, "informational privacy" was used instead of "information self-determination." It was not only a difference in terminology but rather in the underlying concepts. Privacy in the United States was seen as the right of a person not to be disturbed, while the right to determine even the future use of one's personal data was the European position. As the processing of data predominantly happened internally in organizations, and the global exchange of data and information remained on a low level, the difference in concepts didn't matter for a while.

F. Lehner (✉) • A. Dzepina
Faculty of Economics, University of Passau, Innstraße, 43, 94032 Passau, Bavaria, Germany
e-mail: Franz.Lehner@uni-passau.de

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With the increasing use and importance of the Internet, the situation has changed – slowly in the beginning, but becoming increasingly more radical. In the digital era, individuals are not just consuming information but also producing highly sensitive personal data of economic value. As a consequence, the situation has been changing, and the original goal has turned into an abstract idea of little practical relevance. Technological inventions have caused new opportunities but also threats. In the meantime, hardly any technology-driven innovation can be realized without negative connotations or side effects caused by the possibility of surveillance. Big data is turning into a general trend, and software tools permit almost everyone to use artificial intelligence. Big data is confronting people with business models that sometimes even question democratic ideals and concepts of society, fundamental rights, and the way humankind views itself. Even the secret services (e.g., NSA) demonstrate new forms of manipulation, and the big data industry is trying to convince customers that the idea of our fundamental rights cannot be kept in its current form. The big data ecosystem and the combination of people and machine intelligence have started to erode the roots of European culture (Hofstetter 2014, p. 217). Companies, authorities, and individual persons will be affected by the consequences of these changes. Information self-determination is continually being reduced because of the broad use of technologies such as data mining, Internet of things (IoT), RFID, and ubiquitous computing, used for observing and monitoring people (Rouvroy and Poullet 2009, p. 45). Roßnagel (2007, p. 265) therefore doubts that information self-determination can be maintained anymore. Due to the limited influence of the user, it is clear that the responsibility cannot be left to them, and a solution has to be found on a higher institutional and supranational level. Unfortunately, most of the initiatives are still on a national level, which has led to a confusing variety of regulations representing different interests and implications. The first attempts at harmonization can be seen today in the European Union. However, this does not really solve the global challenges, and the differences are still there in an international and globalized world.

The right to information privacy, of course, is not related to firms or organizations but rather describes the right of a person regarding the disclosure and utilization of personal data. Comprehensive and complete information privacy is an illusion, but the blurring boundaries between the private sphere and working life on the one hand and the widespread use of information technology on the other hand have made it clear that we need new concepts and a critical discussion of current practices in a highly digitalized life and business environment. The federal government of Germany has recognized the problem and in 2013 announced a comprehensive concept called “Digital Agenda” to target the problems.

This paper aims to critically reflect on the current situation and its demands from an individual perspective. We will first define the relevant terms information self-determination, information privacy, information behavior, information protection, and information security. Second, we will describe the differences in the perception and realization of information privacy depending on the variety of national policies and laws. Subsequently, we will present a research overview on information privacy. In conclusion, we will depict the current attempts and activities aimed at

realizing information self-determination in Germany and will discuss further needs and challenges.

12.2 Terminology

Information privacy issues are quite complex but also interdependent. They can be studied from many perspectives, including law, economics, psychology, management, marketing, and, of course, information technology. The term *information self-determination* therefore cannot be seen as isolated, and similar terms are often used without a clear definition or demarcation. For this reason, the most frequently used terms will be described briefly in order to provide a common understanding and point to interdependencies. Furthermore, no differentiation between the terms *data* and *information* will be made here. These terms will be used more or less synonymously, because privacy issues always refer to the use of data or, in other words, to information.

Information Self-Determination means the right of a person to decide when and within what limits personal information will be shared with others (Rouvroy and Poullet 2009, p. 45). Information self-determination prevents blurring of different life zones, since it prevents information from medical treatments, family life, and the working world from being combined or mixed together (Hornung and Schnabel 2009, p. 85; Podlech 1976; Trute 2003). The German idea of information self-determination is different from information privacy and quite narrower. Since the term *data protection* creates a sphere where one can feel safe from any interference, it has more in common with information self-determination (Hornung and Schnabel 2009, p. 86).

Information Privacy has been defined as the individual's ability to control the collection and use of personal information (Westin 1969; Stigler 1980). In its simplest form, it refers to the concept of controlling how one's personal information is acquired and used. Information privacy refers to the desire of individuals to control or have some influence over data about themselves. This includes the protection against unauthorized or arbitrary access by state authorities or police. Information privacy includes a personal decision about whether private information should be provided or not (Rössler 2001, p. 17).

Information privacy measures or rules can be in conflict with data processing interests. Companies argue that restrictions concerning the collection, use, and exchange of personal data ignore established notions of property, limit individual freedom of choice, and violate principles of rational information use (Cohen 2000, p. 1373).

The general notion of privacy as a multidimensional construct is also true for information privacy. The literature shows a major consensus that concern for privacy is highly contextual in nature. The context can be social or cultural or involve information sensitivity, type of information collected, what task is being done on a

website, etc. Smith et al. (1996) outlined four dimensions of consumer privacy concerns: collection of personal information, unauthorized secondary use of personal information, errors in personal information, and improper access to personal information. In online marketing, for instance, these dimensions of concern should guide decisions concerning the collection of personal information, control over the use of personal data, and awareness of privacy practices and how personal information is used (Malhotra et al. 2004).

Privacy notices and privacy seals are introduced to inform users about the collection and choices they have in order to protect their information privacy. However, there is a general notion that the length of the notices has led to information asymmetry resulting in an adverse selection of privacy choices (Kelley et al. 2009). This information asymmetry can lead to specific behavior patterns for the handling of data, i.e., the so-called information(al) behavior.

Information Behavior is a human attribute, differentiating us from other living beings. It developed as a result of social and cognitive factors during evolution (Spink and Cole 2007, p. 258f.). Information behavior comprises active and passive information-seeking routines but also different ways of information use. Therefore, it includes face-to-face communication with others as well as passive reception of information, for example, when we watch TV (Wilson 2000, p. 49).

Information Protection comprises all tasks that serve to safeguard data and information. This includes access rights as well as the demand for long-term archiving. In order to improve the privacy protection behavior of the consumer, a greater control over the collection and use of personal data through simplified choices and increased transparency are some of the best practices that have been proposed by the Federal Trade Commission (FTC) in the recent years.

Information protection goes beyond information security, since processes and people need to be protected, not only information. This improvement can be achieved, for example, by a clean desk policy and safe retention of passwords (Schaaf 2015, p. 537f.). Well-implemented information protection mechanisms can lead to a socially responsible and secure society (Toker 2013, p. 754).

Information Security is often described as the securing of confidentiality, availability, and integrity of data or information and is closely connected with all measures for the safe usage of information technology. Not only are confidentiality and availability protected by the implementation of information security measures, business can also benefit. Information security can help to decrease information-related risks through the application of security controls and can therefore ensure the protection of personal and business data (Toker 2013, p. 752f.). Information security provides users an expectation of safe use of data, for example, by providing unmanipulated IT systems and by ensuring admissible data changes and readings (Freiling et al. 2014, p. 16).

12.3 Information Self-Determination: Origins and National Perceptions

The debate on information self-determination began with a census decision in 1983. The *Bundesverfassungsgericht* invented the term of information self-determination in 1983: This legally embedded data protection in the German constitution. The expression has since then been known as a German concept and one of the most important decisions concerning data protection (Hornung and Schnabel 2009, p. 84). Later, in 2008, the fundamental right guaranteeing the integrity and confidentiality of IT systems was introduced. In addition to these fundamental rights, various data protection regulations have been established over the years (Weichert 2013, p. 4).

The *Bundesdatenschutzgesetz*, introduced in 1990, regulates data protection in the nonpublic sector (Juris GmbH 2015, p. 1). The *Landesdatenschutzgesetz* of 2000 protects individuals from the impairment of personal rights caused by the processing of data from public authorities. The regulation for the inspection of records and information access of 1998 insures that all important personal data can be inspected at once (LDA 2013, p. 7).

What almost all legal regulations have in common is that they were initiated and discussed before the broad use of the Internet.

After intensive discussions about the harmonization of standards for data protection in 1995, data protection directives were issued and legislated for the first time for the EU member states. The directive served as a frame for all member states of the EU and had to be completed and implemented individually within each country; however, these data protection directives were not implemented in all countries equally. The reason for this was the existence of different interpretations of the basic terms and concepts. The EU Commission reacted to this situation and decided to reform data protection directives in 2012. The consequence of this reform is the new European Data Protection Directive, which will apply from May 2018.

The new regulations will be very close to what was already implemented in Germany before as the German regulations were taken as model. One of the most important changes will be that the domicile principle will be replaced by the market-town principle. Until the present, the domicile principle has determined the data protection regulations for companies offering services in the EU. In case of juridical conflicts, the laws of the country in which a company has its headquarters were applied. Facebook, for instance, which has its headquarters in Ireland, always had Irish law applied. In this way, it was possible to bypass safety requirements and disregard information self-determination. With the new market-town principle, this is going to change. Companies who want to offer services will have to respect the basic regulation of data protection which applies in the target country. This affects the consumers in a positive manner, as they will have to give their permission for the usage of their personal data (Hansen-Oest and Heidrich 2016, p. 166).

Of course, there are other states with appropriate levels of data protection, such as Argentina, Australia, Canada, Switzerland, Israel, and New Zealand. However,

there are also states such as the United States, Russia, and India that are classified as unsafe from a European perspective due to their low levels of data protection. The Constitution of the United States does not contain an explicit right to privacy, and the privacy act only deals with data held by federal agencies. Information transfer to these states should be prohibited if the protection of personal data is a concern.

What was regarded as important in the past is less helpful today. We find a variety of different data protection laws in different countries. Since companies are engaged all over the world, it becomes more and more difficult to keep a clear view and to enforce or guarantee information self-determination. For this reason, in 2017, a Digital Agenda has been established to deal with problems in information privacy and the broad use of the Internet. It integrates all previous issues and presents new ideas to manage the challenges in the era of digitalization. Even though the importance of maintaining information self-determination cannot be called into question anymore, the Digital Agenda is only the first step on a long road.

12.4 Research on Information Privacy

Advances in information technology have raised concerns about information privacy and its effects and have motivated information systems researchers to explore information privacy issues, including technical solutions to address these concerns. In recent years, there has been a steady increase in studies on information privacy. Discussions have no longer been restricted to business and legal authorities. Scientists have been increasingly attempting to investigate factors of influence and work on new concepts. The discussion has gone beyond principles and normative approaches and has provided a deeper understanding of the complex situation. We aim to give an overview of the research streams and summarize the findings without claiming to be complete due to the multitude of disciplines involved and the difficulty in assessing the increasing number of publications on the subject.

A review of the relevant literature reveals that information privacy is a multilevel concept but is rarely studied as such. We also find that information privacy research has been heavily reliant on student-based and US-centric samples, which has resulted in findings of limited generalizability.

Much of the privacy literature in information systems has focused on explaining and analyzing the nomological network that consists of antecedents to privacy concern and outcomes due to privacy concern (Smith et al. 2011). The literature lacks design and action studies, with emphasis on building actual implementable tools to protect information privacy.

The information privacy literature has predominantly consisted of studies that deal with modeling and measurement of privacy concerns. Information privacy has been defined as the individual's ability to control the collection and use of personal information (Westin 1969; Stigler 1980). Most information privacy studies have been in the context of e-commerce and mobile and Internet services and have been measured by two predominant scales:

- Concerns for information privacy (CFIP) consists of four dimensions: collection, errors, unauthorized secondary use, and improper access (Smith et al. 1996).
- Internet users' information privacy concerns (IUIPC) is a higher-order construct with three dimensions: control, awareness, and collection (Malhotra et al. 2004).

Internet companies have tried to alleviate privacy concerns by providing privacy and terms and condition notices that describe how individual privacy is protected by the company and the controls that the user has in order to protect their privacy and security. However, these notices are often long and cumbersome to read, which leads to disclosure of more information than intended by the individual. Hence, there has recently been a call for information privacy research that includes the design of new theoretically based IS artifacts that can be used to protect privacy, to measure privacy behaviors, and even to elicit such behaviors.

Individuals who are highly concerned with privacy do not engage in sharing data, but privacy paradox studies in the literature have shown that even individuals with high privacy concerns can be involved in privacy-breaching behaviors. One reason for such myopic actions is information asymmetry. Several studies in economics have shown how information asymmetry leads to adverse selection choices by the individual. To reduce information asymmetry, privacy policies and privacy seals are introduced by the merchants. However, the lower usability of the privacy policies in the current format of the majority of cloud merchants such as Google and Dropbox still has not addressed these information asymmetry issues. Further, in 2012 the FTC called for clearer and shorter privacy notices in order to protect consumer privacy in an era of rapid change (FTC 2012).

A representative survey among 509 companies conducted by Bitkom has, for instance, detected that only small companies have thought about and taken measures concerning the new conditions for data storage and processing. Bitkom mentions that on the one hand, only 32% of the companies had heard about the new regulations. On the other hand, 47% of firms had thought about approaches toward privacy by design or data protection impact assessments (Weka Media 2016).

Information privacy concerns have usually been measured in the IS literature using self-reported scales (Malhotra et al. 2004; Stewart and Segars 2002; Smith et al. 1996). While researchers used many variations of these scales using different dimensions of information privacy concerns, there is a general consensus in the literature that information privacy concerns correspond to a person's willingness to render personal information (Dinev and Hart 2006).

Not only have companies and states thought about the principles of information self-determination, science has too. Science has attempted to gain a better understanding concerning the factors influencing the realization of information self-determination.

Stewart and Segars (2002), for example, have defined four dimensions related to information privacy: collection, errors, secondary use, and unauthorized access. They have also described a difference in the perception of information self-determination. Therefore, individuals with a high concern for information privacy think that too much data is collected and that much of the data is inaccurate (Stewart

and Segars 2002, p. 36). In addition, such individuals are more likely to remove their names from mailing lists, complain to government agencies, and criticize offending companies (Stewart and Segars 2002, p. 44).

Malhotra et al. (2004), for instance, have developed a multidimensional scale called "concern for information privacy." The scale was designed to evaluate individuals' concerns about organizational information privacy practices. Furthermore, they discovered that online consumers found it most important to have control over their data stored in marketer's databases. Therefore, they suggested that managers should ensure that consumers could control, add, delete, and modify the information collected about them (Malhotra et al. 2004, p. 337).

Gluck et al. (2016) investigated whether removing privacy practices that most participants expect to occur would lead to a greater awareness of an organization's privacy practices (Gluck et al. 2016, p. 321). They came to the conclusion that condensing long privacy policies into short privacy policies increased awareness. Condensing long privacy policies to policies that only included practices that users were not generally aware of decreased awareness. They additionally explored whether incorporating positive and negative statements into policies would lead to positive effects concerning awareness. However, they did not observe any effects (Gluck et al. 2016, p. 332).

It seems important to revise privacy policies, since those currently in use do not meet users' requirements. Kelley et al. (2010) made a first attempt to gain a better understanding of the comprehensibility of privacy policies. They examined the optimal structure and length of privacy policies for the purpose of comprehensibility improvement. Most policies have been written in a technical language that is hard for laypeople to understand and that is more suitable for consumers holding a university degree. Moreover, consumers feel that they are not able to limit companies' use of their information, even if they set the correct visibility levels (Kelley et al. 2010, p. 1573).

Bélanger and Crossler (2011) performed a critical analysis of information systems literature and revealed that information privacy can be studied at multiple levels. They found that topics such as information privacy concerns, how e-business affects information privacy, and information privacy attitudes and practices appear more often in journals and therefore reflect the main interests of the research community. In contrast to similar research areas, information privacy research has not been bound to a particular theory type. In addition, information privacy research has been based on student samples and US-centric samples, which has resulted in findings of limited generalizability.

Choi et al. (2016) conducted a study focusing on users' initial evaluation of the Facebook app. They found that transactional privacy concerns played an important role in an individual's decision to expose profile information. Moreover, Choi et al. determined that impersonated profile control, in comparison to autonomous profile control, was associated with significantly higher transactional privacy concerns. The results revealed that the users' willingness to allow Facebook apps to control their profiles was influenced by users' transactional privacy concerns.

Pavlou (2011) evaluated the current state of the IS literature on information privacy. He revealed that there is a general consensus in literature concerning information privacy, since the term is defined as a person's willingness to provide personal information. In addition he states that most publications focus on explaining and predicting effects of information privacy. However, IS research should better focus on design and action, in particular, the development of tools helping to protect information assets.

Norberg et al. (2007) wanted to understand why consumers responded the way they did in terms of information privacy. Using a conceptual model called "privacy paradox," they argued that behavioral intention is not predictive of actual behavior. Contrary to earlier findings, Norberg et al. claimed that risk influences one person's intention to disclose information, whereas trust influences actual disclosure contexts. They conducted two studies and found that the level of actual disclosure significantly exceeded individuals' intentions to disclose.

12.5 Will the Digital Agenda Solve the Problems?

Looking back on the plans and objectives for the Digital Agenda 2014–2017, there have been both success and failure within the last 2 years. Sixty-six of 121 individual measures have been put into practice, 46 are still in progress, and 9 projects have not started at all (Bitkom 2016). However, the federal government has recognized the importance of the Internet economy and has set concrete areas of activity and political goals for digitalization. One important building block of the Digital Agenda is the promotion of digital innovations and enterprises. One success that can be mentioned has been the improvement of the legal certainty for WLAN providers through abolition of WLAN interference liability (Eco 2016).

The Digital Agenda describes many problems and areas of responsibility but only a few measures and practical actions. Several associations and companies have been trying to support the German government by developing and publishing position papers proposing solutions for the realization of the Digital Agenda, one of which being the ZVEI (Zentralverband Elektrotechnik- und Elektronikindustrie). Some of the topics addressed have been digital infrastructures, digital self-determination, energy, mobility, healthcare, and living (ZVEI 2015).

Apart from ZVEI, the *Gesamtverband der deutschen Versicherungswirtschaft* (GDV) has presented its ideas toward the Digital Agenda. Since the GDV has been focusing on the protection of customer data, it has followed a form of "regulated self-regulation." GDV has been one of the first sectors in Germany to develop rules of conduct relevant for data protection and has been given consent by data protection authorities for voluntary commitment. Moreover, it will be important to consolidate the 16 federal authorities of data protection, as different standards prevail in the individual federal states. The GDV supports a harmonization even across German borders, since they assist in the European expansion of data protection laws, especially the basic regulation of data protection (GDV 2015). The composition

of position papers enables the contributors to take an active part in professional discussions and to shape the future. In addition, position papers present a valuable way of proposing solutions to problems that are hard to solve by oneself.

The Digital Agenda has not yet been fully realized, and there is still a need for further action in order to reach all of its goals. Since the period of the first Digital Agenda ends in 2017, the German government has come up with a newer version called the Digital Strategy 2025. The Digital Agenda seems to be an appropriate approach for the debate on information self-determination. However, it remains to be seen whether the measures implemented will be sufficient. Nevertheless, it is important to stimulate discussions and to have the assistance by the state and by the regulative authorities rather than leaving everything up to the people to find a solution.

12.6 Need for Action and Further Research

Information privacy in its simplest form refers to the concept of controlling how one's personal information is acquired and used. Information self-determination is much narrower and describes the idea of individuals having the right to decide about their use of data. The expectations and problems related to information privacy are different and depend upon the application used but also the context. Privacy concerns, for instance, in a social networking or in a gaming context may be totally different in the field of healthcare or e-commerce.

Bitkom argues that employees need to be prepared for digitalization and need to educate themselves. Estonia acts as a role model, as it has been offering nationwide free Wi-Fi for years. In addition, it treats Wi-Fi access as a fundamental right and has been paperless for more than 16 years. The Digital Strategy 2025 is the next step on the long journey of informational self-determination in Germany. The abolition of the Wi-Fi interference liability has been a major move in the right direction. The same can be said of the European regulation of network neutrality. Further steps have been made on the European level, since EU Commission has just submitted a proposal for ePrivacy rights. There are plans that these rights shall replace basic regulations of data protection in the EU and will come into force by May 2018. The proposal for ePrivacy rights deals with the modernization of data protection and security guidelines for providers of electronic communication services and networks. It aims to set limits to tracking and profiling of user data throughout the EU (Dachwitz 2017). The Digital Agenda 2020 study, which involved interviews with 500 companies in Germany, showed that only half of these enterprises had begun to set up a Digital Agenda. The middle-sized enterprises especially needed to catch up, as they were prone to underestimate both the speed of digitalization and its complexity and scope. In order to keep up, 60% of Swiss companies have started to plan a Digital Agenda 2020. In Germany and Austria, only 48% of companies have done so (AWP 2016).

Privacy statements but also certificates and seals are used frequently in practice to inform their users about the privacy policy of a firm but also about choices they have to avoid privacy violations. Anyway, the length of such announcements did not really help to improve the privacy protection behavior of consumers and sometimes even leads to a contrary result.

What also needs to be improved is digital education because all areas of life are affected and therefore encouraged to take appropriate measures. Any behavior with discernment requires suitable approaches, technologies, and tools which enable laypersons in the private context to estimate privacy risks. This includes that the transfer and usage of the data will be displayed comprehensible. For education, digital competence should be supported. At schools compulsory computer science teaching should be introduced from secondary level on.

Most of the information privacy research is dealing with privacy concerns in the context of e-commerce, mobile, and Internet services. Newer studies are concentrating on privacy protection and try to measure privacy behaviors but also try to develop privacy artifacts which shall mitigate privacy concerns and help to protect users' personal data. FTC recommended a greater control over the collection and use of personal data through simplified choices by the user but also argue for increased transparency. Scholars therefore need to explore the contextual nature of information privacy in order to understand privacy behavior but also the consequences of privacy violations in different situations. But also the improvement of transparency, measures enabling risk assessment, and anonymization suitable for everyday's business life should to be investigated.

Summarizing one can state that privacy issues are becoming increasingly prevalent. The goal of this article was a holistic description and a state-of-the-art review of research in this field. A cause of the complexity is that information collection, profile control, and general privacy concerns interact with each other and affect user's behavior. Information privacy is therefore both a private and a public matter.

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Dr. Franz Lehner is full professor and holds the Chair of Information Systems (Wirtschaftsinformatik) at the University of Passau (Germany). His research interests cover the areas of knowledge and information management, e-learning, mobile applications and cloud computing.

Aleksandra Dzepina is research assistant at the Chair of Information Systems at the University of Passau (Germany). Her research interests comprise business process management, process mining and information privacy.

Chapter 13
Accessing and Securing Conceptual and Symbolic Knowledge Required for Digital Era Work

Stephen Billett

> … hardly have we approached the problem of understanding the intellectual impact of the printing press than we are urged to confront the psychological implications of computerisation. (Scribner 1985a: 138)

13.1 Accessing and Securing Work-Related Conceptual and Symbolic Knowledge

The majority of what we learn arises through its direct experiencing, albeit sometimes mediated by others. The kinds of learning required for contemporary work are no exception. Indeed, much of the concepts through which we understand our work tasks, what we are attempting to achieve and how they can be achieved through direct experiencing of paid work. The procedures we use to identify those goals and then achieve them, and the bases upon which we proceed with that work, arise through processes of engagement in activities and activities in workplaces and educational institutions (Billett 2015a). Accessing this knowledge for work is important because it does not arise within us – we are not born with it – but has its origins within the world beyond us (Scribner 1985b). Occupations and their particular manifestations in specific work settings arise through the exigencies of history, culture and situation (Billett 2003). We need, therefore, to access and engage with that knowledge inter-psychologically (Wertsch and Tulviste 1992), that is, through engaging with sources 'beyond the skin' and then mediating what can be accessed through suggestions of the social world with what we already know, can do and

S. Billett (✉)
School of Education and Professional Studies, Griffith University,
Messines Ridge Road, 176, 4122 Mt Gravatt, QLD, Australia
e-mail: s.billett@griffith.edu.au

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value. This is how learning from the social world arises and is remade and sometimes transformed through that learning (Bhaskar 1998; Donald 1991). So, these inter-psychological processes are based not only for human learning of socially derived knowledge associated with work but also how the further development of that work knowledge progressed. As new requirements for occupations arise and are responded to at either the occupational level or locally in circumstances of practice, that knowledge is sometimes transformed (Billett et al. 2005).

We need, therefore, to find ways of accessing and engaging with that knowledge and then appropriating (i.e. taking it to ourselves) or learning and its remaking. Much of this process has been and remains premised on individuals being able to engage with this knowledge through our cognitive and sensory processes: through hearing, seeing, feeling, smelling or tasting. Learning this kind of knowledge is not just premised on individuals' cleverness (i.e. ability to manipulate knowledge). It arises through their engagement with social sources of the knowledge to be learnt. Even what is often referred to as higher forms or orders of learning are developed in this way. For instance, deep understanding comprises rich and causal links and associations amongst a range of concepts (Posner et al. 1982; Vosniadou et al. 2002), such as is required for medical reasoning (Groen and Patel 1988) and diagnosis of technical faults and problems (Barley and Batt 1995; Gott 1989; Orr 1996). These links and associations arise from repertoires of experiences comprising individuals' engagement in occupational activities and interactions of different kinds. It is these repertoires of experiences that permit causal links and associations to be established through individuals' active and intentional engagement (Ericsson 2006). Similarly, strategic procedures required for effective planning, monitoring and fulfilling complex and demanding work tasks arise similarly through repertoires of experiences, including opportunities for rehearsal and refinement (Chatham 2009). Through these experiences, procedural capacities (i.e. abilities to achieve goals) are developed based upon individuals' engagement with and consideration of a range of contingencies and factors to be accommodated and appraised, including risks to be assessed and nullified. In both of these instances (i.e. conceptual and procedural development), the knowledge required to perform efficaciously arises through extensive episodes of experiences in work settings, across a range of tasks, and often over extended periods of time, and also through individuals' intentional and focussed engagement in those activities (Ericsson 2006; Malle et al. 2001).

However, a growing element of the knowledge that needs to be learnt for contemporary digitised work cannot be experienced directly. It is opaque, hidden or abstracted in some way and, therefore, individuals cannot be directly experience it. This presents particular challenges for its effective learning, as bases for making accessible and the supporting and guiding that learning may be required. This presents particular challenges for its effective learning. At one level, this is about preparing for experiences that are undesirable or dangerous to experience and learn through. We do not want pilots to experience engine failure or weather-induced stalls or airline cabin crews to experience plane crashes to prepare them effectively for these events. Simulations are organised for them to be confronted by these situations and learn about them in safe circumstances. Yet, more broadly, a growing

feature of work in the contemporary and so-called digital era is the requirement to access and appropriate conceptual and symbolic knowledge that cannot be immediately experienced in work settings (i.e. places where occupations are practised). Because this knowledge is opaque, hidden or abstracted, it cannot be directly accessed, experienced and, therefore, learnt through processes of direct experiencing. It needs, instead, to be secured through other means and in ways not assisted by the cues and clues made available by its presence in workplace environments (Griffiths and Guile 2003). Of course, occupations like science, engineering and health care have long dealt with concepts not able to be directly experienced, e.g. force, vector, microbial activity and electric current. Understandings in those fields are often developed through specific interventions, often in education institutions, which seek to promote access to and the appropriation of these abstracted and symbolic forms of knowledge (Diakidoy and Kendeou 2001; Limon 2001; Vosniadou et al. 2002).

With the extended use of digital technology in many occupations, a broader range of workers and with different levels of preparation and readiness are now required to access, appropriate and utilise these forms of knowledge in and for their work. The advent of digitisation of work activities, means of communicating and constant cycles of change in requirements for work presents new challenges, particularly for those workers who may lack of readiness for such engagement. For instance, their occupational preparation may not have developed the range of conceptual foundations that many scientific engineering and health-care workers enjoy. Readiness, in this sense, refers to having the understandings, procedures and values that permit individuals to engage constructively with experiences and learn effectively from them (Billett 2015b). Consequently, when there is a significant change in work requirements and these changes extend beyond the kinds of knowledge workers possess (i.e. what they know, can do and value), then educational responses need to be developed as part of ongoing learning and across working lives. All this suggests that interventions of some kinds may be needed to assist individuals that come to access, understand and effectively use these forms of knowledge.

This chapter proposes that, across human history, technologies of different kinds have long shaped both work and its learning. Artefacts such as tools and language not only shape the nature of work but also offer means by which learning can progress (Billett 2009a). The contemporary digitisation of work stands as yet another technology and its effective learning, yet one making particular demands on learners (Scribner 1985a). It likely has particular implications for tertiary education and workplace learning experiences supporting the development of workers' capacities across lengthening working lives. Drawing upon recent findings from studies of contemporary work and human cognition, how the learning of these important elements of contemporary work might best be realised through guidance and pedagogic interventions are discussed first. It proposes that particular kinds of experiences are required to make accessible and assist learning these forms of knowledge and in ways that individuals need to come to engage with and mediate these experiences. Much of this development is premised upon individuals' readiness to engage with and shape their thinking and acting about these forms of knowledge (Jensen 2007).

These explanatory propositions draw on literature from work, social constructivism and cognitive science. They offer bases upon which the kinds of knowledge that might be described as being hard to access and, therefore, learn can be engaged with and mediated. Yet, it is essential for effective work in contemporary times that these forms of knowledge can be secured through experiences in both educational and workplace settings. The propositions associated with accessing and assisting the development of these forms of knowledge are advanced with an emphasis on provisions of experiences that are generative of accessing the kinds of knowledge required for digitised work. This includes offering symbolic representations of that knowledge, and also how individuals might come to engage with and construct mental model and conceptions permitting the use and manipulation of that knowledge. Given the person-dependent nature of that process, individually oriented factors, such as personal readiness to engage with, represent and utilise that knowledge comes to the forefront of considerations about developing capacities for digitised work.

13.2 Changing Requirements of Work

Across human history, there has been constant changes in the requirements for paid work as societal needs and requirements evolve, work practices have transformed, workforces vary in their compositions and technologies that emerge are refined and superseded (Whalley and Barley 1997). So, there is nothing particularly new about the changing requirements of work and workers needing to respond to those changes to provide the effective goods and services. The challenges brought about by digitisation are, therefore, neither the first nor will be the last faced by workers. They are part of the ongoing challenge for individuals to develop and maintain occupational competence as their work requirements change and are transformed (Colin 2004). These are the personal projects of lifelong learning and learners across increasingly longer working lives (Jensen 2007). Most of the learning of occupational capacities across human history appears to have arisen through mimetic processes (i.e. observation, imitation and practice) (Billett 2014; Donald 1991) in ways that are largely personally mediated (Downey 2010; Marchand 2008). Indeed, processes of teaching and direct interpersonal guidance appear to be very recent phenomena in the span of human history. So, rather than being taught, it would seem that the vast majority of that learning across human history has arisen through processes of personal engagement and discovery and often in circumstances where it was clearly the responsibility of the novices to learn (Jordan 1989; Marchand 2008; Singleton 1989). It was also understood, from quite early times, that much of this knowledge had to be learnt, because it could not be learnt from others. The Daoist philosopher Zhuangzi (369–286 BC) used a parable of a wheelwright talking to a powerful general to describe the power of personal knowledge over that found in books (i.e. declarative form):

> I see things in terms of my own work. When I chisel at a wheel, if I go slow, the chisel slides and does not stay put; if I hurry, it jams and doesn't move properly. When it is neither too slow or too fast, I can feel it in my hand and respond to it from my heart. My mouth cannot describe it in words, but there is something there. I cannot teach it to my son, and my son cannot learn it from me. So, I have gone on for seventy years, growing old chiselling wheels. The men of old died in possession of what they could not transmit. So it follows that what you are reading are their dregs. (cited in Ebrey 1996)

This parable provides an early example questioning the power of declarative (i.e. statable) knowledge and its role in what is required for occupational performance and its learning. So, whereas statable knowledge is the most valued within many societies, perhaps because of its emphasis in schooling, exams, etc., and can be captured, appraised and assessed, there is much knowledge that cannot be so easily stated, expressed or projected (Plotkin 1994; Ryle 1949). However, the quandary here is that these kinds of knowledge need to be engaged with by individuals to be learnt. This extends to individuals creating representation structures to accommodate them, because these are not provided by what can be experienced directly. Yet, personal discovery through processes of such as mimetic learning may well not be helpful for this kind of learning, as the wheelwright's parable suggests. As this parable also suggests, this process can also be long-term arising through repertoires of experiences overtime, yet throughout developing ways of understanding, responding and advancing this knowledge. Given the constantly changing requirements for work, it may not be possible for such capacities to be the focus of a lifelong project, because it constantly changes. The impact of technology on work, for instance, and the frequency with which those changes arise suggest that dealing with such changing requirements is continuous, as the knowledge to be learnt is fluid and dynamic, and changes potentially outstrip our ability to understand these consequences. This was expressed so well by Scribner (1985a) over 30 years ago:

> … hardly have we approached the problem of understanding the intellectual impact of the printing press, than we are urged to confront the psychological implications of computerisation (p. 138).

The implications here include finding ways to make the symbolic knowledge explicit and/or accessible in assisting individuals coming to engage with it and developing schemes through which they can organise, recall and manipulate it. The latter is as important as the former. It will be learners' intentionality, which extends to their effortful engagement and ability to create structures and means for indexing this knowledge that will be central to its development and in ways that are recallable and applicable.

13.3 Symbolic Knowledge and Working Life

Humans' ability to develop and represent symbolic forms of knowledge in schemes that can be shared, developed further and across generations, is a quality that has sets us apart from other creatures on this planet (Donald 1991). It allows us to

develop capacities that are not generated and held by individuals alone (i.e. ontogenetically) and are lost with their demise. The continuity and development of the human species (i.e. phylogenetic development) are premised on knowledge that transfers and accumulates and are advanced within and across generations (Plotkin 1994; Scribner 1985b). These forms of knowledge are extra-personal, but engaged with and contributed to both individuals' development across their life histories (i.e. ontogenetic) and also to societal continuity and progress. Most notably, the capacity of language, both spoken and written, stands to be a key form of this knowledge. It stands as a potent tool to engage with and conduct socially generated activities, such as occupations with their particular practices, goals and discourses (Billett 2010), and pass on these ideas to others. However, as illustrated by the parable of the wheelwright, across human history, many of these occupations have also been dependent upon sensory forms of knowing such as sight and hearing (Gowlland 2012; Singleton 1989), haptic qualities (Makovichy 2010) and, particularly, those associated with manual dexterity (Sun et al. 2001). It is these qualities of skilfulness that are central to the development of occupational capacities, albeit now much work is now increasingly dependent upon symbolic forms of knowledge and knowing. In earlier times, it was suggested that manual workers did not need to have understandings or possess symbolic and conceptual knowledge (Lodge 1947). It was also suggested by Plato that such workers were incapable of possessing and utilising such knowledge. It was only for privileged others, including God, to engage in the kind of activities which required these forms of knowledge (Lodge 1947). However, we know now that all kinds and categories of workers require understanding to engage in our work because, increasingly, much of it demands the ability to adapt what workers know, can do and value to changing work requirements (Organisation for Economic Co-operational and Development 2013). That is, they need to be able to mediate what they know against constantly changing circumstances and workplace requirements (Billett 2015a). Yet, beyond the extent and scope of these changes, and the increasingly short cycles of change in what constitutes occupational practice, lies a qualitative change in the knowledge required for work: the growing reliance on conceptual and symbolic knowledge (Barley and Batt 1995; Billett 2006; Martin and Scribner 1991).

When that knowledge is absent in workers' capacities, its impacts can be quite profound. For instance, the incident at Three Mile Island almost became a catastrophe to the extent of Chernobyl, because the control room operators at this American nuclear power plant lacked an understanding of its processes beyond what they knew to operate it under normal conditions. This level of understanding, which included a reliance on the control panel, inhibited these operators from being able to respond expeditiously to the emergency as it unfolded (United States Nuclear Regulatory Commission 2004). Only when workers with the required depth of understanding intervened in the control room was appropriate action taken to avoid a catastrophe. In essence, the operators knew the operation of the control panel, but only had surface knowledge of the nuclear power generation process. There are a range of less dramatic examples within banking, health care, commerce, etc. (see Billett 2006). This is largely because much of the knowledge required is not able to

be directly experienced and understood by these workers. Other kinds of capacities and particular experiences are required to make that knowledge accessible. An example here is what occurred with the advent of computer numerically controlled (CNC) lathes. Prior to the advent of these lathes, they were operated by skilled workers who used sight (e.g. colour of swarth), feel (e.g. vibrations), smell (e.g. coolant evaporating) and aural (e.g. sound of tool cutting metal) sensations to make decisions about machining metal. This included the speed they were able to shave away surplus metal. They also used manual measuring devices (i.e. callipers) to ensure that the metal was machined to the required size and dimensions, all of which was undertaken manually.

However, as Martin and Scribner (1991) report, the advent of CNC lathes required the integration of these form of metal machining knowledge with symbolic knowledge and logical skills involved in new informatics (i.e. digital knowledge), which transformed the kinds of knowledge required to operate lathes. Machine operators now had to input numerical coordinates into keypads and then monitor the lathe as it progressed in a predetermined way to shape the metal to its required shape and dimensions. These kinds of symbolic and logical capacities and their development were of quite a different order and qualitatively distinct from those associated with manually based operations. Workers needed high levels of mathematics and of a particular kind, and also an abstracted understanding of how the machining had to occur, and through which to program the lathe. In short, the capacities to operate CNC lathes became closer to those of computer operators than metal machinists, even though the latter's knowledge is essential for knowing how to program and monitor the lathe. So, it is not just coming to access and know the required symbolic knowledge, but how it can be manipulated to achieve required outcomes and also how such abstract concepts can apply to specific tasks that machinists are asked to complete.

The advent of this kind of technology and its increasing use within work and working life (as well is that outside of it) is often referred to as the digitised knowledge or digital knowledge. Earlier, it was referred as 'knowledge work' (i.e. a form of work requiring digital knowledge), which erroneously suggests that some forms of work require knowledge and others do not. This kind of knowledge is, however, more probably seen as being abstract and not easy to engage with or experience. This makes it difficult to learn and manipulate when seeking to apply it to address specific workplace tasks, particularly new or novel tasks such as those that are increasingly becoming a feature of everyday working life (Organisation for Economic Co-operational and Development 2013). Some disciplines have long addressed issues associated with this kind of knowledge through identifying means to represent it. Physics, for instance, deals regularly with such concepts and science education has had as a strong focus of pedagogic practices aiming to make this kind of knowledge accessible to students (Novak 1990; Vosniadou et al. 2002). For instance, analogies and other representation have been used to Newtonian physics, the concept of force needs to be understood differently than how people experience it within an atmosphere influenced by gravity. Hence, science education has used analogies and other means of representing that knowledge to make it accessible and

comprehendible. Similarly, electricians and electronics engineers have long faced this challenge of working with something which cannot be seen, heard and experienced directly.

So there is nothing wholly new here in the growing demands of digitised work. Instead, there is a more general concern for how this knowledge can be made accessible to and learnt by a far wider range of workers so they can use and manipulate this knowledge. A study of truck drivers whose truck operations had become premised by computers that generated information on a visual display unit (i.e. dashboard) found that older drivers often struggled to both access and utilise the range of information made available to them through this visual display (Lewis 2011). They lacked readiness. Rather than relying on the array of information available on the dashboard and despite driving these trucks in a subtropical climate, many of the informants' preference was to drive with the window down so they could hear the engine. This was an important basis by which they drove trucks, changing gears and make decisions about acceleration and deceleration. So, whereas all of that information was available visually on the dashboard, their preference was to be informed about the truck performance through sensory means, through hearing and feeling the vibrations from the engine. Similarly, the introduction of fly-by-wire aeroplanes that have no direct physical link between the joystick and the wing flaps removed the haptic sensation of the stresses the plane was being placed upon that pilots used to make judgements about how the plane should be flown. Such was the gap between what the pilots knew, and how they flew their planes and this new technology, that it was necessary to introduce haptic technology to permitted pilots to have a sensation of flying and the kinds of pressures being applied to the wing flaps and tail.

In summary, the use of digital technology has increased and accentuated an issue for occupational practices and its learning. There have always been, however, requirements for work that are not easily engaged through human sensory systems, yet which are essential for the practice of occupations. Across human history, a gradual growth in the use of this kind of knowledge has occurred as our understandings and explanations move beyond those only based on observation and direct sensory input (Whalley and Barley 1997). Indeed, concepts and processes that are opaque, hidden and not observable have long been evident in human cognition. Ryle's (1949) seminal work which referred to human processes of thinking that cannot be observed – the ghost in the machine – specifically refers to those processes (i.e. procedures) that cannot be observed, readily captured and articulated. Yet, these are central to everyday thinking and acting, including, of course, that at work. Hence, there has been a need to account for and explain phenomena that have to be largely inferred, as Ryle attempted. In recent times, technology itself has provided means to track and capture something of the processes of human cognition through the use of MRI scanners, eye trackers and biometric measures. Whilst opening up possibilities, these processes are still in their infancy and limited in their scope. However, the practices by which humans have developed systems to represent and share symbolic forms of knowledge are long-standing and that required for contemporary work are an emerging challenge.

Consequently, to understand how the impact of the digitisation of work can be addressed in supporting workers' learning, there is a need to consider both what has proved helpful in the past and what new understandings, approaches and technologies themselves can do to assist this learning. There are seemingly two elements here. The first is trying to make accessible the kinds of knowledge that are opaque, hidden or otherwise difficult to access. Here, the concern is what kinds of pedagogic or curriculum practices can be adopted to achieve this outcome. The second is how learners come to engage with and mediate this knowledge and create representations and structures that support their effective use in and for work. This includes their development of mental models and ways of representing and manipulating this knowledge as they apply it in responding to the changing requirements of their work.

13.4 Learning for Digitised Work

A common claim is that adults acquire practical or everyday concepts through participation in ordinary activities, such as work, whereas scientific concepts are acquired through organised instruction. Much of these claims arise from distinctions between what is often referred to as lay and scientific knowledge. For instance, Vygotsky is supposed to have made such a distinction. Perhaps more importantly, the distinction might be not between that which can arise in practice settings and educational institutions, but rather through what kinds of experiences are required to make particular forms of knowledge accessible and understood. What is being referred to as scientific knowledge is more likely to be of the kind which goes beyond what is directly experienced or suggested in the physical and social environment, i.e. inter-psychologically. It includes understandings and practices that are unable to be observed, heard, smelt or otherwise directly experienced. Some time ago, I visited a hard rock mine site that used rock crushing rock equipment to access the ore prior to being processed. The equipment used to crush these rocks was a massive metal ball attached to a mechanical arm, which would drop on the rocks to smash them. When this piece of equipment is being maintained, it is necessary to secure this arm, so that maintenance work can be conducted safely. A supervisor, who was orienting me to the mine site, mentioned that recently an apprentice had used a small bench grip to secure it. Whilst the apprentice was correct in selecting a device like a bench grip to secure this arm, there was a wholesale misunderstanding of the weight and force of this arm and means required to secure it. The apprentice understood the concept of securing the arm, but did not comprehend the amount of force, weight and requirements to be secured. Had the apprentice perhaps observed this equipment in operation and experienced the sound, vibrations and consequences of its operation likely a more substantial form of securing the arm would have be selected.

This illustrates how classroom-learnt knowledge about force, weight, etc., needs to be associated with or embedded within activities to which they are to be applied.

It is necessary to represent a phenomenon, in some way, either through the generation of a symbolic system, such as numbers or letters, or a representation which assists its understanding. Sets of symbols are used to represent electricity, amplitude and current. Symbols that are familiar are used as icons for computers to inform about saving (i.e. computer disc), pasting (i.e. pasting brush) and deleting (i.e. waste bin) documents. Analogies are used to assist and learn about the flow of electrical current (i.e. like water through a hosepipe) or familiar terms used to categorise the sounds that both healthy and diseased hearts make to assist medical diagnosis (Rice 2008). Some approaches to developing occupational knowledge have explicitly tried to draw together two modes of activity (i.e. the everyday and structured experience) to secure principled understanding and effective practices. For instance, Orr (1996) reported how Xerox photocopy technicians learnt how to carry out effectively their work based upon a combination of engaging experiences comprising of structured instructional and then everyday work experiences and tasks. That is, firstly, the novice technicians were provided with understanding of principles and processes through which these machines operated, and then these experiences were enriched by stories from practice. The aim here was to address the issue of how technicians could be prepared for unpredictable tasks for which there may be no simple solutions or easy fixes. So, these technicians needed to develop principled understanding of how the photocopier worked and practices associated with its maintenance, with these followed by the development of strategic practices, heuristics and problem-solving strategies. These strategies included suggestions by experienced technicians about the kinds of problems they might encounter and also how they might address them efficiently and effectively. So, although the technicians had informed understandings about these pieces of equipment, the effective problem-solving strategies involved knowing about the range of factors that makes their work effective. Curiously, in this instance, the development of principled understandings (i.e. sometimes opaque knowledge) was seen as a precursor to the development of effective strategies for enacting those understandings. So, although not wholly focused on the development of symbolic knowledge of the kind generated by digitised work, there are lessons to be learnt here for occupational practice.

In sum, from the discussions above, it is possible to draw three conclusions about learning conceptual and symbolic knowledge of this kind. They are:

1. Hard to capture in written form
2. Difficult to access and learn
3. Cannot easily be ‘taught’, needs to be learnt

These conclusions suggest there is a need to select experiences that can make these forms of knowledge accessible in some way and for learners to engage with them in ways that assist them secure this knowledge. Moreover, individuals’ development of these kinds of knowledge is likely to be person dependent given their particular ways of knowing and learners’ previous experiences (Billett 2009b; Valsiner 2000). It is not surprising that younger people are more easily able to adapt to the use of electronic technology, as this is what they have grown up with. From the toys that they engaged with as infants and children to the activities they need to

participate in and that access to electronic devices have provided them with a level of readiness that earlier generations simply would not have enjoyed. Moreover, as with the truck drivers and airline pilots mentioned above those earlier, their premediate experiences (Valsiner 1998) have legacies in their ways of knowing, thinking and acting associated with those technologies and how they operate. They have become quite familiar, i.e. arisen through long-standing association.

Consequently, a consideration for assisting the development of these kinds of knowledge is the sequencing and duration of experiences required considering how to access, understand and develop it. But equally important is how learners come to actively engage, develop strategic strategies and understand the application of this symbolic knowledge in work situations. From this, issues associated with the selection of experiences and also the learners' readiness are addressed.

13.5 Learning Digitised Knowledge

A key priority is to find ways of making accessible for learners and assisting them secure the forms of conceptual and symbolic knowledge required for digitised work and workplaces. Likely, some of the more effective strategies are those which build upon what individuals already know, can do and value (i.e. those from premediate experiences). Hence, strategies such as the use of stories, analogies, explanations and illustrations mentioned above are likely to be helpful. Many years ago when, as an education student, I was trying to understand psychological ideas and seeking to comprehend difference between Piagetian concepts of accommodation and assimilation, I used the analogy of the mailbox. That is, the processes of accommodation was that which created the mailboxes into which mail (i.e. experience or stimuli) were to be directed. Assimilation was the process by which the mail was sorted into the particular slots based upon its categorisation. Whilst constituting a crude approximation of what Piaget probably intended, it pressed me to understand the two concepts and differentiate between through using familiar concepts. Also, the process of generating differences between these concepts offered a means of representation that was easy to recall and test out their differences as I applied them in my teaching. There are some consonances between the approach I adopted here and what was proposed by Collins et al. (1989) for the development of conceptual models of tasks. They proposed that such a process provides learners with:

- An advanced organiser for attempting to execute the task
  - Bases to utilise feedback, hints and corrections during interactions
  - An internalised guide for independent practice by successive approximation
  - A conceptual model that can be updated (Collins et al. 1989)

An advanced organiser is learners having some initial basis to understand phenomena before they experience and are expected to elaborate it (Ausubel and Novak 1978). If individuals have some prior knowledge of a particular phenomenon to be encountered, they are likely to be able to engage with it more effectively than they possess no particular basis for engaging with it. If students read about a topic prior

to having a lecture on it, they will have some bases to understand, engage with and respond to content rather than focusing on comprehending what is being spoken about it. Hints and feedback can be important. In the example referred above, I developed this concept and then checked it with my lecturer to ascertain whether this was a helpful way of representing these two phenomena. The feedback was positive, and my approach was seen by the teacher as being productive and proactive and has (rightly or wrongly) provided me with a way of representing and appraised the explanatory power of those two concepts. So, for instance, although accommodation is often seen as being the process of generating new knowledge, when things are presented differently, but are the same, assimilation may be more effective process than accommodation, and the creation of new categories may be unhelpful, and issues of subcategories and partial understandings become important.

All of this suggests that generating mental models through making the knowledge to be learnt accessible on the basis of something familiar, perhaps, to overcome its opaque nature stands to have potential for developing means for its effective use, including its refinement. Yet, it will be an opportunity to apply knowledge in a variety of circumstances – procedural development – and the honing and further development of that through successive approximations of what has been modelled as individuals progress towards mature practice that becomes important (Orr 1996). Using a simple analogy, such as a mailbox provides a way of indexing that knowledge, produces its own mnemonics and, also, concrete examples through which it can be both applied and appraised.

The use of pedagogies strategies such as pressing learners to develop mental models may be helpful for engaging with conceptual and symbolic knowledge that is difficult to experience directly. The mediational means of using analogies and illustrations provides a foundation that characterises the use of learners' knowledge and their engagement in a process of meaning-making. However, all of this emphasises learners' readiness to engage in these kinds of activities.

13.6 Learner Readiness

Readiness comprises individuals' ability to engage in and perform activities because they are within the reach of their existing capacities (Billett 2015b). If learners lack foundational knowledge (e.g. grammar and vocabulary for language), it may be very difficult for them to engage with and learn effectively from experiences (e.g. being immersed in a situation where a foreign language is being spoken). Having existing knowledge allows experiences to be construed and constructed in ways that are more likely to be ordered and informed than when they are ad hoc and without effective means of representation. As noted, learner readiness may well be generational because of the activities in which learners have engaged in premediately. As noted, a generation of young people who from infanthood onwards have engaged with electronic technology may well have higher levels of readiness to engage with

it than older generations whose familiarity and ease of usage is distinctly less than younger counterparts. Recently, an elderly couple approached me having purchased an electronic tablet and seeking assistance as they could not get it to work. They have seen other people using these tablets to make contacts, search for information, make bookings, etc. However, they did not know that you had to be connected to the internet through Wi-Fi or a physical connection for this to occur. There observations of people using these devices had not permitted them to know that the information was being provided through Wi-Fi. When advised about this requirement, they were surprised, but also embarrassed. Hence, you cannot make assumptions about learners' readiness. Other adults of their age, however, may have had access to computers and the Internet through their work and would know that you require to be connected to the Internet to undertake searches, secure information, make bookings, etc., but the personal experiences of this couple had not furnished those understandings.

It follows that different forms and levels of 'learners' readiness may require quite different kinds of educational responses. These older learners may need particular kinds of assistance to support their learning, but also in environments where they can productively engage and not be overwhelmed, intimidated or even humiliated by their lack of readiness. So, provisions of continuing education for older workers might be quite different than for younger ones, for instance. In all, given the person-dependent nature of developing the capacities required for digitised work, and the diversity of those requirements, the readiness of learners is an essential consideration.

13.7 Accessing and Securing the Symbolic Knowledge Required for Digitised Work

In conclusion, this chapter has sought to set of some bases to account for the kinds of knowledge required for the so-called digitised work. It has emphasised that across human history, we have developed the capacity to go beyond responding to what we experience directly and to accumulate and utilise knowledge of this kind across individuals' lives and in ways that permit the transmission and development of that knowledge across generations through the use of symbolic knowledge. This is part of the genius of human capacities. So, in creating ways to represent, share and utilise the kinds of symbolic knowledge required for digital forms of work is an extension of what human development has been long premised on. That is going beyond responding to sensory contributions and abstracting knowledge and then manipulating it to secure the kinds of progress that has distinguished that development from those of other species on this planet.

It has been proposed here that accessing and securing this knowledge is far from being beyond all humans' capacities. Within all of this, it transpires that learning is central and teaching is important, but mainly to support that learning and not as a

form of knowledge transmission. Like so much of the development of higher-order human thinking and activing, these capacities arise through the presence of human-developed and socially derived symbolic knowledge systems, on the one hand, and individuals' engagement with, their remaking and sometimes transformation of those systems, and in ways that are person dependent and purposeful, on the other. Consequently, and importantly, learner's readiness and intentionality are key issues, with individuals' premediate experience being central to being able to engage with, learn and manipulate the symbolic knowledge required for digitised work.

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Dr. Stephen Billett is professor of adult and vocational education at Griffith University, Brisbane, Australia, and also an Australian Research Council future fellow. He has worked as a vocational educator, educational administrator, teacher educator, professional development practitioner and policy developer in the Australian vocational education system and as a teacher and researcher at Griffith University.

Chapter 14
The Digitalization of Work and Social Justice: Reflections on the Labour Process of English Further Education Teachers

James Avis and Cheryl Reynolds

14.1 Introduction

This chapter explores the digitalization of work with particular reference to the labour process of further education teachers in the UK. We have in mind those teachers who work in colleges of further education and more broadly in vocational education and training. It is important to acknowledge that further education, or what has sometimes been referred to as the education and training sector, includes a diverse range of activities. These encompass vocational education and training, adult and continuing education, functional skills, general academic as well as vocationally orientated education. In the latter case, the curriculum offer ranges from entry- through to degree-level qualifications. The age span ranges from 14-year-olds to adults of any age, with provision being similarly diverse and delivered by both private and public organizations. Digitalization and information communication technologies (ICT) constitute an ever present backdrop to teachers' labour across this diverse sector. Interactive screens of all kinds are ubiquitous, with both staff and students constantly drawn into engaging with their work and one another through tablets, smartphones, laptops and computers.

Whilst our discussion is located within a particular social formation, namely, England, that has specific features, nonetheless the argument has a wider purchase that extends beyond this location. Neo-liberalism, austerity, digitalization, precariousness and the marginalization of vocational education and training are features of societies in the global north and south (Pilz 2016). In what follows, we set teachers' labour within the broader socio-economic context in which it is located. In addition, we consider the relevant theoretical discussions that inform our argument before addressing the specificity of the labour process.

J. Avis (✉) • C. Reynolds
University of Hudderfield, Queensgate, HD1 3DH Hudderfield, UK
e-mail: J.Avis@hud.ac.uk

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There are two points of which readers need to be aware. Firstly, the education and training sector in the UK, and in particular England, has been viewed as being for 'other people's children' and as with vocational education and training is seen as having low status (Bathmaker 2014a, b). Few members of the governing and dominant classes, and indeed of those who research the sector, have graduated from further education. Secondly, and lest we be misunderstood, we wish to distance ourselves from those arguments that locate digitalization within an overly technicist and determinist analysis. As with any technology, digitalization in a capitalist society is a site of struggle embedded within social relations of power. This is notwithstanding moments when digitalization could be seen as exercising a degree of agency; though to the extent that this occurs, it will be channelled through the relations of power in which it is embedded. O'Keefee (2016) has illustrated the manner in which the algorithms that underpin the assessment of adult competencies are based on a range of assumptions, methodologies and instruments which are linked together in a complex manner. The digitized data produced as a result of these complex processes will be drawn upon by policy makers to shape evidence-informed practice and consequently will have material effects. Much the same claim can be made about data that informs PISA (Program for International Student Assessment), TIMSS (Trends in International Mathematics and Science Study), PIRLS (Progress in International Reading Literacy Study) and so on, with these metrics informing practice. Such data provides a backdrop to performative practices against which managers and state officials judge educational institutions, processes that are linked with benchmarking and the assessment of teachers (Williamson 2016a).

14.2 Socio-economic and Political Context

Regardless of purported political orientations, politicians of both left and right accept the current hegemonic dogma that education should pursue competitiveness and that if achieved, a successful and vibrant economy will contribute to the wellbeing of all members of society. This assertion has some affinity with neo-liberal constructions of the economy and the uncritical celebration of the market as seen in the policies of the current Conservative government in the UK and its coalition and New Labour predecessors. In addition it is also a feature of policies that veer towards the social democratic, with McDonnell who at the time of writing is Labour's Shadow Chancellor suggesting that:

> restoring trade union rights and extending them to ensure workers are involved in determining the future of their companies is critical to securing the skills, development and innovation to compete in a globalised economy. (McDonnell 2015 Unnumbered)

At the same time, these constructions of the economy, regardless of their inflexion, operate on a capitalist terrain. That is to say, they accept capitalism, albeit that in the case of those having social democratic sensibilities, the concern is to soften the harshness of neo-liberalism in the hope that a fairer and more just capitalist

system is feasible (Hutton 1995, 2010, 2015). However, it is important to recognize that capitalism remains capitalism and that it is concerned with the extraction of surplus value by whatever means possible (Huws 2015). The point is that to the extent that the system is fairer, this does not derive from the logic of capitalism but rather from the balance of force between labour and capital. The contraction of inequality in the period following the end of the Second World War was the outcome of struggle and was not a result of the beneficence of capital as can be amply demonstrated in the current conjuncture. Over the last 30 years or so, capital has attempted to claw back the concessions won by the working class in the earlier period resulting in a significant deepening of inequality.

There is a paradox, in that the state's commitment to the rhetoric of competitiveness and the development of the economy is accompanied by the assumption of upskilling and the necessity that all members of society are required to develop skills in order to render themselves employable. The irony is that this call is set within a context in which levels of inequality are returning to those found before the Second World War. There has been what some have described as a hollowing out of the class structure. That is to say, the eradication of managerial and administrative jobs as well as other middle-level positions with digitalization is being mobilized to facilitate the restructuring of the labour process. Roberts (2013) analyses the loss of 'middling' jobs, with Brown et al. (2011) referring to digital Taylorism. The latter refers to processes in which the formerly skilled jobs of 'knowledge workers' have become standardized and deskilled – a process facilitated by digitalization. The result is a labour market in which there is polarization of skill (Cedefop 2012). Such processes are reflected in what Allen and Ainley (2007, 2014, and see Allen 2015) describe as the insecure working/middle class located within a pear-shaped or hourglass class structure. This class structure is characterized by increasing levels of inequality as can be seen in the polarization of income and wealth as well as skill (Dorling 2011, 2014; and see ONS 2014). In comparison with the period following the Second World War, rates of upward social mobility have stalled. It is important to acknowledge that earlier rates of mobility derived from changes in the occupational structure rather than the pursuit of equality (Hoskin and Barker 2014). Precariousness has now become all pervasive with underemployment, unemployment and over-qualification becoming a feature of many people's working lives (Standing 2011; Marsh 2011). This co-exists with the continued significance of what Keep and James (2010, 2012) describe as 'rotten' jobs, with people 'churning' between low-paid, low-skilled jobs, interspersed with periods of unemployment (Shildrick et al. 2012). Writers such as Blacker (2013) extend this argument and suggest that 'The current neoliberal mutation of capitalism' has shifted towards 'a mode of elimination that targets most of us' (P.1). Marsh (2011) adopts a not dissimilar argument (and see Gorz 2010). In other words, swathes of the working and middle class have in effect become redundant being part of a 'surplus' population that is no longer required by capital. There is a link here with those arguments that address the salience of immaterial labour, digitalization and cognitive capitalism. These arguments suggest that surplus value is generated in practices external to the capitalist organization.

14.3 Immaterial Labour, Digitalization and Cognitive Capitalism

It is important to acknowledge the uneven development of the means of production whereby earlier forms sit alongside those that have developed contemporaneously. The shift from Fordism to Post-Fordism, with the latter emphasizing team work and the salience of knowledge, can be used to represent the significance of immaterial labour in the current conjuncture. For Lazzarato (2006), immaterial labour encompasses to two aspects. The first involves cybernetics and computer control – the mobilization of digital technologies. The second includes a range of activities that are not normally considered to be a feature of waged labour. In this instance, Lazzarato refers to 'the fixing of cultural and artistic standards' and so on (Lazzarato 2006: 132). In this case, there is an emphasis on identity as well as the development of particular forms of subjectivity. As with other writers associated with Italian workerism, the move towards immaterial labour is seen to have arisen in part as a result of capital's response to worker struggles against Fordism and what Lotringer (2004: 11), Tronti (2007) and others have referred to as the 'refusal of work'. In addition, some of the features of Fordism and its alignment with the Keynesian welfare state supported the development of mass education systems which provided the foundation for the increased emphasis on knowledge in the current conjuncture. Vercellone (2008) refers to 'the constitution of a diffuse intellectuality generated by the development of mass education' allied to increasing levels of training and the social struggles that secured 'the spread of social income and welfare services' (unnumbered). This resulted in conditions favourable to the development of the knowledge-based economy. Whilst the preceding argument appears to question notions of deskilling and the prevalence of 'rotten jobs', this is only an apparent contradiction. Firstly, as Gramsci (1971: 9) reminds us 'all men [sic] are intellectuals' and that despite the constraints surrounding Fordist work processes, surplus value was and is generated through the activities of workers – that is to say, the mobilization of variable labour power. Even in the most humdrum types of work, there will be scope for the exercise of intellect (Avis 2010). This could be used to make the labour process more manageable through the use of 'workarounds' and the like. Secondly, in the current, conjuncture digitalization has deepened the significance of intellect which has become aligned with the development of an enterprising subjectivity. This subjectivity articulates with networked relations and project-based employment both of which are a feature of precariousness. In this instance, work has the potential to 'invade' all of life, whereby:

> one's entire life is put to work, when knowledges and cognitive competences of the workforce (the *general intellect* that Marx spoke about in his *Grundrisse*) assume the role played by machines in the Fordist period, incarnated in the living productive bodies of cooperation, in which language, effects, emotions and relational and communication capacities all contributed to the creation of value. (Marazzi 2011: 113)

Some commentators have argued that the salience of language, emotions and relational and communicative skills reflects the feminization of labour (Morini

2007). This assertion draws not only on gendered stereotypes but also the suggestion that these features are a significant attribute of immaterial labour. In addition, such arguments acknowledge the way in which life outside waged work in capitalist organizations contributes towards the development of surplus value. Women's domestic labour would be a case in point, but so too is the labour of the precarious worker, as is the manner in which the exercise of the general intellect can create value external to the capitalist organization.

14.4 Digital Labour

For Frayssé and O'Neil (2015: 15), digital labour refers to the affordances offered by ICT that facilitate 'labour everywhere and at any time'. Importantly, it also enables people 'to work unwittingly when engaged in leisure, communication, and consumption' (Frayssé and O'Neil 2015: 15). Often digital labour is used to refer to the production of value outside waged relations and in particular stresses the significance of user engagement with social media as well as the Internet. Such engagements were thought to offer users an ability to express their 'species being' as well as enabling them to be involved in non-alienating activities (but see Fisher 2015: 126). In such accounts, the collective processes encompassed in engaging with the Internet were thought to provide not only empowering but also democratic possibilities (Benkler 2006; Shirky 2008). Such practices were thought to presage the transformation of society and the development of new forms of sociality. Terranova suggests that these celebratory accounts mobilized a 'cyberdemocratic model' (2004: 135) that sought to revitalize the public sphere of civil society. A range of terms have been used to capture such prefigurative possibilities: peer to peer (P2P), crowd sourcing, co-configuration, mass customization, prosumption, producer, collaborative consumption, the sharing economy, social production, etc. All these terms emphasize collective processes which have broken down previous dichotomies and are thought to anticipate fundamental societal change. Engeström (2010), as with Adler and Heckscher (2006), argues that the logic of capitalist development which derives from the transformation of the forces of production is towards the incipient socialization of the means of production. Engeström (2010: 232) in this instance draws upon Victor and Boynton (1998: 233) to illustrate the direction of change in the modes of production, from craft towards social production (Avis 2016a). Digitalization plays an important role in this process.

Whilst it is the case, in Engeström's terms, that digitalization can transform the mode of production, there are however a number of caveats that question the progressive direction of such change. Perhaps we should view digitalization as embedded in capitalist relations. After all, the Internet is predicated upon a material infrastructure as well as the activities of capitalist organizations such as Google and Facebook. Terranova (2004) utilizes the notion of channelling to describe this context, arguing that this is a more appropriate description when set against accounts that view digital work as taking place outside capitalist relations. Rather, as

Terranova (2004: 94) suggests, these relations 'are the result of a complex history where the relation between labour and capital is mutually constitutive [and] entangled'.

What is distinctive about digital labour, or perhaps more correctly what has been intensified as a result of its development, are the ambiguities surrounding such labour. Marxist analyses have considered the relationship of digital to un-/productive labour. In this case, user activity on the Internet can be construed as a source of 'free' unwaged labour. For example, it can contribute to the development of open source materials of varying kinds, which can be, and are appropriated by capital to generate surplus value – or as some would argue rent (see Frayssé 2015). User profiles generate data that can be 'mined' and sold as a commodity to capitalist organizations (Scholz 2013: 1–2). In this instance, user labour, whilst unpaid, can result in capital's acquisition of surplus value, and in this respect, such work can be viewed as productive. Terranova (2004) amongst others warns against an oversimplified understanding of digital labour, with Jarrett (2015) arguing that the distinction between unproductive and productive labour is overdrawn, as are a number of other binaries – consumer/producer, author/reader, speaker/audience, reproduction/resistance, use/exchange value, exploitation/self-actualization and so on. As Andrejevic (2013) argues, digital labour is multifaceted and can at one and the same time exploitative and a source of pleasure, or as Jarrett (2015: 215) notes, 'consumer labour can be simultaneously the "unproductive" generation of socially meaningful use-values and the production of the exploited and exploitable audience-commodity'. However, what is particularly distinctive about digital labour and its articulation with the socio-economic formation is the manner in which all of life is put to work in what can be described, post Tronti, as the social factory (Ross 2013: 25). Here the boundaries between work and non-work and labour and pleasure have become permeable. The notion of the social factory seeks to capture these ideas.

14.5 'All of Life Is Put to Work': The Digital Labour of Further Education Teachers

The preceding sets the socio-economic and political terrain in which the subsequent discussion is located. English further education/vocational education and training encounters the full force of neo-liberal state policy, characterized by funding reductions (Avis 2016b: 13) an increasingly casualized and feminized workforce (Simmons and Thompson 2007) who face precarious working conditions (Daley et al. 2015; Lucas and Crowther 2016). This workforce is heavily surveilled through performative practices concerned with target setting, internal college self-assessment and Ofsted inspections (Ozga 2016). These processes are benchmarked against the digitalized data produced by supranational organizations such as PISA, TIMMS, the OECD and the EU, which in turn impacts upon the practices of sector workers. Digitalization articulates to teacher practice in any number of ways and can be seen

in the ubiquitous computer screens in foyers, learning centres, computer rooms and classrooms (Decuypere and Simmons 2016). Word and PowerPoint are almost unnoticed through their normalization.

The 'terrors of performativity' (Ball 2003) are well rehearsed in the literature, with these being currently intensified and exacerbated by reduced funding (Lucas and Crowther 2016). Some time ago, Avis summarized the key findings of research on the labour process of further education teachers. This research agreed on a number of elements surrounding this work, which have remained in place:

- Loss of control
- Intensification of labour
- Increase in administration
- Perceived marginalization of teaching
- Stress on measurable performance indicators (Avis 1999: 251)

Further education institutions, since the early 1990s, have been required increasingly to operate as commercial enterprises, competing with one another in quasi-markets created, maintained and controlled by the state. The mechanisms for control include policy imperatives, shifting qualification frameworks and the use of performance-related funding based on recruitment, retention and achievement. The promotion of 'diversity' and 'choice' and the notion of student as consumer have become central features of both policy and popular discourse.

The last three decades have seen the decline of collegiality and the rise of the further education 'manager'. This change is typified by the replacement of academic titles such as 'Head of English' or 'Principal Lecturer' with the language of the commercial world such as 'line manager', which points towards the encroachment of a discourse and practice of managerialism into further education. This represents a wholesale shift towards a kind of technical rationalism predicated on performance management, accompanied by an emphasis on performative notions such as efficiency, entrepreneurialism, income streams and core products. Ball (2003) and Randle and Brady (1997) have made the compelling case that this performative shift has led to the proletarianization of teaching. Further education teachers operate under systems of increasing regulation, stringent mechanisms of inspection and validation and extensive systems of measurement, monitoring and control. Further education practitioners are increasingly co-opted into their own subjugation through the requirement to produce operational and strategic plans and self-assessment reports. Institutions are forced to operate under all-pervasive quality 'regimes' within a target-driven culture.

These ideological and material shifts have been accompanied by significant changes in the material environment of further education, in terms of the nature of sites of learning and technologies typically employed. The literature on further education teachers' labour process plays down the significance of digitalization in the intensification of labour. We draw on the words of a key informant to illustrate changes in further education teachers' work, using this to point towards the affordances for a neo-liberal project provided by digitalization. Our informant moved to further education from a secondary school in the 1980s:

> At that time, College Reception was a tiny frosted window into an office and you had to knock and wait, sometimes interminably. It was expected that you would know where you were going. It wasn't friendly. There was no competition and no choice. Incorporation in 1992 was the real start of the marketisation of Further Education and that's when things really began to change. Now you get these big, bright, open, funky reception areas with sofas to bring people in.

These physical changes to the further education environment were accompanied by the proliferation of performance-led funding models, which began to alter the nature of further education work and provided a powerful spur to its digitalization. Our informant commented:

> [Prior to 1992] there was no real accountability. Nobody ever tackled people about poor results. At incorporation, funding changed enormously. They tried all sorts of different mechanisms to draw down funding. They gave you 5% of funding for everyone you interviewed then incremental amounts for each term you kept them, then 5% for the pass. That's when the data really started to drive home. But there was no single system. People developed their own ways of getting print-outs of student attendance. That was the first form of digitalization. I had a little Amstrad and was looked on as being an IT wizard!

The uptake of digital solutions was uneven, as was the shift from paper to digital records, and there was a period when colleges were compelled to keep *both* in order to satisfy regulators:

> The [Funding Council] would check your digital records but then select a random sample where they wanted to see the actual form with a photograph of the learner and their signature. The College would take a photo of every student and staple it to the top of the form. But then it would get filed in the wrong place. You could only ever find 85% of them and that wasn't high enough for the [Funding Council]. You had a strange mismatch between what was held on computers and the hard copy forms.

These recollections chime with the way funding changes have subsequently been reported:

> [The] output related funding system generated a perverse incentive structure... Providers engaged in 'unit farming' (entering students for extra qualifications within a single course, thereby increasing the number of funding units without having to increase student numbers) and 'unit maximisation' (prioritising those students who would attract the greatest number of funding units). (Panchamia 2012: 3)

Digitalization played an important role in the tracking and in some cases fabrication of data in response to funding imperatives (Denham 2002).

Similarly, the link between funding and retention meant that further education practitioners were increasingly charged with keeping their learners on the course for as long as possible, and digitalized records became the trigger for the new work of chasing recalcitrant learners.

> This form of data was very much driven by funding and people trying to exploit or subvert funding. That's when the developing relationship between 'bums-on-seats' and results started to come in. Enrolments, retention and achievement really came through and... staff were given these print-outs of non-attenders and asked, 'Have you rung this person?' And teachers would answer, 'Well, no, this is FE [Further Education]! They're adults. I shouldn't have to chase them. You'd got a mindset shift'.

This reflects patterns of infantilization commented on by Education Group II but more importantly points towards the re-engineering of teachers' labour. Colley (2006) discusses the emotional labour involved in tracking students as well as the uses of texting to ensure, or at least encourage, attendance. This represents an extension of teachers' work to what was formerly seen as the domain of welfare workers (Avis et al. 2011). In addition, emails and social media create permeable boundaries between home and work. Zukas and Malcolm (2015) illustrate this in the case of university academics, but much the same argument can be applied to further education teachers (Page 2015). Emails demand attention and swift reply in order not to fall foul of student satisfaction surveys and the like. Page (2015) suggests that further education teachers' personal use of the web blurs the boundaries between home and work. More importantly he suggests such use enables teachers to develop their skills in the use of Facebook, Twitter and other forms of social media that can enhance pedagogic practice. It can also provide short-term respite from the demands of work which can be returned to with renewed vigour, being 'a means of increasing worker productivity and developing... digital literacy' (Page 2015: 443).

Digital affordances that serve the exponential expansion in the demand for data and market indicators are often implicated in changing work patterns within further education and frequently seen in a technically deterministic light by teachers, who blame technology for imposing new requirements to digitally monitor and record data. However, behind the technology, political imperatives are at work to harvest and shape those that best suit their aims. In this context, further education leaders will seek out means to generate the kind of data that serves institutional needs to display efficacy. This inevitably generates a market for technologies that can 'capture' and display positive outcomes (Williamson 2016a). Digital solutions can be interpreted both as a response to political and social transformations as well as channelled by particular interests to encourage change in a specific direction.

An example of such a solution, arising out of Ofsted inspections lies in the growth of learning analytics. This is defined as 'the measurement, collection, analysis and reporting of data about learners and their contexts, for the purposes of understanding and optimizing learning and the environment in which it occurs' (Ferguson 2012: 305). This definition leaves out one of the key aims of learning analytics. As well as optimizing learning and its environment, this kind of data creates an audit trail of the work of an institution. Learning analytics can be seen as another instance where 'all of life is put to work'. The traces people leave when they use digital environments as part of a programme of study are appropriated in the work of assessing an institution's effectiveness. These traces are amenable to interpretations that shape the curriculum, and when done convincingly, institutions garner rewards in the form of higher inspection grades.

Data traditionally used for this purpose includes attendance monitoring, student retention and achievement and progression to employment. More recently, however, the growth of e-learning and the explosion in educational use of electronic resources means that more and more data about learner behaviour is generated automatically and in harvestable form. Frequency and duration of student login to virtual learning environments (VLEs), numbers of 'hits' on learning resources and frequency and

type of library borrowings can be readily cross-tabulated with student grades. Insights that hitherto have gone unrecorded or been too costly to glean from the plethora of paper-based, individually held records become eminently retrievable, searchable and accessible to computer-aided statistical analysis. This provides institutions with the incentive to encourage or compel teachers to make use of digital environments to accomplish learning tasks because in doing so, they assist the institution in impressing public statutory regulatory bodies. Whether this is the *best* way for people to learn or teach remains a moot point, and this question is often set aside, with the assumption that 'digital is better' in and of itself, resulting in the kind of 'technological somnambulism' deplored by Winner (2014: 261). Negative dispositions towards technology and digital environments are dismissed as 'luddite' and seen as a weakness of the student or practitioner that must be overcome through greater digital literacy (Rutkowski 2016).

One way in which learning analytics is becoming operationalized in further education is through the growth of 'student dashboard' solutions, in which:

> data coming from learning platforms can be made actionable by analysing and presenting it in ways meaningful to different stakeholders… [through] a single display that aggregates multiple visualizations of different indicators about learner(s), learning process(es) and/or learning context(s)'. (Schwendimann et al. 2016: 532, 533; and see Ozga 2016: 74; Williamson 2016b: 4)

The ostensible purpose of this kind of close monitoring of learners is to inform the processes of personal tutoring and curriculum design in ways that benefit the learner. Schwendimann et al. feel justified in asserting that although 'these fields are still relatively young, their explosive growth already provides enough literature to justify a systematic review' (2016: 532). However, in constructing this review, they make the worrying assertion that the majority of studies address 'general constructs such as usability, usefulness or user satisfaction, whilst very few studies actually look at (and provide evidence for) the impact of these technologies on learning' (2016: 533). An 'explosive' growth in the take-up of a system that has no convincing evidence base for impact on learning suggests that other, more immediate purposes are being served. A feasible ulterior motive, given the pressure to compete in the marketized arena of further education, is that of generating an audit trail of interaction to justify the continued survival of the institution. Public funds are appropriated in the service of the audit of learning rather than its development.

In the same way as the rise in learning analytics and student dashboards can be interpreted as a response to marketization and accountability, they can also be seen as mechanisms by which institutions and employees become controllable by the state. In fulfilment of Foucault's pre-digital vision of a panopticonized society, the social need for mutual scrutiny and oversight engenders digitalized work, rather than arising out of it:

> Our society is one ... of surveillance... behind the great abstraction of exchange, there continues the meticulous, concrete training of useful forces; the circuits of communication are the supports of an accumulation and a centralization of knowledge; the play of signs defines the anchorages of power; it is not that the beautiful totality of the individual is amputated,

> repressed, altered by our social order, it is rather that the individual is carefully fabricated in it, according to a whole technique of forces and bodies. (Foucault 1991: 217)

The representation of the individual learner within a student dashboard is a fabricated individual and the technique of forces and bodies that constructs her in the digital world. The play of signs is a play of click-throughs, logins, library borrowings, grades and attendance monitoring swipes. The anchorages of power are the funding and inspection imperatives that demand the monitoring of such signs. Whether the beautiful totality of the individual is deliberately amputated or repressed is arguably lost in this fetishization of the learner as a set of digital markers. Moreover, the existence of student dashboards compels new forms of work for further education educators, requiring they are used consistently across institutions and sectors. Regardless of existing practices for supporting learners according to their individual dispositions and programmes of study, institution-wide policies on dashboard use, with prescribed times and frequencies of dashboard-based meetings, are recorded and accrued on the dashboard. A system that is ostensibly designed to free practitioners from the burden of additional work in collating student data assumes a tyrannical hold over their time and energies and compels compliance, regardless of the impact on learners. The auto-recording of platform usage means that teachers and learners are subject to the 'vigilance of intersecting gazes' (Foucault 1991: 271) and are compelled to behave as if they are constantly being assessed and inspected.

A further example of the consequences of marketization, surveillance and control in further education lies in the proliferation of e-portfolio solutions. More than 50% of US colleges and universities now offer some form of e-portfolio experience (EDUCAUSE Center for Applied Research 2013). E-portfolios are a collection of digital artefacts that ostensibly shows a learning journey over time, characterized as a representation of professionalism and professional identity (Malita and Egetenmeyer 2011). They were developed from the early 1990s by universities and adult education providers for assessing learning and evidencing prior achievement and were initially locally hosted digital collections and later web based. Because they are eminently shareable and can be commented on or jointly editable, they can be a site for developmental dialogue with teachers and others, what Dominguez refers to as the 'bi-communicating dimension' (2011: 12). Such tutor practices are routinely date-stamped and logged automatically, impossible in paper-based portfolios. The development of digital literacy that is potentially stimulated by e-portfolios is mooted as a way to produce the flexible knowledge workers required by the global economy. However, the panopticonization of teacher activity that e-portfolios afford provides a perverse incentive to engage with learners in this way rather than through alternative, arguably richer media. Face-to-face or phone conversations are not automatically logged and hence 'invisible' to regulatory bodies and institutions. The e-portfolio and its use become shaped by auditable requirements, and this is glossed behind its prima facie purpose to stimulate learner development and present the scholarly, professional identity of its contributors. Moreover, institutions are required to buy into e-portfolio platforms through licencing agreements. In Marxist terms, and considering education in market terms, the providers of such platforms

effectively own the 'means of production' and are able to control how these means are shaped and provided over time. Who does this digitalization serve? Ultimately, Ofsted measure impact in ways that provide government with a vindication of their policies, and with political ammunition, they need to retain power. The work of lecturers is co-opted in the service of the political arms of capital and of capital itself.

In the preceding, we have brought together two sets of arguments that illustrate the manner in which digitalization allied to the 'power of numbers' constitutes a technology that serves to recalibrate teachers' work (Hardy 2015). This is a form of governmentality that is lodged on a very particular terrain, that of a neo-liberal and capitalist state.

14.6 'Busy-Work' and 'Bullshit' Jobs

This section may appear to be out of kilter with our earlier discussion, but it offers a particular vantage point from which to view digitalization and its impact on further education teachers. Paradoxically, 'busy-work' and 'bullshit' jobs co-exist with austerity and a surplus population that is extraneous to the requirements of capital. This can be evidenced by rates of un- and underemployment, set alongside those jobs that invade the whole of a person's life. Graeber (2013) associates 'bullshit' jobs with the growth of administrative and pointless work often found in the service sector. In such work, large numbers of people carry out tasks 'they secretly believe do not really need to be performed' (np). Teaching would not normally be considered in such terms, though many of the activities that further education teachers are involved in have a resonance with Graeber's (2013) 'bullshit' jobs. There is an affinity here with performativity and the surveillance of teachers' work. Ironically much of this has been facilitated by the growth of digital technologies allied to the requirement for ongoing accountability as well as the preparation for Ofsted inspection, processes of self-assessment and the like. Glaser (2014), in a commentary on Graeber (2013), suggests:

> Work that people find genuinely creative and meaningful… is now often supposed to be done unpaid. Whilst technology has failed to liberate people into a life of leisure, it has succeeded in shunting non-bullshit work into non-work time. (Glaser 2014: 88)

The academic labour process would be a case in point, but for many of those who work in education at a time of austerity, intensification and cost cutting, putative non-work time is frequently used to get the job done (Fleming 2014: 1–2). The irony is that much of this work could be thought of as 'busy-work' necessitated by performative regimes of dubious value that keeps us busy and saps our energy. Perhaps this is why Glaser (2014: 83) states, 'a population that is busy and tired is less likely to revolt'. There is another aspect to such processes where we become unduly focused on the institutional and local, and where we can rail in a safe place against the inequities of neo-liberalism, but stop short of wider political engagement.

We are reminded of Marcuse's (1965) notion of repressive tolerance, but in two rather different senses. Firstly, and in the light of our previous comment, we can talk amongst ourselves, occupy the moral high ground and describe our practice and engagement in radical terms. We may be voicing our dissent or indeed engaging in *parrhesia* (Foucault 1983), speaking on behalf of silenced others, writing our blogs and so. These practices also align with a second and slightly more tenuous notion of repressive tolerance, whereby dissent and resistance can facilitate capitalist adaptation. That is, to say capital's appropriation and domestication of dissent (Boltanski and Chiapello 2007: 27–30). These last points may be somewhat overstated and indeed stand as something of an autocritique. This is of course not denying the importance of workplace struggles, but these comments serve as a salutary corrective to an exaggeration of our significance by problematizing what can be seen as 'the self-presentation of moral purity' (Srnicek and Williams 2015: 8).

Notions such as 'busy-work' and 'bullshit' jobs also draw our attention to the paradox of work. This arises both in terms of research that analyses the labour process of further education teachers and that which considers the significance of waged labour for our students and wider society (Avis 2014a, b). Waged labour is at the centre of the current doxa and is seen as pivotal to life and wellbeing. At the same time, increasing numbers of people find themselves part of a surplus population that is no longer required by capital. Yet in recent years, the amount of time spent in waged labour has increased, and for many workers, the distinction between life and work has been eroded (Srnicek and Williams 2015: 115). This may appear paradoxical but can be seen as the way neo-liberal capitalism can 'keep [us] all up to the mark' (Olssen 2003: 200). Although capitalism celebrates waged labour, and 'demands that people work in order to make a living, yet it is increasingly unable to generate enough jobs' (Srnicek and Williams 2015: 126).

14.7 By Way of Conclusion

We have focused largely on the pernicious impact of digitalization on the lives of further education teachers serving as a corrective to more optimistic accounts. The digital affordances that are conscripted in the service of capital to control labour in further education lend themselves equally to resistance. Open networks, operating responsively to participation in real time, enabling the recording and sharing of views can become sites for solidarity and counter-narratives amongst further education workers. A recent example lies in the creation of the 'Tutor Voices Community' on Facebook. Growing out of the celebration of the resourcefulness, tenacity and integrity of further education teachers portrayed in *Further education and the twelve dancing princesses* (Daley et al. 2015), this community describes itself as 'a democratic campaigning network for educators in the Further, Adult, Community and Skills sector' (Tutor Voices 2016). It calls upon its members to respond to policy through lobbying and links to research, to raise awareness of practitioner issues, to promote critical pedagogy and to provide national, local and virtual spaces for

practitioners to share ideas and gain strength from one another. The point is that the digital, as with any other technology, can be aligned differently and therefore its enactment is the outcome of political struggle, with all the contradictions that involves.

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James Avis is professor of post-compulsory education and training at the University of Huddersfield. His research interests straddle the political economy of education and teachers' labour process, as well as education and skills policy.

Cheryl Reynolds is a senior lecturer in education at the University of Huddersfield. Critical perspectives on the use of technology in teaching and learning provide the main focus for her research interests. She is the social media manager for the *Journal of Vocational Education and Training*.

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