VOCATIONAL EDUCATION AND TRAINING REPORTS

Robert Helmrich | Michael Tiemann (Eds.)

Defining Work Tools: Studying Effects of Digitalising Work Tools

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Contents

Robert Helmrich and Michael Tiemann

Introduction: Work Tool 4.001 – Odyssey on the Labour Market

The idea that tools which are created by people and then become so sophisticated that eventually they turn on us and oppress us is often cited in popular culture – just think of 2001 – Space Odyssey or the Matrix trilogy. The general understanding is that people should be using work tools and work tools should be our expansions – not the other way around. But recently technological developments have made us aware of the impending possibility that work tools could at least be complicated enough for us to not understand them anymore. This can be adressed as a consequence of digitalisation. There is an anthropomorphic perspective, where machines and humans constitute combined entities. The actor-network theory (Latour 2005) can be seen as promoting this view. There is also an anthropocentric view on technology, which is often implicit. Here, techniques are seen as tools being used by people. There is no symbiotic relation between the two. If you look more closely at today's theories on the relation between social and technological development you will find that most theorists and theories allow for something more than a strict hierarchical relation of user and tool (see BIBB 2019).

The contributions to this reader draw on different theoretical backgrounds and so here we see different positionings on the "anthropomorphic-anthropocentric-scale". They constitute examples for empirical research into the actual effects of technological change in the form of new or renewed technical tools people work with. In this sense it could be described as a rather "hands-on" approach to find out more about the impacts digitalisation might have on qualification and the labour market.

Developments on the labour market may, then, affect the working lives of many people. Of course, the impact will vary – if there is only a new version of some specialised software which only few people use, the impact will be relatively low. But if we are talking about nearly half of today's jobs being substituted, an estimation often connected to a 2013 study by the Oxford scholars Frey and Osborne (Frey/Osborne 2017), then the impact will be enormous. It justifies journalistic and scientific analysis, public debate and possibly also political strategies to answer the most pressing questions.

The debate which arouse around the often cited Frey/Osborne study is interesting in at least two respects. First, the debate, both public and scientific, managed to somehow overlook past trends. Second, the debate did not yet look at one of the chief parts of technological change in the workplace, namely work tools.

Past trends are somewhat contradictory to what could be assumed on the grounds of the current debate. The digitalisation of economies acts primarily on the human-to-machine ratio. There are studies showing that technological change – in the past most often implemented in the world of work through automation and the rising use of robots (Michaels/Graetz 2015) – has led to increased production. Labour market participation also increased in these times, despite the human-to-machine ratio decreasing. Technological inventions, one could argue, have made it possible to organise work so that more people could participate in the labour market. The idea that monotonous, programmable work will be automated and thus people will lose their jobs is simply short-sighted (Bonin et al. 2015; Autor 2015; Helmrich et al. 2016). Job tasks are bundles of singular tasks which can be different for one job even within one and the same firm, depending on how workplaces are organised and on the abilities of workers. This is not to say that there will be no changes at all. But they might be less frightening than one would expect (Helmrich et al. 2016; Wolter 2016).

Human labour input needs and uses work devices to produce goods. Digitalisation affects these work devices and acts upon them: Due to technological change they are altered, they disappear or new devices are invented. We see developments which could lead to future workplaces looking rather different than today's. While in the past robots were caged in, we are seeing the advent of interactive, mobile robots, possibly equipped with artificial intelligence but certainly connected to other services and databases. It is envisioned that these robots will take up tasks in outpatient and home care (Vercelli et al. 2018), while in some cases artificial intelligence will take up tasks in diagnosis [IBM Watson being the most prominent work tool being used in research (Bakkar et al. 2018)] as well as medical centres (albeit with problems: Schmidt 2017). These are tasks and practices of which most people have at least some vague idea. But is there more?

Work devices and tools can be used to link several analytical perspectives to investigate the effects of digitalisation on workplaces and employment. These effects include the structure and amount of labour demand, shifts between occupational fields and changes within them, changes in working tasks and the task composition of jobs, job requirements and the changing relevance of qualifications. Another aspect which an analysis of work tools helps to understand is the demand for specific competences within occupations. Work devices also lend themselves to an analysis of a workspace-specific understanding of said changes.

When we proposed a session at the WORK 2017 conference in Turku on "The change of workplace due the digitalisation of work tools" we had the idea that maybe some overarching ideas or theoretical fragments would occur to integrate different (future) developments of technological change. It was and still is clear to us that one needs to look at the concrete development of work tools in order to fully understand these changes and their impacts. So we

proposed investigating changes in occupational requirements and tasks due to the increasing saturation of workplaces with digital and digitalised devices and gaining a deeper understanding of the social and occupational consequences of these developments.

Work tools are central to the organisation of workplaces, which in turn are dependent on the organisation of work in a firm and along (global) production chains. Work devices are very comprehensive and omnipresent. They make up the operative core of digitalisation. With them we can analyse which changes are going to take place in the requirement profiles of different groups of employed persons, occupations and tasks. Studies have shown that only half the firms with employees performing low-qualified tasks (which usually do not require any kind of vocational training) let these employees use digital devices (Helmrich et al. 2016). On the other hand, this shows that usage of such devices and software often requires specific qualifications, which are gained through vocational education and training or by studying.

The fact that we received a large number of proposals proved to us that we were on the right track. But we also soon learned from the proposals that, at least for the time being, specificity hinders generality. That is to say that work tools, their development, use and impacts are so diverse that it would not be feasible to try and push them all into one theoretical framework. Instead we focussed on recurring themes, on the question of a more universal definition of work tools and to some extent typical uses. We invited the best proposals to contribute to this reader. The articles included here went through review processes, first for presentation at the conference and then for publication in this book. We would like to thank all reviewers for their contribution and the authors for their patience during this time-consuming process.

The themes we found form the thread along which the articles are ordered: From the definition of work tools and a general topography to the use of specific tools in specific contexts by apprentices and workers, to firms' views on some of these issues and competences needed today and in the future. Our reader thus arranges specificity along the idea that we first need to establish how work tools can be defined and catalogued, how they are implemented and used in the workplace, and what people will need to be able to know and do in order to make use of them.

The first article presents a taxonomy of work tools based on a definition of work tools which all articles in this reader refer to. Güntürk-Kuhl, Lewalder and Martin use the description of work tools in job advertisements to get a collection of work tools which are currently being used and then allocate them to their taxonomy of eight main categories and 40 subcategories. Use of this taxonomy of tools is not restricted to any particular topic and it can be applied to various issues and can be used in various contexts. Some of those are discussed in the article, like observing and extracting tools in a variety of data sources, showing their developments over time and between different fields of usage, i.e. workplaces, firms and branches.

The following two articles focus on implementation and use. Kessler raises several questions about the impact of technological change as digitalisation. He wants to find out how requirements of occupational skills change, how a possible demand for new skills is connected to work tools and how such tools form these new skills. In this way the article scrutinises the interdependencies between digitalised work tools, skills and changing qualifications and the changes imposed on the latter two by the introduction of new work tools. A case study from the Swiss banking sector shows how new qualificational demands are met with the introduction of tablets in initial vocational education and training.

While these tablets are introduced to a "new generation" of banking clerks, Tuomivaara, Ala-Laurinaho and Perttula look at a situation where existing work tools are used in daily work routines and changed by the workers using them. The work tools they focus on are enterprise resource management (ERP) systems in woodwork and accounting. They show how the theoretical frameworks of activity system models and expansive development cycle models can be applied to explain the invention and adaptation of new work tools by their users. These users form requirements and work together to find solutions with given and new tools, which can be explained within the IT reinvention cycles framework.

Weller, Lukowski and Baum investigate the firms' perspectives. Based on an employer panel survey they are able to show that the usage rate of work tools depends on the level of routine tasks. Though software is the most important tool for all employees, the influence of digital tools differs between the different groups.

The concluding article by Widen and Karim establishes which competences individuals need to have when working with digital work tools. By looking at media competences they answer this question with the introduction of a critical digital competence which allows workers to assess requirements and help them find ways to handle digitalised and digital work tools.

We have already mentioned that every article in this reader relates to a specific definition of work tools, namely

> Work tools are material and immaterial objects required to perform occupational tasks and activities. Work tools may be used by persons as well as machines. Using a work tool requires specific abilities and skills, which are part of the description of a workplace as well as occupational tasks and activities to be performed and are closely linked to work tools. Work tools are not raw materials, building materials or substances being worked on, but rather what is used to work on these materials. Software, information (such as legal texts), standards, models or concepts and what is used to perform services can thus also be work tools.

This definition was derived from a project to build a taxonomy of work tools at the Federal Institute for Vocational Education and Training in Germany (see Güntürk-Kuhl/Lewalder/Martin, p. 11 in this book). In our view it is broad enough to sufficiently cover the realm of work tools and also open to new tools which might be developed in the future. What it does

not tell us is how "digital" a work tool is or how potent it is to substitute work tasks. Future research will look at these aspects, but for now we can use the idea of grades of digitalisation and automation (see Güntürk-Kuhl/Lewalder/Martin, pp. 11–32 in this book) to understand the fundamental relations of these with work tools.

Güntürk-Kuhl, Lewalder and Martin propose a five point scale for automation and digitalisation, where the highest score would be assigned to so called "Cyber-Physical Systems". When work tools have been ranked according to these dimensions, it will be interesting to see what the actual relationship between substitution and supplementation actually is. Assessing the work tools described in this book, the tablet computer in the banking industry (Kessler, pp. 33–53 in this book) would be classified with the value 4 for digitalisation and the value 3 for automation. As Kessler points out, tablets are tools supporting and enabling humans to perform certain tasks and activities but they cannot do anything self-controlled. The ERP discussed by Tuomivaara/Ala-Laurinaho/Perttula is classified in the same manner. ERP is a software product which has no physical representation, that is it is completely digital (value 4). But nowadays ERP is, like the tablet, limited to tasks and operations which a user tells it to perform, leading to a value of 3 for automation. In both cases the work tools change the organisation of work in the workplace, but do not necessarily lead to less job security. One of the questions here would be whether the supplementing effects are mediated by the qualification of the people using these tools or if they have been designed for their capabilities.

Establishing and empirically testing a causal relationship between technological developments as they show themselves in the implementation and use of work tools and changes in employment is only one of the many interesting questions for further research. We think that this reader will be a very good starting point for developing new research agendas.

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Betül Güntürk-Kuhl, Anna Cristin Lewalder, and Philipp Martin

Taxonomy of Tools at BIBB

Abstract

This article presents the basic concept of the work tools taxonomy of the Federal Institute for Vocational Education and Training (BIBB). Work tools are defined as tangible and intangible objects, used by a person or a machine to perform a task. By an automated operation the work tools were extracted from the digital job advertisements provided by the Federal Employment Agency. The Taxonomy consists of eight main categories which are divided into four levels. The category system is continuously updated. It completely covers the range of work tools in its basic structure. The method of automated extraction and automated categorization can also be applied to different data sets and thus can be transferred to different scientific issues.

1. Introduction

Technological progress is changing many aspects of work, including the ways in which companies and occupations are organised, the means via which intermediate and final goods are produced, and ultimately also the tools which are deployed. Changes to tools (and to their use) may provide information on technological advancement and on the resultant effects on occupational activities and requirements. The process of recording and systematisation offers the opportunity to use tools as a vehicle for describing the demands and tasks of a job. It also enables the identification of changes on a cross-sectional and longitudinal basis. For this reason, a system of this nature needs to be both comprehensive and current as well as sufficiently flexible to be able to map newly emerging tools and differentiations.

Tools within this context are defined as being material and immaterial objects[1] which a person or a machine needs for the purpose of exercising an occupational activity. Thus, we define work tools as such:

> Work tools are material and immaterial objects required to perform occupational tasks and activities. Work tools may be used by persons as well as machines. Using

1 This definition only includes elements and equipment used in the work process and does not encompass the materials, components or goods which are produced.

> a work tool requires specific abilities and skills, which are part of the description of a workplace as well as occupational tasks and activities to be performed and are closely linked to work tools. Work tools are not raw materials, building materials or substances being worked on, but rather what is used to work on these materials. Software, information (such as legal texts), standards, models or concepts and what is used to perform services can thus also be work tools.

This article presents the basic concept behind a categorical scheme for tools developed at the Federal Institute for Vocational Education and Training (BIBB). Although the system is subject to continuing updates, its fundamental structure fully maps the range of tools. It is applicable to various datasets and transferable to different issues.

2. Database and method

Various sources are suitable for the recording of tools. Some empirical surveys (such as the BIBB/BAuA Employment Surveys) identify tools in this way, and they are also discernible characteristics within occupational information systems (e.g. the Federal Employment Agency's "Berufe-Net"). Survey data contains information on tools which are actually used. One drawback is, however, that this information is usually limited by sample sizes which tend to be small and are either not capable of mapping information on a current basis or else cannot do so over the course of time. Occupational information systems have involved a pre-selection process with regard to the inclusion of individual tools in the system. The consequence of this is that no (completely) up-to-date data may be included. Changes over the course of time are also more difficult to trace. Although these systems provide a link to occupations, there is no connection with jobs.

Alongside these information sources (with their benefits and drawbacks), data from job advertisements was also used for the development of the systematics and for empirical analysis. Especially job advertisements make no mention of the tools used in the occupation every day, but any new technologies or particularly relevant tools which are introduced will usually be found in the advertisements. This means that we are able to assume that analysis of job advertisements is well suited to monitoring penetration of the world of work by (digital) tools and the change of occupational activities. In addition, job advertisements set out a direct link between jobs and the associated tasks, requirements and also tools. Job advertisements can be used to render changes in these connections comparable over the course of time, while data also covers the current margin. Links between tools, skills, occupations, branches and many more aspects besides can be made visible through the additional information in the job advertisements.

This study focuses more on the development of new technologies, on the shifting of relevancies and on the discontinuation of activities which may be executed via automated means than on the analysis of typical tools. The assumption made is that an effective identification of tools and the tracing of such developments is based on a large number of data points.

Since 2011, the Federal Employment Agency (BA) has been providing BIBB with all advertisements for vacancies which are reported by the cut-off date of October 15th. This amounts to approximately 400,000 per year, a figure which includes about 100,000 advertisements for training places. Alongside the full text and title of the advertisement, BIBB receives meta information on the occupation, the company's economic sector, the number of employees and the qualification level. This information can be statistically evaluated in coded form. Job advertisements are available across all fields of activity and branches of industry, and these enable both quantitative and qualitative evaluations to be made.

Text and content analysis procedures can also be used to subject existing occupations to qualitative analysis and thus allow possible new profiles to be identified. It is also possible to carry out further research on the advertisement texts, and they enable aspects such as the level of specific individual skills and combinations of skills to be tapped into.

Job advertisements registered with the Federal Employment Agency are not representative of all vacancies; the analysis of job advertisements does not claim to pursue this goal. The focus is rather on illustrating developments for individual occupations and on responding to the issues. The objective is to make statements on occupations with high and low attendance, because the assumption must be that these occupations are particularly likely to display changes and can be viewed as an advantage of this database.

Since qualitative text analysis is not efficient for larger quantities of data, such as the information available here, BIBB has entered into a cooperation with the University of Cologne and begun to apply automated extraction methods. The first stage of extraction was the discerning of tools in order to be able to evaluate their changes or developments.

To that end, the text of the job advertisement was automatically classified into four sections:

- Description of the company ("We are")
- Job description ("We are seeking")
- Competence requirements made of the applicant ("We expect")
- Other (e.g. "Submit your application now!")

This pre-structuring of the text makes the further extraction easier since individual items are only sought in certain classes. Tools, for instance, are only searched for in class 2 (description of the task) and in class 3 (description of the competence requirements).

A complex learning procedure is used for automated classification (see Hermes/Schandock 2016). In order to provide the programme with guides for class alignment, examples are input on the basis of examples which have been correctly annotated manually. The model formed by this training data provides a foundation based on which a classifier is able to carry out alignments of data which has not yet been characterised. The formation of a model can take place in various ways, for example by context or meta information. In simple terms, the

algorithm calculates which words and combinations are statistically likely to occur within a class and thus improves its precision when making the alignment. The better the training data is in terms of depicting representative examples of the classes, the more effective the alignment to the right class will be. As part of the process, individual sentences such as "You have experience in creating media using Photoshop and Coral Draw" are identified as a competence requirement and characterised as class 3. Once the job advertisements have been classified, the rules-based machine learning procedure and the extraction of information take place.

The definition of certain extraction rules permits tools to be discerned. For example, a rule is formulated which states that any noun following the formulation "You have knowledge of using ..." is a tool. Referencing of various linguistic and structural information is conducted. Within the scope of the monitored learning procedure (for information on the method see Geduldig 2017), verification needs to take place as to whether the terms extracted actually constitute a tool. In this way, the programme is able to learn and can also identify related terms. These stages are deployed on a repeated basis, and more hits are generated with each iteration.

The next stage involves a matching procedure in which all terms once defined as tools are found in the respective class within the whole dataset and are indicated as such.

A flow rate of approximately 1.2 million job advertisements identified a total of 2.6 million tools which can now be analysed at the level of economic sectors, occupations, company size classes etc. (see Chapter "Distribution of tools to the taxonomy categories").

3. Development of the tool taxonomy

The BIBB tool taxonomy was developed on the basis of the tool concept drawn up by Troll (2002). During the further course of work, this concept, which brings together different tool categories using a five-stage mechanisation scale, proved no longer current and not sufficiently comprehensively focused for the purposes of the project. As a consequence, the categories were expanded and realigned in some cases.

Furthermore, a consideration of tools in the BIBB/BAuA Employment Surveys and observation of tools in the job advertisement database on a sample basis made it clear that attention had not previously been paid to digital tools/software in particular. The tool taxonomy has been and continues to be extended and refined on an ongoing basis of iterative evaluation loops from the job advertisement database (see previous chapter "Database and method", pp. 12–14 in this article).

During the course of this work, eight main categories and 40 subcategories emerged. The main categories were divided in three to eight subcategories. The number of subcategories was merged and the number of levels was reduced in order to make the taxonomy clearer and more stringent.

The BIBB tool taxonomy (see Table 1) is broadly defined in thematic terms and thus lends itself to future research projects and issues (identified tools for each category are shown in brackets).

Table 1: Taxonomy of tools

1. Tools, devices
1.01 Ordinary hand tools (tool, makeup, rasp)
1.02 Ordinary devices (pump, pan, binder)
1.03 Electrical devices (air conditioner, stove, lamp)
1.04 Powered hand tools (drilling machine, angle grinder, airbrush, hair dryer)
2. Machines, installations
2.01 Manually controlled machines (lawn-mower, cutting die, sewing machine, high pressure cleaner)
2.02 Automatic computer-controlled machines (milling machine, machine tool, production machine, lathe)
2.03 Installations in industry and agriculture (production line, facility site)
2.04 Installations for energy generation and conversion (heating installation, wind energy plant, switchgear)
2.05 Agricultural and construction machines (concrete mixer, gantry crane, chipper)
3. Measurement devices, diagnostic tools
3.01 Ordinary measurement devices (folding rule, micrometre gauge, calliper gauge)
3.02 Electronic measurement devices (sensor, microscope, survey equipment)
3.03 Computer-controlled diagnostic tools, analysis systems (X-ray, computed tomography, diagnostic system)
4. Computer, EDP devices
4.01 PC, notebook, tablet (pc, computer, notebook, ipad, tablet)
4.02 Computer for controlling machines and installations (control system, Heidenhain, Fanuc)
4.03 Server, network technology (network, citrix, router)
4.04 Peripherals (scanner, printer, monitor)
4.05 Navigation devices (navigations system, GPS, electronic vessel control)
5. Software
5.01 Standard office software (MS-Office, excel, word, e-mail)
5.02 Operating systems, system software (Windows, Linux, VMWare)
5.03 Databases (SQL, Oracle, Access)
5.04 Tools for software development and administration (JAVA, HTML, PHP, Visual Studio, Eclipse)
5.05 Specific application software (CAD, time registration, DATEV, Photoshop)
6. Office and communication devices
6.01 Ordinary writing utensils (letter, dispatch documents, stationary)
6.02 Cell phones, RT units (cell phones, iphone, intercom)
6.03 Recorder (dictaphones, video cameras), playback devices/ reproducer (camera, video equipment)
6.04 Telephone systems, fax (phone, telecommunications, fax)

Table 1: Taxonomy of tools

7. Vehicles, means of transport
7.01 Ordinary means of transport (bikes, wheelbarrows)
7.02 Cars, motorcycles, taxis, buses (passenger car, automobile, transporter, coach)
7.03 Trucks (truck, articulated train, haul truck)
7.04 Construction and agricultural vehicles (excavator, wheel loader, tractor)
7.05 Lifters, freight elevators, forklift (forklift, floor-borne vehicle, crane)
7.06 Trains (train, railroad, rail car, railway traction vehicle)
7.07 Ships (ship, boat, towboat, sailing yacht)
7.08 Aircraft (airplane, aircraft, helicopter, flying object)
8. Other devices
8.01 Therapeutic appliances, sports equipment, toys, musical instruments (medicine, wheelchair, treatment chair, respirator, workout device)
8.02 Personal protection equipment (working clothes, protective equipment, respiratory protection, welder equipment)
8.03 Legal texts, reference works and similar (accident prevention regulations, industrial code, German Social Security Code XI)
8.04 Books, literature, files (circuit diagram, work instructions, recipe, file)
8.05 Mechanical and electrical cash registers, electronic checkout, computerised tills, barcode readers *(checkout, handheld scanner, card reader)*
8.06 Standards, models, concepts *(HACCP, hygiene standards, DIN standard)*

Source: own representation, based on Troll (2002)

4. Expansion of the taxonomy

Software

In accordance with the above definition and empirical analyses of areas such as the job advertisements, the BIBB tool taxonomy was expanded by adding category “5 Software” as a separate main category.

The following considerations led to the introduction of this main category: Software is a tool which is increasingly at the forefront of various occupational activities. There is hardly a workplace which does not encompass a task which is executed with the assistance of software in some form or another. In order to be able to record these activities and identify their areas of potential for change, it is not sufficient to observe them via the tool “4.01 PC, notebook, tablet”. Especially in the case of the topic of digitalisation/automation it would appear useful to consider these tools in a more differentiated way. After all, the potential offered by software to automate an occupational activity does not necessarily have to be used.

According to ISO/IEC 2382, software is divided into three main groups, namely application software, system software and system-related support software. The dividing line between application software and system software is blurred. For example, software may be used to develop an application as well as for user functions (spreadsheets, word processing or database systems suitable for end users). Developers will view their tools as application software in the same way as bookkeepers do their accountancy software.

By way of contrast, system software and system-related support software are programmes which are necessary for the correct running of a computer system, as are all programmes which assist with programme development by providing such instruments as compilers, test tools or general services (formatting, file administration, data transfer etc.) but which do not produce any user-related benefit. Examples include operating systems, compilers for various programming languages and data back-up programmes.

Application software can be installed locally on a workplace computer (desktop application) or on a mobile device (mobile application, app). It can also run on a server accessed by a workplace computer or mobile device (client server or web application). Depending on technical implementation, such software may be executed in batch processing or dialogue mode (with direct user interaction).

Application software can be further subdivided into standard software and individual software. Standard software is deemed to be a clearly defined area of application and can be acquired as prebuilt products. Individual software, on the other hand, is developed in a targeted way for use by a particular customer or company.

Standard software can in turn be subdivided into functionally related, cross-functional and branch software. Functionally related and cross-functional software is branch neutral (horizontal market) and tailored to a certain area of deployment. The transition from functionally related to cross-functional software is fluid. Typical examples of functionally related software include accountancy software, CAD or production planning and control systems (PPS). Cross-functional standard software, on the other hand, may be deployed in several functional areas of the company. This is applicable to office packages or ERP (Enterprise Resource Planning) systems.

Because the main significance is attached to tools which are connected with occupational activities, the variety of different types of software should be taken into account when considering and categorising these tools. In order to be able to align the types of software stated in the job advertisements, matches found should be sorted in the category of “application software” or “standard software” in particular. Consideration was also accorded to a detailed systemisation on the basis of the categories of functionally related software, cross-functional software and branch software.

The categories of system software and system-related support software do not appear to be useful for further systematisations and analyses because they help to operate the respective system or run the application software installed on the system rather than being tools by definition. Apart from a few exceptions relating to the development and maintenance of the system software, they will therefore not be tools and can be left out of the account. The main category “Software” contains the subcategories “5.02 Operating systems, system software” and “5.04 Tools for software development and administration”.

The masses of different individual mentions of software in the job advertisement database make it necessary to sum them up in few categories. Different types of software have

been collated to form categories such as “5.01 Standard office software” and “5.05 Specific application software”. These categories are used as designations here and in the taxonomy.

Legal texts and models as a tool

Legal texts (e.g. German Social Security Code II, construction law) are aligned as tools to the subcategory “8.03 Legal texts, reference works and similar” because these statutory foundations represent the “hand tools” of certain occupational groups (lawyers, legal assistants, notaries etc.). The focus here is on the law itself rather than on the physical edition of a legal text in the form of a book or a digital compilation. Legal knowledge in occupations which involve application of the law fulfils the same function as the material science involved in textile processing occupations in which knowledge of fabrics constitutes part of the basic theoretical principles which enable textiles of different types to be produced. Such legal knowledge constitutes the foundation which allows the “tool” of law to be used. In the case of textile processing occupations, tools are the sewing machine, the equipment used by tailors and construction software. In occupations which involve application of the law, the relevant legal text is the tool. The consequence of such a definition will be that law cannot be digitalised. It is, however, entirely possible for juristic decision-making, argumentation and advice to be digitalised and automated on the basis of the tool of law.

The same applies in respect of the subcategory “8.06 Standards, models, concepts (HACCP, sanitary standards, DIN standard)”. This subcategory encompasses tools which do not necessarily need to be of a material nature but which may still constitute fundamental tools for the daily work of certain occupational groups.

5. Distribution of tools to the taxonomy categories

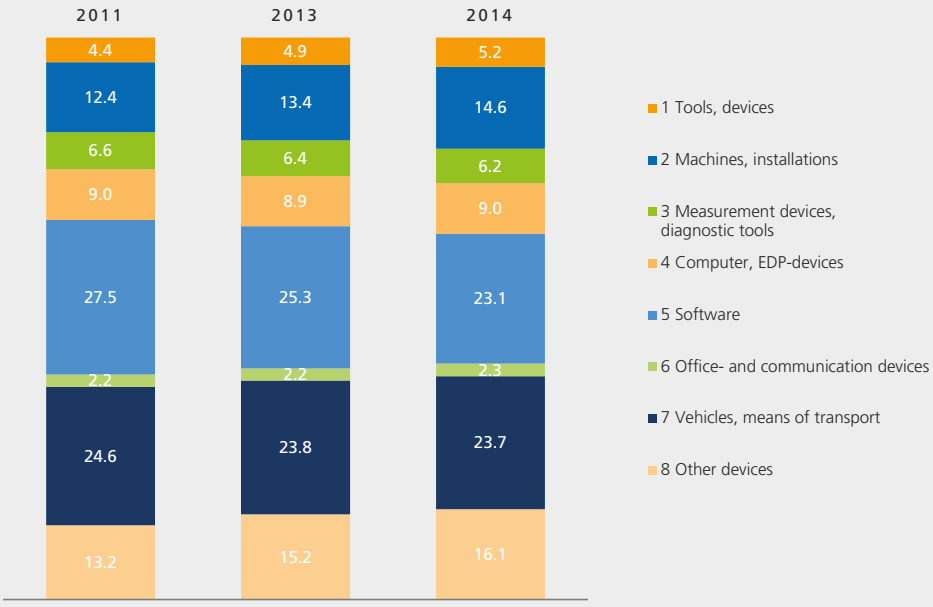
The structuring of tools in the existing categorical scheme made it possible to manage the majority of tools. The frequency of distribution of the tools across the individual categories provides information on the tools which are in demand in the BIBB job advertisement database. Figure 1 shows the frequency of distribution of tools across the main categories in the years 2011, 2013 and 2014. One column represents the total number of tools mentioned in the respective year. The values in the graph show the proportion of the main categories as a percentage of the total number of tools stated. In 2011, for example, 27.5 per cent of tools mentioned were aligned to the category “5 Software”. The corresponding figure for 2014 was 23.1 per cent.

The category “7 Vehicles, means of transport” contains the largest number of mentions by some distance (approximately 24% in 2014), followed by “5 Software” (about 23%) and the mixed category “8 Other devices” (16%). On the basis of the automated extraction procedure (see Chapter “Database and Method”) for the tools from the online job advertisements[2],

2 An analysis of online advertisements which goes beyond the Federal Employment Agency’s job advertisements is being planned (see Chapter “Forecast”).

efforts can now be made to establish permanent monitoring. As shown above, this monitoring process can point out the change in distribution of the tools in demand on the labour market over time. The distribution across the main categories depicted in Figure 1 can also be generated for all subcategories. One interesting aspect, for example, is the distribution of tools within the individual main categories.

Figure 1: Frequency of distribution of tools across the main categories in 2011, 2013 and 2014 (in %)

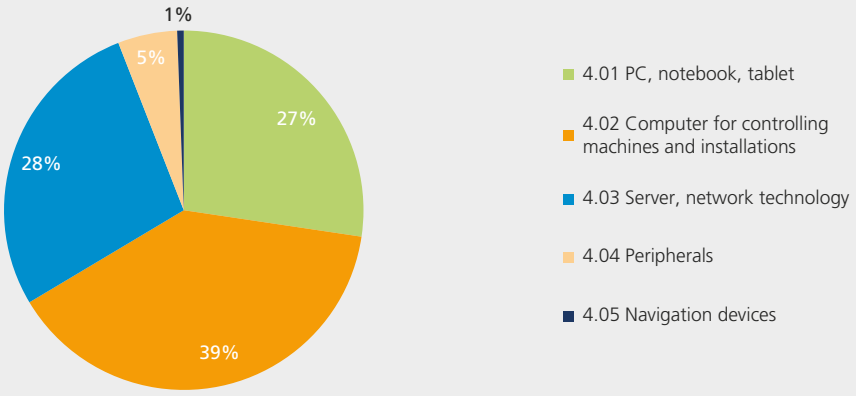


Source: BIBB job advertisement database, own calculations

Sometimes accumulations occur in individual subcategories within the main categories. Figure 2 provides an example of this by showing the distribution of mentioned tools in the main category “4 Computer, EDP devices”. “4.01 PC, notebook, tablet” accounts for about 27 per cent of mentions within that category. The largest proportion, however, is “4.02 Computer for controlling machines and installations” with about 39 per cent of mentions. In addition, category “4.03 Server, network technology” is mentioned more often than the personal computer, notebook or tablet with about 28 per cent of mentions. The least frequently mentioned categories of tools are “4.04 Peripherals” with about five per cent and “4.05 navigation devices” with about one per cent of mentions. The taxonomy helps to make the distributions visible. Automated extraction makes it relatively easy to create datasets from different databases. This provides an opportunity to permanently monitor the tools currently in demand on the labour market or to use old cohorts for comparative purposes if the database is available.

Figure 2 shows the frequency of distribution of tools within the category "4 Computer, EDP devices" (on the basis of the years 2011, 2013 and 2014).

Figure 2: Frequency of distribution in category "4 Computer, EDP devices" (in %)



Source: BIBB job advertisement database for the years 2011, 2013 and 2014, n= 94.939

Clusters of individual tools may also occur within the subcategories. The category "2.02 Automatic computer-controlled machines" contains 21.745 tool mentions. "CNC", "milling", "CNC milling" and "milling machine" account for some 40 per cent of these (8.612). We recommend that anyone wishing to make statements on the distribution of tools by categories start by thoroughly familiarising themselves with the taxonomy and the data.

In most instances, there is more than one identified tool in a single job advertisement. Table 2 shows three examples of such sets of tools.

Table 2: Tool sets in single job advertisements

Advertisement ID	Main category	Subcategory	Identified tool
188	7 Vehicles, means of transport	7.04 Construction and agricultural vehicles	Excavator
		Cars, motorcycles, taxis, buses	Vehicle
	2 Machines and installations	2.05 Agricultural and construction machines	Farm machine
5088	1 Tools, devices	1.01 Ordinary hand tools	Rasp
	7 Vehicles, means of transport	7.07 Ships	Towboat
		7.01 Ordinary means of transport	Means of transport
11477	3 Measurement devices, diagnostic tools	3.03 Computer-controlled diagnostic tools, analysis systems	Diagnostic system, visual display system
		3.02 Electronic measurement devices	Sensor system
	4 Computer, EDP devices	4.03 Server, network technology	Network, network system
		4.02 Computer for controlling machines and installations	Handler

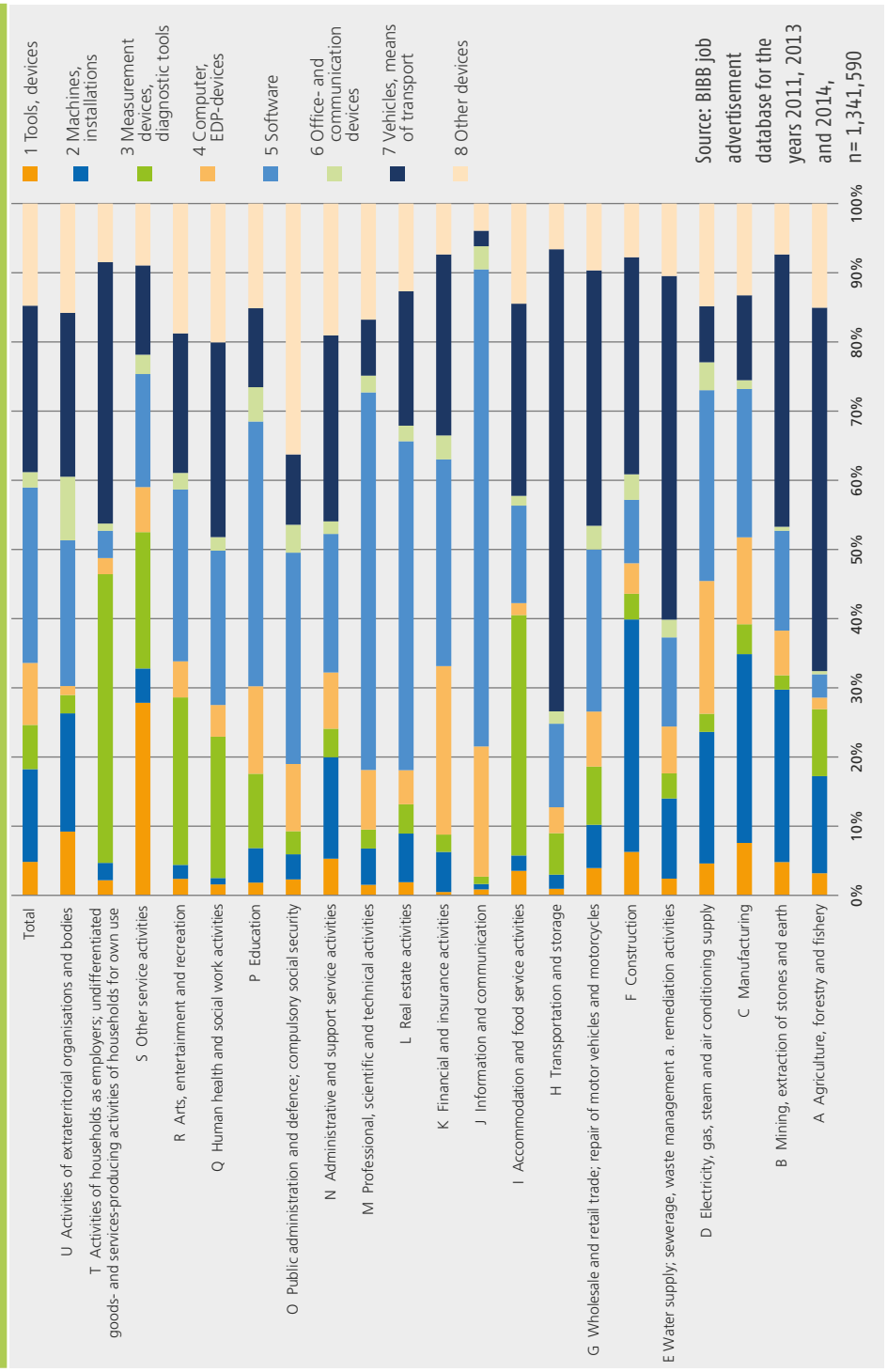
Source: BIBB job advertisement database, own representation

By examining such tool sets it is possible to get an idea of the actual job which is searched through that single advertisement, as well as a possible skill set which would possibly be needed to match the requirements. Possibly shifts can be found in the tool set for single occupations or branches of industry over time and therefore it is essential to examine more data points for further conclusions.

Distribution of tools to sectors, distribution within a sector in time comparison terms, distribution in terms of comparison between occupations and distribution in terms of comparison of skills within an occupational group are all presented below on the basis of the main categories. Depending on the research issue, detailed analyses are possible in the subcategories or at tool level.

In terms of the Federal Employment Agency's job advertisements, tools are distributed (main categories) to economic sectors as follows (WZ2008):

Figure 3: Distribution of tools within the economic sectors (in %)

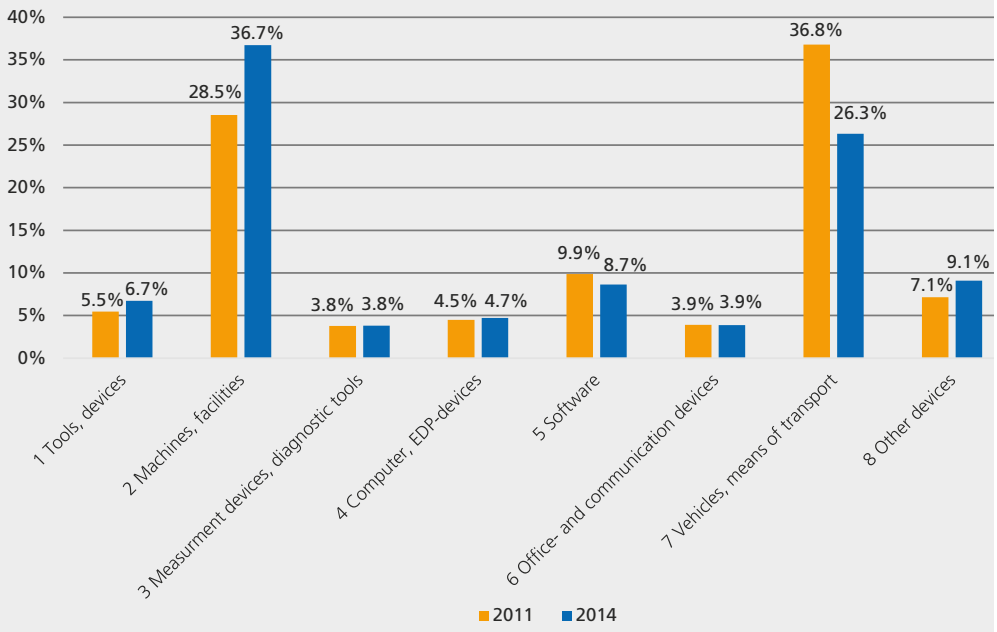


Average distribution across all sectors (Figure 3, top bar) shows that mention of software and vehicles is made very frequently in the job advertisements. Distribution across economic sectors clearly shows the relevance of the tools and significant differences between the sectors.

Above-average mention of vehicles and means of transport is discernible in economic sector A "Agriculture, forestry and fishery". This mainly relates to cars and agricultural vehicles such as tractors or other commercial vehicles which are mentioned in job advertisements. In economic sector B "Mining, extraction of stones and earth", the primary mention is of construction vehicles. Many machines and installations occur in the sector F "Construction". There is a particular emphasis here on "Installations for energy generation and conversion", i.e. predominantly heating systems and equipment. In the economic sector J "Information and communication", nearly 70 per cent of the tools mentioned are software names. This is not a surprising result given the fact that this sector mainly includes programmers and software developers. In "Other devices", sector O "Public administration and defence; compulsory social security" primarily contains legal terms such as "legal regulation", "regulation" and "administrative law" etc. The economic sector H "Transportation and storage" is more likely to include mentions of "lorry", "car" and "articulated lorry" as typical tools.

Basically the tools mentioned also correlate with the occupations and with the typical tools which predominate in the various sectors.

Figure 4: Time comparison for the construction sector for the years 2011 and 2014 (in %)

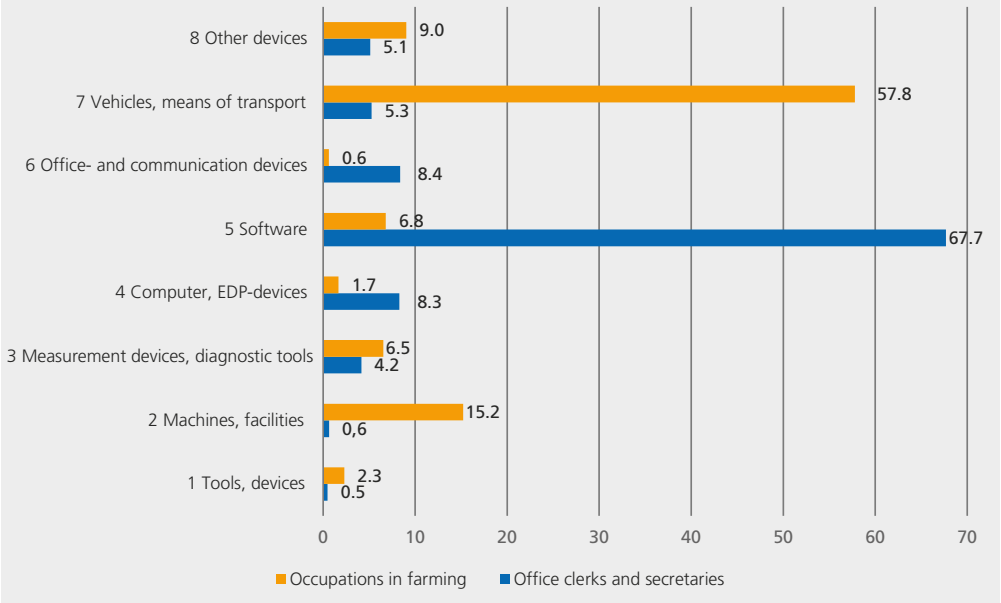


Source: BIBB job advertisement database 2011: n = 21,453; 2014: n = 27,711

Figure 4 shows possible changes for the *construction sector* over the course of time. Whereas machines and facilities were mentioned in the sector in approximately 28.5 per cent of cases in 2011, the corresponding figure for 2014 had risen to 37 per cent. During the same period, mention of vehicles and means of transport fell from 37 per cent to 26 per cent. The differences could result from a fluctuation or a measuring variation. The text mining program can only find tools when they are explicitly included in the text. We assume that if a tool is new and not yet established it will occur more often than if it is starting to be more commonly used. Therefore, we can say that an increase in the share of one category could be interpreted as a new demand on the labour market. At the same time, a decrease could be interpreted as a tool becoming more established, that it is still implicitly requested or indeed a reduced demand on the market. Therefore, anyone intending to interpret the data must be aware of this issue and consider other information. More data points need to be analysed to be able to make a valid conclusion regarding developments. Deeper analyses and statements regarding changes are also possible on the level of subcategories at separate points in time.

Figure 5 depicts the various distributions of tools across occupations in *agriculture* and *office jobs*. The latter present a classical picture in which about 68 per cent of tools mentioned are software names, in particular office products. Compared to this, software is only mentioned in just under seven per cent of occasions in the agricultural occupations. By way of contrast, vehicles are stated in the agricultural occupations in 58 per cent of cases, whereas the corresponding figure for office jobs is only five per cent.

Figure 5: Comparison of occupations (in %)



Source: BIBB job advertisement database for the years 2011, 2013 and 2014, agricultural occupations n = 1,438, office jobs n = 28,999

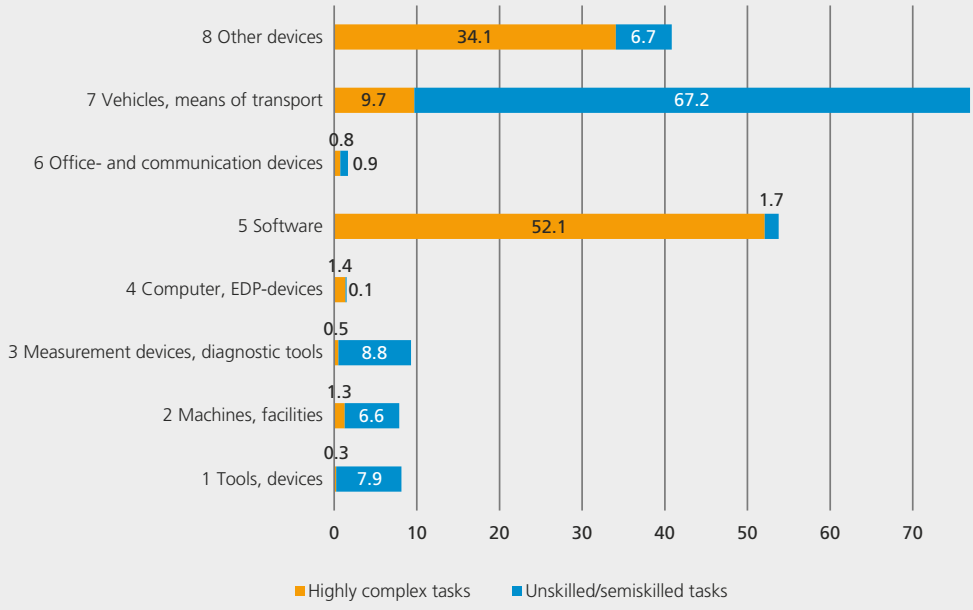
These differences within occupations and sectors can also be analysed in relation to various company size classes.

Figure 6 relates to the construction sector and shows different tools at different requirement levels within an occupational group. In order to illustrate the differences in the requirement levels, the two poles of unskilled tasks/semi-skilled tasks and highly complex tasks were selected for comparison.

Vehicles and other means of transport are mentioned in over 67 per cent of cases in jobs in which tasks are normally performed by unskilled persons. The corresponding figure for positions involving complex tasks is only 10 per cent. By way of contrast, software names are mentioned on 52 per cent of occasions for complex tasks. Only about two per cent of advertisements for unskilled tasks contain these references.

The same tendency applies to mentions of software in other sectors. The higher the requirement level, the greater the number of software names mentioned in the job advertisements.

Figure 6: Differences in requirement levels in the construction sector (civil engineering) (in %)



Source: BIBB job advertisement database for the years 2011, 2013 and 2014, unskilled/semi-skilled task n = 772, highly complex tasks n = 795

Legal texts and other reference works account for 84 per cent of the 34 per cent of mentions of "Other devices" for complex specialist tasks in the civil engineering industry. Examples include terms such as "HOAI – Fees Ordinance for Architects and Engineers" and "VOB – Contracting Rules for the Awarding of Public Works Contracts".

6. Recommendations for further research

The taxonomy of tools is not bound to any particular topic and can thus be applied to various issues and can be used in various contexts to observe tools via a variety of data sources.

The taxonomy and data extraction methods used in our research should be applied to other online job advertisements, including the Federal Employment Agency's. This would enable a comparison to be made between both data sources and a possible shift in distributions. The taxonomy could also be refined and validated by including additional data sources.

Concurrent to the development of the taxonomy of tools a scaling of the degree of digitalisation or automation of tools will be created. The purpose of this scaling is to assist with the recognition and analysis of changes in tools and thus of the change in jobs which takes place as the result of a stronger degree of digitalisation/automation. According to Ulrich (1968), the lowest stage of automation is always work which is purely human in nature (physical or mental). Higher stages result through the utilisation and aggregation of tools, equipment, machines, apparatus plants etc. This gives rise to four main levels:

1. Decrease in the use of humans as "power machines"
   The burden on humans as providers of energy is reduced. However, people continue to perform mechanical work (machines, apparatus etc. are still operated, equipped and used)
2. Decrease in the use of humans as "work machines"
   Control and measurement systems are added to the mechanical system, whereby apparatus, devices and equipment take over the functions previously performed by humans
3. Decrease in humans as a "setting, operating, measuring and switching mechanism"
4. Decrease in humans as an "optimisation mechanism"

This gradation produced by Ulrich served as the basis for further considerations. A distinction is drawn between digitalisation and automation. A fully digital tool (especially in the category "5 Software") does not necessarily also automate stages of work.

The aim is to localise the tool categories or subcategories within a space between the degree of digitalisation and the degree of automation (see Table 3). In each case, a five-point scale serves to present the data series for the degree of digitalisation and automation. Table 3 shows the gradations and criteria on the basis of which a tool can be localised on the scales, exemplary data points are shown greyed out. Additionally, the tools being processed in the chapters Kessler (p. 33 ff. in this book) and Tuomivaara/Ala-Laurinaho/Perttula (p. 54 ff. in this book) are classified by way of example. The tablet computer in the banking

industry (Kessler, p. 33 ff. in this book) is classified as value 4 for digitalisation, because the tablet itself and all the apps running on it are highly digitalised and the whole process of handling a tablet and controlling the programmes is performed via algorithms. In terms of automation, tablets are classified as value 3 because all the tasks being performed on them need the user to perform certain inputs and commands. As Kessler points out, the tablet is a tool which supports and enables humans to perform certain tasks and activities (as for which activities see Kessler, p. 35 in this book) but it cannot do anything self-controlled. The ERP mentioned by Tuomivaara et al. (p. 54 ff. in this book) is classified in the same manner. ERP is a software product without any physical representation, that is it is completely digital (value 4). However, nowadays ERP is, like the tablet, limited to tasks and operations which a user tells it to perform, which leads to the value 3 for automation. The cells currently filled with explanations are those in which a degree of automation and a degree of digitalisation correspond with each other, since these represent the ideal points of reference for the tool subcategories to be aligned in future.

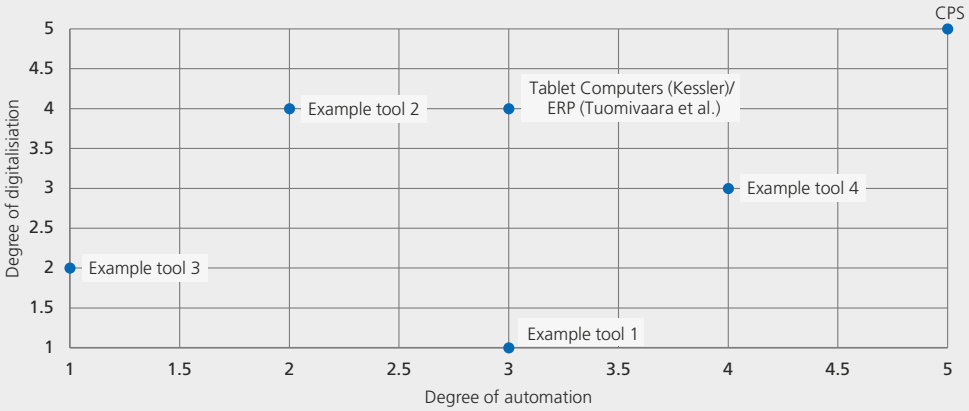
Table 3: Schematic representation of the scaling of the degree of automation and degree of digitalisation

Degree of automation		1 Analogue/ no digitalisation	2 Low digitalisation	3 Medium digitalisation	4 High digitalisation	5 CPS (cyber physical systems)
	1 no automation	handpowered, operation though muscular strength *typewriter, handsaw*	Example tool 3			
	2 low automation		Mechanical operation, partially through muscular strength *drilling machine, relay operated machines*		Example tool 2	
	3 medium automation	Example tool 1		Electro mechanical operation through machines, with low interconnectedness *Cash register system with barco-descanner (without connection to warehousing and accounting), turning machine with stored program control (spc), medical diagnosis tools, cnc-operated machines, which can read and interpret construction papers*	*Tablet computers (Kessler, p. 33 ff. in this book)* *ERP (Toumivaara, Ala-Laurinaho, Perttula, p. 54 in this book)*	
	4 high automation			Example tool 4	Digital control systems, fully automated machines/ facilities with local networks *Automated high bay warehouses, autonomously driving trains, cars, etc.*	
	5 CPS (cyber physical systems)					Sensor-actuator-systems, active and self-adjusting, digital and global fully automated supply chains, global networks

Source: own representation

Figure 7 depicts what is planned with the identification of tools and their assigning to a degree of automation as well as to a degree of digitalisation: it is possible for the identified tools to occur at any points on the two scales. Further work will show the data points of the actual identified tools.

Figure 7: Degree of digitalisation and degree of automation of tools



Source: own representation

The analysis of skills developments in the job advertisements and the observation of changes in tools offer particularly important results for early recognition of different or new qualifications. Digitalisation and automation on the labour market can also be expected to exert an influence on the qualifications of employees in a company. This development may possibly be reflected in the job advertisements in the form of changed demand for skills or the mentioning of new tools and new competencies.

A very similar procedure is being developed for the extraction of competencies and tasks. The change in competence requirements due to digitalisation and automation is another field of research that can be examinded by the "BIBB job advertisement database".

7. Appendix

Table I: Distribution of tools within economic sectors (in %)

	1 Tools, devices	2 Machines, installations	3 Measuring devices, diagnostic devices	4 Computers, EDP devices	5 Software	6 Office and communication devices	7 Vehicles, means of transport	8 Other devices
A Agriculture and forestry, fishery	2.4	11.6	8.2	2.4	5.8	0.3	44.0	25.2
B Mining, extraction of stones and earth	2.7	24.6	1.7	4.2	16.3	0.7	38.1	11.6
C Manufacturing	6.4	25.8	4.1	10.4	24.6	1.3	11.5	15.9
D Energy supply	3.6	25.4	2.4	13.8	28.2	3.8	7.8	15.1
E Water supply, sewage and waste disposal and rectification of environmental pollution	1.7	11.3	3.4	5.1	15.1	2.5	49.0	11.9
F Construction sector	4.8	39.7	3.1	3.3	9.3	3.2	25.9	10.6
G Commerce, maintenance and repair of motor vehicles	3.4	5.0	7.8	7.8	26.9	3.2	34.4	11.5
H Transport and warehousing	0.8	2.0	5.8	3.8	14.3	1.7	64.4	7.3
I Hotel and restaurant trade	1.7	1.9	30.8	4.9	20.4	1.2	21.8	17.4
J Information and communication	0.8	0.7	0.9	13.7	74.9	3.2	2.0	3.8
K Provision of financial and insurance services	0.4	4.9	2.4	18.0	38.6	3.3	22.3	10.1
L Real estate	2.0	6.8	4.1	5.0	48.0	2.2	17.8	14.0
M Provision of freelance, scientific research and technical services	1.3	5.3	2.5	7.4	56.8	2.3	7.9	16.6
N Provision of other economic services	4.3	15.7	4.1	7.5	22.5	1.7	25.3	18.9

Table I: Distribution of tools within economic sectors (in %)

O Public administration, defence, social security	1.9	3.7	3.3	8.5	34.4	3.9	10.3	34.1
P Education and teaching	1.6	4.7	10.4	11.0	42.4	4.7	10.5	14.7
Q Healthcare and social services	1.3	0.9	20.7	6.1	23.3	1.8	24.9	21.1
R Art, entertainment and recreation	1.1	1.6	21.9	8.8	31.7	1.9	14.5	18.4
S Provision of other services	21.8	4.3	20.7	7.8	23.3	2.6	10.8	8.6
T Private households with staff	1.5	2.0	31.4	7.8	21.1	0.7	28.3	7.2
U Extra-territorial organisations and bodies	6.5	21.5	2.2		18.3	7.5	25.8	18.3
Total	3.9	13.7	6.2	8.0	28.5	2.1	22.2	15.6

Source: BIBB job advertisement database, own calculations. n = 1,341,590

Table II: Frequency of distribution of tools across the main categories in 2011

	Frequency	Percentage
1 Tools, devices	15,162	3.5
2 Machines, installations	54,597	12.5
3 Measuring devices, diagnostic devices	28,875	6.6
4 Computers, EDP devices	37,822	8.7
5 Software	129,679	29.8
6 Office and communication devices	9,243	2.1
7 Vehicles, means of transport	100,900	23.2
8 Other devices	59,203	13.6
Total	435,481	100.0

Source: BIBB job advertisement database, own calculations

Table III: Frequency of distribution of tools across the main categories in 2014

	Frequency	Percentage
1 Tools, devices	19,869	4.2
2 Machines, installations	69,122	14.8
3 Measuring devices, diagnostic devices	27,207	5.8
4 Computers, EDP devices	35,346	7.5
5 Software	125,324	26.7
6 Office and communication devices	10,013	2.1
7 Vehicles, means of transport	102,183	21.8
8 Other devices	79,511	17.0
Total	468,575	100.0

Source: BIBB job advertisement database, own calculations

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Stefan Kessler

Changing Requirements in the Skills of Bankers: The Role of Work Tools and the Role of Learning

Abstract

The dissemination of new digital technologies in the world of work has recently brought up many questions regarding the potentiality of fundamental shifts in the qualification structure across a variety of sectors and industries. While tasks might be executed by digital technologies, these new working technologies might put qualified work at stake and change the skills requirements in various occupations. This contribution seeks to discuss the interrelations between the digitalisation of work tools, the skills and changing work tasks of qualified workers within an increasingly information-based working environment. Work tools might be digital devices, software algorithms, and networked systems as well as the working technologies needed to produce these tools. New work tools require workers to adapt to new occupational prerequisites and thus entail learning processes. At the same time – through learning – new work tools also offer opportunities to expand their professional expertise and to develop new practical skills. After examining the consequences of digitalisation for vocational skills and for learning, the interrelations between new work tools, skills, and learning are further illustrated in a case study from the Swiss banking sector, where tablet computers were introduced into initial vocational education and training (VET) as tools for vocational learning and as prospective new work tools (i.e. in the field of consultation).

1. Introduction

Technological changes in the world of work can be described as a change in work tools or, more generally speaking, as a change of working technologies. People use work tools in order to produce goods, services, and other objects of value creation. These could, for example, be machines, computers, or other instruments of specific use in a working context. Work tools could be the scissors, ribbon, and foam a florist uses to arrange flowers in an attractive way. Work tools are also used to produce these tools to work with. Again, these could be machines

to build these machines, software that runs on these computers, and instruments that are being used to assemble scissors. When looking at work tools in such a way, there are, strictly speaking, two possible end points in a ranking of work tools: The lowest order of work tools would be just one step above the very bottom of production (i.e. tools to work on raw materials), while the highest order of work tools would be much harder to grasp. Not only programming software can be work tools but also, for example, the codes written in order to contribute to build intelligent and autonomous learning algorithms that, again, can be used for data mining to create new information that can be further processed. Technological innovations can lead to (sometimes radical) new procedures at both ends of this spectrum and thus, again, manifest in new work tools. Reversely, the manifestation of new work tools could be regarded as indicative of undergoing changes in the world of work that might not be immediately apparent the other way round. Therefore, reversing the perspective and focusing on work tools could be rewarding for research.

One benefit of focusing on work tools as a research perspective is to provide an alternative approach to studying the impact of technological change on work in general or, more specifically, on occupational tasks and activities. Changes in the composition and interrelationship of work tools can be investigated and interpreted in the context of a changing working landscape. This approach could provide fresh perspectives and insights into the investigation of the effects of digitalisation of the world of work on changing tasks, task requirements, and skills needed to pursue these tasks. However, digitalisation should not be regarded in deterministic terms but should rather be understood as a dynamic process. Technological progress is, at once, the cause and the effect of new or initial technological and societal problems that create a continuing impetus for technological development (Mokyr/Vickers/Ziebarth 2015, p. 46).

A second benefit of focusing on work tools is that the above conceptualisation allows for two perspectives: work tools can be regarded as either the cause or the effect of changing working technologies and conditions. Take the "Industrie 4.0" scenario in the German manufacturing sector, for example, where humans interact with intelligent and networked technology in so-called "cyber-physical systems". In this scenario, work tools can be seen both as the carrier of these changes (i.e. advances in network technology and computer intelligence) as well as the new systems themselves that workers interact with when they maintain and control the automated processes. Therefore, the reciprocal processes in the changing conditions of work and working technologies can be analysed.

A third benefit can be seen in the study of workplaces and specific working contexts. Here, not only questions such as who uses which work tools and to what purpose can be raised, but the various interests behind the use and implementation of new work tools that shape the working context can also be investigated. Considering the workplace as a "contested terrain" (Briken et al. 2017, p. 5), where not only companies have interests but also social and cultural concerns come into action, work tools can provide a non-normative look at what is happening underneath the surface of the present aforementioned changes in the world of

work. Yet, as work tools are produced with a specific objective in mind, they are not neutral in that they are not free of interests. Work tools should, therefore, be seen within the economic, cultural, and social context of their making and of their intended and actual use.

Finally, work tools can provide learning opportunities, as new work tools cause workers to re-arrange and re-organise working procedures and their work behaviour (Baethge/Oberbeck 1986, p. 33). Fuller and Unwin (2010, pp. 203–204) argue that workers – possibly at any stage in their occupational biography – reflect the occupational and/or organisational context in which they work and thus engage in a "learning journey" that will eventually lead them to deepening their expertise and professional knowledge. Therefore, focusing on work tools can also lead to a deeper understanding of opportunities and restrictions in regard to learning in the contemporary workplace. While learning is most likely informal and non-standardised in the context of daily work, work tools can also be the subject of education and training in a more formalised context.

This contribution adopts this specific perspective to study the interrelations between the introduction of new work tools, the skills and changing work tasks of qualified workers that engage in highly information-based and customer-oriented services, and learning. These interrelations will be illustrated in a case study from the Swiss banking sector, where tablet computers were introduced in initial vocational education and training as tools for vocational learning and as prospective new work tools. In particular, the case study addresses the following questions: What skills will become important in the future in regard to tablets being introduced in training? What role do the new work tools play in view of the changing requirements in the skills of bankers? And what is the role of learning? Following Helmrich and Tiemann (2020, p. 8), work tools can be defined as "material and immaterial objects required to perform occupational tasks and activities" (see Foreword in this volume). In the context of the case study the work tools of interest are, therefore, (1) mobile working devices, namely tablet computers, that support bank employees in the working process in various settings. Due to the smallish form factor, mobility, connectivity, and simplicity, tablets can be handy tools for on-site consulting, since they make all the relevant information accessible on a mobile device (similar to the purpose of a consultant's briefcase). A tablet can also be used for presentations during customer meetings or for taking notes in a similar context. Furthermore, (2) the information that is accessible on these devices as well as software applications and tools for work organisation (e.g. taking notes, business calendar) can also be regarded as (immaterial) work tools.

The following section briefly discusses the impact of digital working technologies on the world of work. The second section reviews the present state of the debate regarding the consequences of digitalisation for qualified work and for the definition of occupational skills while highlighting the role of learning in this respect. In the third section, the implications of digitalisation for occupational skills in the Swiss banking sector that have been discussed in recent studies are outlined. The case study is then presented in section four. The conclusions discuss the changing requirements in the skills of bankers with respect to the digitalisation

of the work tools and the role of learning. The main argument is that although work tools play a vital role for the working ability of workers – thus a digitalisation of work tools may support workers' digital employability – the ability and attitudes towards learning become fundamental prerequisites for future bankers.

2. The digitalisation of work tools

In the last few years, there has been much debate in the public domain and in academia on how digital technologies and the process of digitalisation will change the future working landscape (Briken et al. 2017, p. 1). Technological developments and innovations such as the massive spread of the mobile internet, intelligent networking technologies, robotics, and a new quality of capitalising data and information for value creation prove a challenge for traditional industries and well-established businesses as well as for work and employment in various sectors. In a recent report, Frey and Osborne (2015) state that the impact of digital technologies on the world of work "has arguably been more disruptive than anything seen in the past" (ibid, p. 7). As the speed of technology diffusion further increases and digital technologies contribute to creating enormous wealth with even lesser capital needed (ibid., pp. 12–13), we are, arguably, only at the beginning of what Frey and Osborne, among others, call the "digital age".[1]

While there is a consensus today that the digitalisation of the economy – although not being a new phenomenon – has reached a tipping point (Degryse 2016, p. 50), its effects on work and employment are being discussed diversely. The scenarios range from a predicted massive substitution of low- to medium-qualified work due to the computerisation of core work tasks (Frey/Osborne 2017; Brynjolfsson/McAfee 2014) to future prosperity leading to "new markets and new jobs" (OECD, 2016a) in the digital economy (see in summary: Hirsch-Kreinsen 2016). As labour resources are freed up and production costs are lowered due to the automation of work processes, production procedures, and new work tools (Jud Huwiler 2015, p. 11), these developments have the potential to facilitate new forms of work and provide new prospects for employment (see Haberfellner/Sturm 2016, p. 66). Degryse (2016, pp. 17–18) sums up four possible forms of the impact of digitalisation on the labour market: the destruction of jobs, creation of jobs, job shift to platforms and crowdsourcing, and a change in existing jobs. With respect to the latter, a related line of the debate is focusing on the consequences for skills and qualifications. The common argument is that the facets of digitalisation *will*, in the mid or long run, produce shifts in the qualification structure of the labour market due to further technological progress and new forms of work organisation (Padur/Zinke 2015, p. 30). Hence, large parts of the future workforce may ultimately need a different skill set in order to stay productive and employable.

1 The authors see the advent of the "digital age" in close relation to the time frame of the rise of corporations such as YouTube, Facebook, and eBay – thus roughly around the beginning of the 21st century.

In this regard, the present discussion highlights the importance of education and training. It is argued that through learning and through training for new, often so-called "digital skills", some of the challenges related to digitalisation and employment could be met (e.g. to tame the risks of an impending qualification mismatch in the labour market or to gear up for the emergence of new business areas). Companies use digital technologies in order to retain flexibility and productivity at an organisational level, to interact and cooperate with customers and suppliers, and to internally process and externally exchange data and information (Arvanitis et al. 2017, pp. 14–15; Helmrich et al. 2016, p. 59). With increasing exposure to digitalisation, companies also tend to be willing to invest more in training (Lukowski 2017, p. 44). Within this scope, *digital tools* can provide a means for timely, cost-effective, and efficient training, support learner diversity, and train new competencies (Callan/Johnston/Poulsen 2015, p. 297). At the same time, these tools can also be *work tools* in a broad variety of contexts and fields of application, to which workers have to adapt. From an individual perspective, it is therefore argued that workers, too, in order to stay flexible, should invest in their digital skills portfolio – be that through workplace learning or through formal education and training. It seems that as long as skilled workers are able to adapt to changing requirements in the workplace and as long as they manage to use new technologies as work tools their jobs and positions will not be at risk (Bonin/Gregory/Zierahn 2015, p. 20).

3. Is qualified work at stake in a time of brilliant technologies?

In their widely received book, Brynjolfsson and McAfee (2014, pp. 173–180) argue that in a "time of brilliant technologies" the prospect of technological unemployment seems much more likely than ever before – even considering the some 200 years of empirical evidence they provide in their brief review of the history that this has actually never been the case before.[2] The general argument is that "[c]omputers and other digital advances are doing for mental power – the ability to use our brains to understand and shape our environments – what the steam engine and its descendants did for muscle power" (Brynjolfsson/McAfee 2014, pp. 7–8). Disruptive innovations such as machine intelligence and exponential technological progress could eventually make human work obsolete – or more autonomous and creative, depending on one's point of view.

3.1 How brilliant do we want "brilliant technologies" to be?

The assumption that is generally made for the Anglo-American countries is that many routine cognitive and manual tasks on a medium skills level could be completely automated and carried out by digital technology – thus leaving a "hole" in the middle.[3] This assumption can-

2 Mokyr, Vickers and Ziebarth (2015) and Autor (2015) come to similar conclusions.

3 Frey and Osborne (2017, p. 265) calculated that a total of 47 per cent of today's jobs in the US are susceptible to computerisation.

not easily be transferred to the German-speaking or even European context (Arvanitis et al. 2017, p. 22; Bonin et al. 2015, p. 23; Tiemann 2016, p. 18). It also requires rather large scale and extremely complex measures for work tasks and "qualified work" to work out. Therefore, researchers may have a hard time in tracking down the actual effects of digitalisation on work and employment (see Pfeiffer/Suphan 2015; Rohrbach-Schmidt/Tiemann 2013 for a more detailed discussion of this topic).

In addition, it is important to consider contextual factors, such as the economic structure of a sector/industry, its occupational composition, and the socio-economic context of skills provision linking the education system to the labour market (Buch/Dengler/Matthes 2016; Helmrich et al. 2016; Lukowski/Neuber-Pohl 2017). As Autor (2015, p. 27) points out for the US, today's education and training system is faced with providing the right combination of "specific vocational" and "foundational middle-skills levels of literacy, numeracy, adaptability, problem solving, and common sense" to the worker in order to thrive in the middle-skill jobs of the future. In contrast, in the German-speaking countries, vocational education and training (VET), which is well accepted in these countries, has proven to be a remarkably stable yet flexible concept of providing qualified workers for the labour market (Hotz-Hart/Rohner 2014, p. 194; Kraus 2009, p. 67). Assuming that technology and the organisation of work are both arbitrary objects in the work process – they are highly situation-specific and not necessarily generalisable – vocational qualifications represent the effort of defining the skills needed to be of use beyond a particular work situation and working context (Gonon 2002, p. 65). Depending on how digital technology intermeshes with human work in a specific working context – as a mere tool, as a partner, or as its descendant (see Frenz/Heinen/Zinke 2016, p. 33; Hackel 2017, p. 27) – and thus depending on what capacity to support, complement or supersede human work capacity is being ascribed to digital technology, study results differ in terms of whether digitalisation will impact on vocational qualifications and thus ultimately will cause a de-skilling or up-skilling of workers.

Hence, it is also a question of how "brilliant" we want technology at work to be, and, therefore, also a political question: to what extent does a threatening technological unemployment seem inevitable and in what way would this also involve the delegation of control and responsibility to the machine as a prerequisite? As Hof (2017, p. 11) puts it: "Man starts the machine, but who is going to turn it off?"

3.2 The prospects for qualified work

Is digitalisation therefore putting qualified work at stake? On the one hand, if the visionary concept of the "Industrie 4.0" prevails and thus leads to a "fourth industrial revolution", it would be unlikely that its implications would be limited to the field of industrial production, but also affect the services sector and the crafts (Tenberg/Pittich 2017, p. 33). On the other hand, since it is likely tasks and not occupations that are being automated in the first place and since not all workers engage in the same activities (Bonin et al. 2015, p. 19), it is arguably a matter of the adjustment of occupational contents and the skills of the workers (see

Tiemann 2016).[4] Baethge and Baethge-Kinsky (2006, p. 167) argue that in the last decades in both the industrial and the services sectors mechanisation and computerisation have not resulted in the mass substitution of qualified work. Rather, they see technology mainly in the role of supporting human work during this time frame, assuming a valorisation of professional expertise and experience.

However, as workers are increasingly being forced out of the actual production of goods and services into a more distant controlling and user position, this can lead to the loss of experience and expertise to the point where workers are no longer able to uphold a comprehensive understanding of the complex operational processes they are involved in (Spöttl 2016, p. 69). Gonon (2002, p. 71), too, mentions this potential gap that is imposed by new technology and new work tools in the workplace. As a consequence, he feels that formal education has a responsibility for helping shape such an understanding that could not be gained directly "on the job" (i.e. only through a critical distance to the application-oriented use of new technologies at work).

3.3 Learning as a means for greater flexibility

What is more or less implicit to the discussion of what kind of skills will be needed in the future and how these skills could be obtained is the role of learning. As mentioned in the above, learning is seen as a viable way for both companies and workers to retain, or re-gain, flexibility in the digital age (Bonin et al. 2015; Callan et al. 2015; Lukowski 2017). As the digitalisation of the world of work rapidly progresses – as do work tools – learning, and thus also education and training, is becoming a key factor (Buch et al. 2016, p. 7). One of the main incentives why companies will invest in learning (i.e. through education and training) is to directly provide the workforce with the skills needed, rather than to rely solely on appropriate qualifications and the readiness of workers on the external labour market (Hotz-Hart 2008, p. 100; Schmierl 2011, p. 27). With regard to dual VET, where learning takes place in the workplace as well as in vocational school, companies more likely engage in training if the share of specific skills in the curricula – in contrast to general skills – is higher by comparison (Hotz-Hart 2008, pp. 100–101). In the case of Switzerland, training companies generally do not have a direct influence on defining the aims and contents of a specific VET programme, but they can claim their interests through participating in professional and industry associations that are, in turn, assigned to this task.

The "skills match" between the qualifications and competencies being taught or trained by means of a curriculum and those required by the companies remains a fragile construct. Within the Swiss context this manifests in the yearly fluctuation of companies that are being enrolled in apprenticeship training in comparison to those that primarily pursue external

4 Although there are exceptions: for example, Tiemann (2016, p. 22) argues that in the German commercial services sector occupational tasks might have been replaced by new technologies while, in parallel, overall employment decreased between 1986 and 2012.

recruitment strategies (Müller/Schweri 2012, pp. 49–50). A common strategy among the bigger companies and industries can be seen in the outsourcing of training activities to industry-led professional organisations and to external training centres, which gives them an edge over smaller firms in tailoring the training to meet their prospective qualification needs.[5] Another trend can be seen in building training alliances in order to share training costs and risks. In this way, smaller and highly specialised firms can also engage in training through covering only a certain part of the training curriculum.

Besides the manifold paths that companies pursue in order to build up a skilled workforce, there is much consensus about the key skills future workers should acquire. Next to a sound level of specific occupational knowledge, ICT-related generic skills (i.e. knowing how to use digital devices in a work context), social, communication, and interactional skills, as well as problem-solving and self-organisation competencies are gaining in importance in technology-rich working contexts. There is growing evidence that the digital workplace, which involves the use of digital work tools such as advanced computer-controlled systems, tools for networking with customers, tools for work organisation, and big data applications, makes work not only more particularised (see section 2.2 above) but also more demanding (Lukowski/Neuber-Pohl 2017, p. 11). It is to be expected, therefore, that the introduction of new work tools also entails learning processes and new work practices, and thus requires a certain amount of flexibility on the part of the workers. Whereas a new quality in the interaction with digital technologies, their use in the work process, and the resulting change in work practices upholds significant opportunities for learning, the new work tools make learning – and also attitudes towards learning – a necessary prerequisite.[6] In the digital age, too, companies still depend on subjective knowledge and experience. Therefore, workplaces cannot be organised according to technical concerns alone but also have to account for individual and collective practices (Briken et al. 2017, p. 5), including learning processes and opportunities to learn. Without systematic approaches that enable learning in such contexts, however, learning would be reduced to a radically individualistic enterprise, relying solely on the flexibility and adaptability of the individual. While the present debate about fostering "media literacy" and "digital skills" in general education and in VET makes a similar point, it remains an open question how the corresponding efforts to digitally upgrade formal education and training will translate into relevant learning practices and opportunities in the later workplace.

5 Such practices can be traced back as far as the beginning of the 20th century in the industrial sector, and – with some time lag – also in the services sector (Elsholz 2016, p. 6).

6 Similarly, Baethge and Oberbeck (1986, p. 33) argue that technological change leads to a change in work behaviour. That includes, for example, interaction with the (new) work tools and modes of communication with customers and colleagues. Baethge and Oberbeck call the sum of established behavioural patterns with regard to the daily use of work tools the "Arbeitshabitus".

4. Implications of digitalisation for occupational skills in the Swiss banking industry

The banking industry is an important branch of the Swiss economy. Its relative gross value added was more than 5 percent in 2015 (BFS 2017). It is expected that a considerable amount of high-volume routine tasks in the middle and back office in the industry, such as banking operations, transactions, accounting, controlling and data management, as well as in the front office such as consultation, transfers, and sales can be carried out or supported by digital technology in the near future.[7] In a recent study, Deloitte's researchers estimate that although "only" 15 percent of activities will be mostly or fully outsourced within the next few years, banks have clear intentions towards expanding the automation of processes within the same period (Deloitte 2016a, pp. 2 & 12). While banks are under pressure to innovate and constantly evaluate their business models, digitalisation is seen as a multiplier for the present changes in the world of banking. Through further innovations in digital banking (e.g. online payments, "robo advising", digital platforms and individualised investment options) some tasks that are related to data collection, counter work, statistics, and accounting will be mostly automatable, whereas activities with a higher share of direct contact with customers are less exposed to automation (Deloitte 2016b, pp. 24–25). In any event, classical clerking work is said to be subject to a significant decline (Iten et al. 2016, pp. 60–61; Sachs/Meier/McSorley 2016, p. 11). Hence, observers say that future work in the sector will be "interesting, creative, rarely repetitious, but also very demanding" (Sachs 2016).

In view of the above, contact with customers and clients remains an important business field that is expected to gain in importance given that today's young people are becoming an important client base for banks. Yet, consultation work itself is also at the point of change, as new work tools and technologies emerge and diffuse within the sector. For example, digital assistance systems help consultants to provide tailor-made solutions to customers by having real-time access to information of possibly any criteria of relevance in the decision-making process. Furthermore, mobile devices also increasingly allow these systems to be used for on-site consultation. But even in a standardised consultation setting, which is highly structured, personal advice through interaction and communication remains an important domain of human action. As the Head of Private Banking at one of the major Swiss bank puts it: "Even technology adept customers demand a consultant made of flesh and blood" (Papp 2016). Nevertheless, consultants are expected to stay up to date with new technological developments and new work tools as well as to know how to use these devices in the working context.

In terms of the question of what skills are being demanded from the future workforce, two recent studies highlight the following (Iten et al. 2016, p. 61; Sachs et al. 2016, pp. 10–16): First, sound generalist knowledge that includes general education, mathematics, and a general understanding of the disruptive nature of digitalisation paired with banking exper-

7 However, not all jobs are expected to be exposed to offshoring and substitution due to digitalisation. Like in any other industry there are tasks that are more and some that are less susceptible to automation (Iten et al. 2016, p. 46).

tise. However, "knowing all the facts" loses its significance in the face of the ubiquitous access to relevant information. Second, communicative and interactive skills. These are needed to communicate and exchange information internally as well as to the customer. Third, know how (and where) to find the relevant information and know how to use digital working devices, tools, and platforms for work organisation. This also involves problem-solving skills and "networked" thinking. Finally, entrepreneurial skills such as creativity and a sense for change in general – as expectedly the digital transformation is not over yet. Against this backdrop, a high degree of flexibility and adaptability, the ability to learn, and "convertible expertise" are regarded as being highly relevant in the future.

5. Case study: Work tools and learning in the banking sector

Providing the future workforce with those aforementioned skills is a common concern among the key stakeholders in the banking industry. Since probably up to a third and more of the present industry's core workforce has completed an industry-specific three-year apprenticeship programme prior to employment, the development of appropriate training strategies in order to keep pace with present and forthcoming developments proves a challenge for the industry. It is within this framework that, in 2012, tablet computers were introduced in initial VET in order to support the learning of these new skills, with the prospect that these tools might also act as future work tools. This case study discusses the role of these new work tools in view of the changing requirements in the skills of the bankers in the field of consultation and in what way these tools possibly increase the learner's flexibility and employability by providing learning opportunities.

The banking apprenticeship in Switzerland is located at secondary level 2 in the Swiss VET system. During the three years of apprenticeship, apprentices regularly visit the workplace (2–3 days a week) and vocational school (1–2 days a week). In addition, they attend so-called intercompany or cross-company courses, which constitute a "third" learning site next to the workplace and vocational school.[8] It is there that the tablets were introduced as a joint approach by the training companies in the sector. Since 2012, a tablet computer has been given to each apprentice for use as their personal primary learning instrument and as a possible future work tool. The tablets allow apprentices to access all learning materials locally independent from a cloud-based content management system that has been made accessible through an app specifically designed for that purpose. Additionally, the use of a variety of third-party apps for learning organisation, task management, and note-capturing have made the tablet a versatile instrument for various learning applications, including ad hoc web searches, creating individual knowledge maps, accessing the catalogue of learning objectives, and for the documentation of the learning process. Due to security and priva-

8 These courses are a special characteristic of the Swiss VET system. They are mandatory for every occupation and thus are a regular part of any VET programme in around 230 regulated professions. The aim is to train additional basic and domain-specific skills. A similar concept also exists in the German VET system.

cy issues, a direct connection between the tablet and the banks' internal systems could not be institutionalised. However, apprentices are encouraged to use the tablets outside of the courses too (e.g. in the workplace, at vocational school, and also at home).

5.1 Method

The sample of this study consists of nine course trainers that were interviewed during a three-year externally funded project (2013–2016) on the training-related use of the tablets as a tool for learning and as a prospective future work tool.[9] The interviews took place during the second year of the project in summer 2015 and were between 45 minutes and 90 minutes long. They were semi-structured along a guideline that focused on several topics, including teaching and learning, the role of the tablet in the apprenticeship, and the training aims that are pursued. From a methodological point of view, the course trainers' expertise can be considered as particularly insightful. Being in the role of "ultimate implementers" (Edward et al. 2007, p. 158), the course trainers hold specific knowledge about social and organisational processes, structures, and events within their professional context (Littig 2011, p. 7). However, experts are not mere "information providers" as they are situated within a specific professional and organisational context (Littig 2011, p. 6). The interviews were analysed using content analysis (Gläser/Laudel 2006; Mayring 2000). The content of the interview was categorised and structured along central themes using the MAXQDA software. For this case study, the analysis focuses on three superordinate topics: (1) the skills of bankers that will become important in the future, (2) the role of the tablet as a new work tool, (3) and the role of learning. It is important to note that the interview quotes presented below were translated from Swiss German into English for better understandability.

5.2 Results

According to the Swiss Bankers Association, the main aim of the intercompany courses is to deliver domain-specific know-how and insights into banking. The official catalogue of learning objectives of these courses, which is published by the Swiss Conference of Commercial Training and Examination Branches, does not, however, mention what competencies are to be trained using a tablet (SKKAB, 2011). Therefore, the course trainers were asked in the interviews about the potential benefit of using a tablet for learning and how this relates to fulfilling the training goals.

In line with the research questions, the findings are presented around three topics: (1) the changing conditions in the world of banking as a framework for the demand of new skills for workers in the sector, (2) the role of the tablet as a new work tool, and (3) the role of learning (i.e. learning as a skill itself).

9 See Kessler 2016, pp. 128–130 for a description of the project.

Changing conditions in the world of banking

First of all, digitalisation was seen as a major driver of the changing conditions for future work and business in the industry. It is expected that systems will get more complex, globally connected and shorter in lifetime, and that banks will have to adapt to new technological developments in order to stay competitive. As one of the course trainers puts it:

> *These [developments] probably can't be stopped anymore. Now you can choose: Do you want to get aboard and go along with these [developments] or do you want to just wait and see … and eventually be overtaken?* (34m, 42)

Daily work is expected to become highly information-oriented and less repetitious, requiring the future worker's problem-solving capacities, flexibility, and know-how to deal with new situations – be that in the back office in order to "bring the systems forward" or in the front office when dealing with customers and selling products. The future career prospects are regarded critically in comparison to earlier days in the sector against the backdrop of digitalisation:

> *Maybe let's put it that way: A bank apprenticeship has always been regarded as a good apprenticeship in a certain way, although this might have diminished a bit. […] Today, the career prospects for bankers are just not the same as they used to be. And then the question [emerges] of what to teach. And so you teach other things. Nowadays, a bank employs way more people than 10 years ago … well, maybe "way" is a little exaggerated … and has grown to a much bigger apparatus in the background, whose intent is to bring the systems forward through innovation and digitalisation. Because more and more is done by the systems rather than by humans. And this, I think, is also a reason why that [i.e. the tablets] came up in the banking sector.* (35w, 78)

The notion of digitalisation and its impact on the world of banking was a characteristic topic in the interviews with the course trainers. Digitalisation is seen as the inevitable new economic and social reality that banks, and bankers, have to cope with. The "bigger apparatus in the background" (see the above quote) that is needed to develop new future business strategies and that might have actually created many jobs in the last few years could ultimately turn out to be the cause of a wave of job losses in the field of clerking work, as recent studies highlight (see section 3 above). In relation thereto appeared the question of how these developments could be actively shaped rather than eventually being confronted with a fait accompli. In this view, graduates that are aware of the present dynamics in the sector were regarded as having a distinct edge over older workers in the sector.

The role of the tablet as a new work tool

Beyond a mere theoretical understanding of the new world of work, more practical skills regarding the use of new work tools were also highlighted by the course trainers. They frequently stated that banks are already exploring the possibilities of a tablet as a consulting tool in daily consultancy work. It is there, in the front office, that the course trainers also see the main application area of such mobile work tools. "The consultants visit customers' homes more often again, and for that purpose they need mobile devices" (30w, 53). Therefore, the apprentices are to learn how to use a tablet as a prospective future work tool – because "[…] media literacy is written in big letters; it really has become a factor" (18m, 80). For example, having a tablet at hand in a customer meeting could mean showing the customer where to find the relevant information on the Internet. Being able to stay informed, to organise and to evaluate information are seen as critical skills for a future banker. In the words of one course trainer: "There is no way back if you want to stay employable in the sector" (30w 53).

Indeed, some banks already use tablets for this purpose. Others are still reluctant, but feel the pressure to catch up. For example, one of the five major banks set its priorities to digitalisation more in back and middle office tasks in the last years (Hody 2016). It was only in 2016 that tablets were piloted as consulting tools. As the Head of Private Banking quoted in the above states: "Making consultation an experience is only possible if you have work tools that work flawlessly and well-trained consultants. Otherwise, the potential of the tablets is not going to be fully exploited" (Papp 2016). Yet, there are still reservations about these new work tools with regard to undesired side effects in the field of human interaction. "[The tablet] is supposed to be an aid for the discussion with a client and should not lead to a situation where client and adviser have their eyes on the tablet only and stop communicating with each other." (Papp 2017, p. 2).

Finally, a need for workers to adapt to new, suddenly changing circumstances – either task- or job-related – is seen as a natural consequence of the current trends in the sector. Several imperatives arise from this perspective, which could be read as follows: be innovative, think fast, think outside the box, adapt quickly to different situations, be open for all things new. Getting accustomed to using a tablet as a tool for learning (e.g. through working with certain applications, capturing thoughts and ideas, and organising the learning materials and solutions to exercises) was, therefore, thought to help apprentices to gain a specific feeling of how future work will be organised in the fast-paced, new world of work.

> *I mean, from my viewpoint, the recipe is "learning by doing" … that every apprentice had to use it [i.e. the tablet]. […] Definitely, there are the very engaged apprentices that get easily inspired and can quickly adapt. After two months of use, they really have no problems anymore and understand how this thing works. And then you've got the ones that even in the second year of the apprenticeship still have problems. I think this may be also a question of attitude, you know. On the one hand, I think, okay, it's the tablet. However, I think it is also openness towards the new. And that is for me … I often tell them, it is a precondition to be*

> *open, to give a chance to discover something new in order to meet the challenges in our working environment. And I think that sometimes apprentices totally reject that.* (40m, 45)

Whether more or less engaged, apprentices are expected to adapt to using a tablet as a tool for learning over the course of the apprenticeship. However, not all apprentices were willing to do so. Not only initial attitudes towards technology use for learning, but also other factors led to this situation: there was mention of technical problems, partly due to the new IT infrastructure and the technical scope of the devices, and partly due to some issues with the digital learning environment in the beginning. Furthermore, there were also obstacles in the workplace. For example, banks still have to rely on paperwork for legal reasons to a certain extent. Furthermore, some banks are rather restrictive in regard to the use of private devices at work due to internal security policies. The tablets that were given to apprentices were in this case seen as private devices coming from outside the internal bank systems. While not much can be said about the current level of dissemination within today's banks, these restrictions make it hard for some of the apprentices to try out the tablet as a work tool in a real work setting.

Skills requirements and learning

As regards the third topic of interest, the new training objectives relate directly to distinct sets of skills that could be identified in the analysis and that are gaining priority in terms of training. These can be summed up as follows: while the delivery of specialised banking knowledge is still regarded as the number one training objective, a first set of skills relates directly to the working context such as the handling of digital data and information, communicating with customers, doing consultation work, on-site presentations, and so on. In this context, a tablet would come in handy as a tool to support these activities. As indicated above, some banks already use tablets as a consulting tool that might eventually replace the consultant's briefcase.

> *I am convinced that tablets are going to replace the good old briefcase. For sure, I think this is going to be the main field of application of such mobile devices. Say: the consultant won't come with this huge leather case anymore where he has all this brochures, leaflets and other stuff. No. That's going to be a small, handy thing. Where you may also be able to show some things in animations to the customer. I think that this is going to be the main field of application.* (34m, 50)

A second set of skills aims at a deeper understanding of media and the value and quality of information. That could, for example, be knowing stock prices as well as showing customers how and where to find information and what the trustworthy sources are. Finally, a third set aims at self-organisation, learning to learn, as well as having a repertoire of methods at hand for dealing with constant change and adapting to new situations. The tablet will, thus, provide new opportunities for learning both in training and later in the workplace. Whereas

the first and second set of skills represent more the "close to future work" practical and methodical skills, this third set is being regarded as important in terms of gaining the flexibility that is being demanded by future employees in the sector. A future worker is expected to be a learner that is constantly rising to the challenges of the contemporary world of work. Therefore, he would need the respective skills for and attitudes towards the self-management of his learning and career paths as well as the flexibility to look beyond the horizon and not only see just "the one best way" (35w; 74). To know how to use a digital device purposefully as a tool for learning and for working would thus not only help the sector to move the digitalisation project ahead but also to widen the horizon of future bank employees.

The above views on tablets as a tool for learning and prospective future work tool have demonstrated the opportunities but also some of the peculiarities of the new digital workplace as a site for learning. The advent of mobile handheld devices has opened new fields of application, as shown above in the case of tablets being used for consultancy work. For those working with these devices, this would offer opportunities to expand their professional competencies in domains such as new media, information technology, and interaction with customers. In providing an interface between the working context and the sphere of learning, the new work tools could support the development of new practical skills and could help shape an understanding of the growing relevance of data and information in the working context. At the same time, the dissemination of new digital work tools creates its own dynamics within the sector and forms a narrative of how future work will be organised – either being transformed or being replaced by digital technology. Within this narrative, firms, individuals, and the VET learning sites might orientate their actions and norms towards different referential contexts and thus differ regarding at what stage tablets as new work tools initially become relevant to their view. For those apprentices, for instance, whose contract training company would have no plans to digitalise its consultation business in the near future, the use of tablets in intercompany courses might not appear obvious from the beginning. The interplay and the coordination between the different learning sites, then, gains special attention in providing the kinds of learning opportunities described above. However, because training activities likely vary according to the corporate context, the balancing of intercompany training aims and firm-specific interests becomes a delicate issue, which is in fact a well-known issue within the Swiss VET context and is not unique to the banking sector.

6. Conclusions: Digitalisation of work tools and learning

This contribution raised several critical questions regarding the changing nature of work tools and its impact on qualified work in a time of fast-paced technological progress, commonly termed the "digitalisation of the world of work". How does the requirement of occupational skills change against the backdrop of digitalisation? In what way does the demand for new skills relate to the introduction of new work tools? And in what way do the new

work tools facilitate the formation of these skills (i.e. through the provision of opportunities for learning)?

As seen in the case study above, the Swiss banking sector is facing major changes both in work organisation and in the allocation of work tasks to machines – thus also changing the relevance of work tools. Information is being regarded as a key commodity in the global race for new business models to stay competitive and to attract new customers. Whereas the automation processes in companies and organisations are somewhat of a black box, because technological change affects the workplace only gradually and in an almost imperceptible manner (Baethge/Oberbeck 1986, p. 33), there are also areas where this change manifests in the outer appearance of work and so becomes visible to the eye of the researcher. The new work tools, as referred to in the above case study, are sought to overcome the image of the traditional bank consultant, signalling an industry in transition and the demand for a dynamic and highly flexible modern workforce. The role of the new tools (as shown for the context of consultation) is twofold: they are not only to allow the consultant to quickly access corporate data and information that is needed in the consultation process on-site but also, in turn, to help shape his skills to adapt to an increasingly information-rich and fast-moving working environment. The new tools, then, are not seen to make the consultant himself obsolete anytime soon but rather to change his role in that they detach tasks such as data processing and output preparation from his range of activities and leave him more flexibility in selecting, customising, and communicating information to the customer. Whether and in what way this makes work more demanding and/or more particular is open to further research.

Closely related to this is the question of how the actual demands for new skills translate into relevant learning processes and how the (new) work tools can provide a framework for this kind of learning. While the digitalisation of work tools certainly is closely linked to new occupational prerequisites in the digital age, the role of learning is somewhat dwarfed in the present discussion. Work tools have always been the "new companions" of human work at any point in history. Also, there have always been predecessors in the past, as there will be descendants in the future – tools that support and enable humans to perform work tasks and activities. With that in mind, and aiming beyond such metaphors of the history and the future of technological progression, it is worth focusing on the change in work tools and its conditions, as this can help to understand how work itself is changing, what skills are high in demand, and what that means for human interaction with – or with the aid of – technology in the future. The new work tools unfold their impact on learning in two ways: in that they demand constant adaption and thus make learning a prerequisite; and in that they potentially provide learning opportunities that become institutionalised as part of the working context. The study of work tools and the institutional contexts in which they are deployed can, thus, help to consider the opportunities and constraints for initial and further learning in present and future workplaces. This, in sum, makes the study of work tools a promising approach for further research.

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Digitalization Fosters Continuous Reinvention of IT Systems and Work Processes in Network of Organizations

Abstract

Digitalization and advanced information technology (IT) offer new, innovative possibilities for organizing work in networks. Computer-based technology lays the ground for new kinds of services and products and boosts the effectiveness of production processes. However, if we are to gain anything from the potential innovativeness of digitalization, we need a more practical understanding of and methods for implementing new systems and a reinvention of the use of the old systems.

The aim of this article is to introduce a framework for analysis through which we can more practically understand the continuous, interdependent development of work, processes and IT systems as tools. By analysing the developmental processes of IT tools in case networks – here the accounting and wood procurement sectors – we demonstrate the use of the framework and show how the development of everyday work practices and IT systems is and should be tightly interconnected.

Our framework explores digital change at three levels. First, it presents the changes in work and its organizing using an activity system model, focusing on the tools, object and outcome of work, community, rules, and division of labour. We describe the changes, via two job descriptions, that digitalization has caused and is expected to cause in these case networks. Second, using the expansive development cycle model, we analyse the change in service production in a network of small and medium-sized (SME) accounting enterprises, their customers and their accounting system supplier. The example shows how several minor novel solutions generate a new digital service concept. The third level and model concerns the continuous, interdependent development processes of work and IT systems in everyday work. We analyse the developmental practices of integrated IT systems using the framework of IT reinvention. Through reinvention, the use of the system changes to pursue new goals. We present two examples of such developments.

Finally, we evaluate how the framework provided a basis for the analysis of continuous and interdependent development of work processes, IT systems and their use. A more profound understanding of the systemic connections will provide a basis on which to create practical guidelines for IT implementation and to promote IT reinvention. We also discuss how the framework helps us grasp how occupational safety and well-being at work are connected to the continuous digitalization of work.

1. Introduction

Digitalization and advanced IT offer new, innovative ways in which to organize work in networks. However, technological development is often a long way ahead of the structural, organizational and other social innovations needed to make use of novel technologies (Miettinen et al. 2008; Alasoini 2003; Perez 2002). The principles of mass production have long prevailed in the management, structures and division of labour of organizations (Hamel et al., 2007). This may lead to difficulties and deficiencies in using new digitalized devices, systems, platforms and other instruments as tools in service and production processes. Thus, organizations need a new operational model, or logic, for their production and services to fully exploit the possibilities of digitalization (e.g. Haapakorpi/Alasoini 2018).

At the core of digitalization we find continuously renewing IT systems. In this article, we focus on integrated IT systems, such as enterprise resource planning (ERP) systems, which managers, employees and other actors (e.g. suppliers) use as shared work tools for planning, controlling and managing processes and work. Digitalization means that, along with the electrification of operations, also tasks, processes and organizations are reformulated as past practices, conventions and structures are rejected and new ones developed. System integration causes either purposely developed or unobservedly emerging changes towards a wider integration of tasks, processes and organizations, with interplay in networks. Potential safety risks may also arise within changed working methods. It is thus vital to investigate the consequences of introducing and reinventing IT tools for work, as well as the premises they offer for further developing the work and operational logic of organizations and networks.

Data systems that integrate knowledge from organizations' separate systems, i.e. ERP systems, are the heart of networks' knowledge-based work (Klaus/Rosemann/Gable 2000). Furthermore, as in our case networks, data are also gathered from other stakeholders and open source systems through automatic procedures. For enterprises that compete in global markets and for public organizations that struggle with the fluency and efficiency of their production, such systems are essential strategic equipment (Sakas/Vlachos/Nasiopoulos 2014). Thus, a great deal of effort is currently being invested in the development and implementation of such integrating solutions and systems.

The purpose of implementing new integrating systems in organizations is the renewal of business concepts and production or service logics, which in turn requires changes to processes, work practices and tasks. In addition, the transition from the conventional management logic of knowledge and materials (Botta-Genoulaz/Millet 2006; Falk 2005; Menor/Tatikonda/Sampson 2002) to the promotion of the evolution of services focuses on the continuous development of a system's usage in addition to service development (Huang/Hsu/Chiau 2011; McAdam/Galloway 2005). Therefore, adopting an integrating system is not a one-off implementation, but rather a continuous, long-lasting process with concurrent development of the system, its usage, work processes and tasks.

According to research, such technological renewal seldom proceeds or succeeds as planned (Toivanen 2006; Huang et al. 2004; Griffith/Zammuto/Aiman-Smith 1999). Organizations' continuous developmental actions concerning systems and their use in the post-implementation phase have not been sufficient or effective. For example, the experiences of a system's usefulness for business intelligence has not increased after the implementation phase (Antoniadis/Tsiakiris/Tsopogloy 2015). It seems that the system's advantages are not realized and its novel characteristics are not perceived or applied.

Previous research has described the introduction and use of systems via different kinds of models, such as implementation, acceptance, adaptation, adoption and diffusion models (Nevo/Nevo/Pinsonneault 2016; Rice/Leonardi 2013; Straub 2009; Venkatesh/Bala 2008). However, many of these have limitations: some do not, for example, take into account the systemic features of the introduction process regarding the flow of time and constant change of the work processes. Therefore, those models have failed to advance the innovative post-adoption use of these systems (Nevo/Nevo/Pinsonneault 2016; Korpelainen 2012).

In this research, through introducing an analytical framework, we aim to gain some insight into how to successfully adopt the integrating systems and support their post-adoption use. The main question is: How can we better understand the continuous and interdependent development of work, processes and IT systems? First, we present and evaluate the changes that work processes and organizational structures undergo when a new ERP system is implemented in a network of organizations. The changes in work and its organization are analysed using activity system and expansive development cycle models, and the concept of service and production logic, all derived from the methodology of Developmental Work Research (DWR) (Virkkunen/Newnham 2013; Engeström 2000, 1987). The activity system model highlights the relationships between the different elements of dynamically changing work. At the same time, the organizations strive for new operational models as a strategic step in developing the use of digital tools – thus, the emerging new production/service logic forms the larger context for change in these organizations.

We then analyse the process by which new tools are adopted and the use of the old tools is adapted along with developing work practices. The developmental practices are analysed via the framework of reinvention (Nevo/Nevo/Pinsonneault 2016). During reinvention, the use of the system changes to pursue new goals. We focus on the continuous and interdependent development of the work and the IT systems in the post-adoption phase.

In this article, we present case examples from two different sectors, namely forestry and accounting. We chose these two sectors due to their current phase of digitalization. In both cases, new services and business logics are developing, and the use of integrating systems is enabling networking and breaking down the borders of organizations.

Next, we describe the integrating IT systems as tools. After this, we define the data used in this article and introduce the theoretical framework and the concept of reinvention. Then we analyse the changes resulting from the use of the integrating systems in the case organizations. This is followed by an analysis of the post-adoption use of systems and developmen-

tal actions in accounting and wood procurement processes. In the concluding section we discuss the analytical framework that comprises the models of the activity system, the expansive development cycle and reinvention, and evaluate the benefits of such a framework. Our aim is to find out how to better exploit the potential of new technology in networks.

2. Integrating IT system as a work tool

In this article, the integrating IT system is understood as a tool that records, mediates and processes knowledge. It may be a set of different IT systems that managers, employees and other actors (e.g. suppliers) use to plan, control and manage processes and work, and which transmits knowledge from separate locations or systems to its users (Falk 2005; Klaus/Rosemann/Gable 2000). These kinds of knowledge-gathering and reporting systems are used to manage enterprises' resources and production (Powell/Strandhagen 2011; Kumar/Hillegersberg 2000) to increase an organization's efficiency, both economically and functionally. Logistical principles and IT tools are aggressively employed also in the service production, in both the public and private sectors (Botta-Genoulaz/Millet 2006; Menor/Tatikonda/Sampson 2002).

In this study, we hypothesize that a new system will affect work in many ways. Following the ideas of the activity system model (Engeström 1987), an ERP system is a continuously changing tool that introduces new kind of tasks and modifies the way in which old tasks are carried out; it enables a new kind of division of labour and requires new kinds of skills and knowledge. The knowledge in the ERP system is shared among different organizations and that enlarges the community, changing work towards integrated and networked processes. It may affect the roles, rules and instructions of the community, for instance, through different kinds of user roles in the ERP system. It forms a new kind of integrated databank and may thus offer possibilities for new kinds of information-intensive services and outcomes. Thus, an entire renewed work activity with new features of object may emerge.

3. Data and methods

We gathered our data from two case networks: accounting and wood procurement. In the accounting field, the centre was the IT supplier and the close members were accounting enterprises. The network was based on shared interests in digitalizing the accounting processes. The wood procurement network comprised a large forest company and small and medium-sized forest machinery and transport enterprises, all aiming for efficient wood procurement processes. The forest company bought in the cutting and transportation phases of the procurement process as services from the enterprises.

In both networks, we interviewed managers, employees in various positions, entrepreneurs, system suppliers and customers. In the accounting network we interviewed four accountants; three managers, two of which were entrepreneurs; and three of the accounting

enterprise's customers. On the IT system supplier's side we interviewed two concept managers, a service co-ordinator and a product owner. More data were gathered via observations of developmental events and service situations arranged for the accounting enterprises by the system supplier. The total number of interviewed people in the accounting network was 14.

In the wood procurement process, we interviewed ten forest specialists from the forest company working in purchasing, production planning and control, and transport planning and control. We also interviewed four entrepreneurs, one foreman and four drivers working in cutting and near and far transportation, and three people (managers and change agents) working in system development, making the total number of people interviewed 22.
To elaborate the results of the interviews, the researchers organized a workshop for the interviewees and key managers in both networks. Though not all interviewees were able to participate due to their work duties, the accounting workshop had six and the wood procurement workshop 12 participants. These discussions also matured the data and interpretations.

In both cases, the interviews took place in the phase of continuous development of IT systems and work practices. In the accounting case, the jointly used IT system was in the post-adoption phase, during which minor features were developed on the basis of feedback from the users. In addition to this, the system supplier and the accounting firm's representative modified the business model together. The interviewees took part in these development processes.

In the wood procurement case, the forest company's current ERP1 system was coming to the end of its life cycle. Preparation for the implementation of the new ERP2 and related new IT systems for machinery and transportation enterprises was underway. The transportation enterprises were somewhat familiar with the IT logistics system, as it was already partially in use. During the preparatory phase, the central focus was on the new operational model that ERP2 would both enable and require in the network.

The interviews were thematic and consisted of the following themes: background information; personal work, work tasks and processes; the use of IT, especially in networks; changes in work and IT use; work development and IT system implementation practices; well-being and safety at work; and future considerations concerning work and IT use. The observation session focused on the practices that potentially enhanced reinventive actions in IT systems.

The qualitative analysis was based on the content analysis method (Krippendorf 2013) in which the transcription texts of interviews are classified via principles that arise from the theory base of the research. Our theories are described below. The codes used were derived from the concepts of the theories, and tailored and operationalized according to the content of the data. The text segmentation in coding was based on the semantic meaning of the sentence or period of the text in which the units of analysis were components of the action system, development cycle and reinvention process.

Our analytical framework comprised three different models that were used to analyse the qualitative data gathered via interviews and observation. DWR methodology (Engeström

1987, 2000; Virkkunen/Newnham 2013) approaches work changes as a systemic, ongoing process and combines practice-level changes with larger organizational transformations. The DWR offers an activity system model to investigate work (Engeström 1987; see application in Figures 1 and 2). The model describes the basic structure and elements of work: the actors in the work (subject), the object they aim to affect and transfer into outcomes during the work process, the tools they use in this process, the others involved (community), how the tasks are divided (division of work), and the rules that guide and control the work.

The second model, also derived from the DWR, was the cycle of expansive transformation of an activity system (Engeström 1987; Virkkunen/Newham 2013). The disturbances and anomalies of everyday work, as well as the new demands of the operational environment and customers indicated contradictions within the activity system and with other activity systems. Questioning the current operating model, and creating novel solutions to the contradictions through experimenting, furthered the transformation towards a new operating model. The model was used to change analysis of service production in the network of SME accounting firms, their customers and their accounting system supplier. The case showed how several minor solutions and attempts proceeded, through testing, to generate a new digital service concept (see Figure 3).

Third, we analysed the continuous, interdependent development process of work and IT system via the model of IT reinvention. The model, i.e. reinvention as a temporally situated self-agency theory, provided the foundations for understanding how users reformulate IT use as well as obtain new insights into developing it in the post-adoption phase (Nevo/Nevo/Pinsonneault 2016). It situated the actors in the flow of time, identified the key subprocesses of IT reinvention and explained how the present and the past influenced the adoption of IT. IT reinvention is future oriented; the user sets and attains new goals and envisions alternative uses for IT. It is self-determined and self-motivated action.

4. Changes in work caused by digitalization

In the following sections we present the results of the analysis using the three models and thus demonstrate their usefulness in depicting relations between new or reinvented IT tools and work changes.

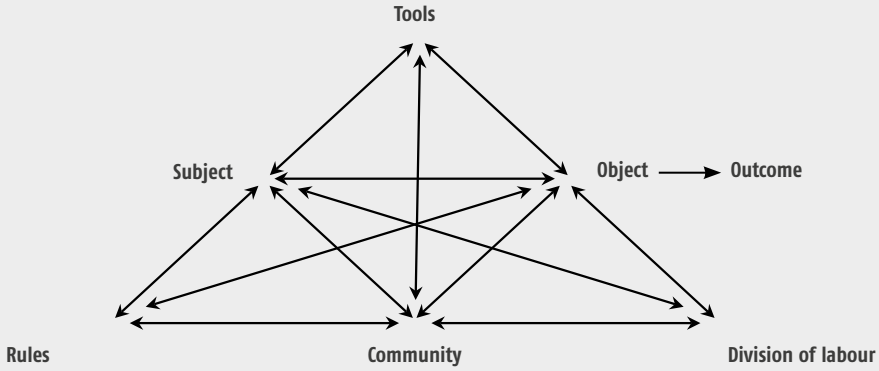
Next, we introduce the changes that occurred in accounting and wood procurement by way of focusing on the tasks of the accountant and forest operator. The descriptions are based on our analysis of the interview data. The changes in work are represented using the activity system model, which highlights the influence of IT as a primary driver of change.

Accounting case

Figure 1 depicts the past, present and future work of an accountant as an activity system. The tools and means used by accountants have changed from paper materials and separate IT systems to electronic data, data transfer and more integrated IT systems. An accountant's work tasks have also altered along with IT development. The automation of data recording has replaced manual work, and service portals have replaced face-to-face services. In the future it is expected that accountants and their customers will use even more integrated systems together. Mobile and online services will exchange data and advanced algorithms will make processes more automated. The tasks that automation will change are, for example, the recording of purchase and sale invoices, making personal legers, timing payment traffic, opening and closing accounting periods, and gathering financial statements. At the same time, tasks such as the revision of information in the integrated system, system guidance, monitoring finances, and consulting will be emphasized more. An accountant will become more of a consultant, and fluent accounting processes will become more integrated with developing business models.

In the past division of labour, a customer delivered accounting material and figures, a system supplier provided a separate accounting system, and an accountant recorded, posted and reported. Now the materials come across system interfaces and shared systems. A system supplier provides these shared systems and interfaces, which are then further developed in co-operation with accounting enterprises. Thus, accounting enterprises receive up-to-date financial data for business, and more automated statutory reports and notifications. In parallel, the co-operating community grows and the confidential one-to-one relationship between an accountant and their customer is replaced by a network of service producers and developers such as related business consultants and firms and system suppliers. The growing network and technology-mediated communication reformulate the basis of confidentiality from personal relationship to formal agreements and issues of information security.

Figure 1: Past, present and future work of an accountant, depicted using the activity system model



	Subject	Tool	Object	Community	Divison of labour	Rules		Outcome
Future Work	Consultant on accounting, economy, IT systems	Advanced ERP integration, online & mobile tools, process automation, algorithms and reports	Accounting and revision, business monitoring, economic consulting, system guidance	Network of service producers and developers: consultant, accountants, other business stakeholders, suppliers, authorities	Co-development in networks to gain up-to-date economics for business, automated statutory reports and notifications	Diminishing control	→	Integrated book-keeping with developing business concept
↑								
Present	Accountant, advisor	Electronic data transfer, IT systems integration, beginning automation, service portals	Accounting, tax return counselling, system guidance, revision	Reliable accounting firms, customers, authorities, system supplier	Materials come across system interfaces, shared systems, Accountant: process and system use, Supplier: shared systems and interfaces	Laws and regulations of accounting, taxation	→	Sound accounting procedure, notifications, fluent processes
↑								
Past	Accountant, recorder	Paper material, electronic data recording, separate IT systems, face-to-face service	Accounting: recording purchase and sale invoices, personal leger, payments traffic, seasons, financial statement, tax return	Confidential relation between customer and accountant, authorities	Customer delivers accounting material and figures, System supplier: provides a separate accounting system, Accountant: record, make posting and report	Laws and regulations of accounting, taxation	→	Statutory accounting and sound accounting procedure, authoritative notification

Source: own representation, based on Engeström 1987

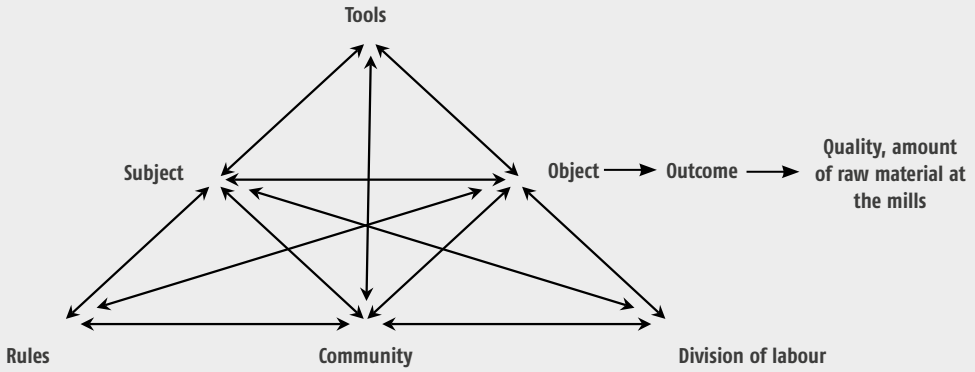
Wood procurement case

Production planning and control in the wood procurement process includes combining information about the stands marked for cutting, the raw material needs of the mills, locations and the contractors' capacity to make plans and instructions for cutting and logistical operations. Previously, the forest operator (subject), with the title of 'harvesting foreman', produced detailed harvesting instructions for contractors, harvesters and forwarder drivers (outcome), using different kinds of data systems, notes and their own Excel and calculation sheets as tools (Figure 2). Practical supervision often included face-to-face interaction or phone calls with contractors or individual drivers (community).

Today, the forest operator produces short-term (two- to three-day) pre-plans and sets targets for quality and the amount of timber for harvesting enterprises. The enterprises then internally fine-tune the plans for specific harvesters (changed division of work). The planning tools comprise shared data systems (ERP 1), with more detailed, online and continuously updated data, although personalized Excel and calculation sheets are also still used. The main interaction with different actors in the process is via mobile and online information systems. Any occasional direct contacts are predominantly between the forest operators and the entrepreneurs, who then further inform their drivers.

The next technical development step in the planning of the wood procurement process is the implementation of the ERP 2 system (new tool). ERP 2 uses algorithms and data in the more integrated IT systems to produce automated plans, instructions and reports. This integration emphasizes the responsibility of each actor to ensure the correctness of the raw data and information in the systems, to be used for the co-ordination of the entire procurement process. These developments will further change the role, tasks and outcomes of forest operators: their tasks will include monitoring the systems and problem-solving in cases of disturbance or anomaly, and will presumably extend the planning period to a couple of weeks as well as enlarge the scope of instructions into areal plans. This will then leave more decision opportunities for the entrepreneurs to plan their harvesting processes and optimize their own businesses.

Figure 2: Past, present and future work of forest operator, depicted using the activity system model



	Subject	Tool	Object	Community	Divison of labour	Rules (concerning organizing & management)		Outcome
Future Work	New title & role: Forest specialist	ERP 2, online & mobile tools, automated algorithms and reports	Open data-banks; digital-ized, integrated, automated data & procedures; online, up-to-date	Core-Entre-preneurs & network	Forest Special-ist: mid-term planning, monitoring, problem solving Entrepreneurs: short term planning; All: produce & ensure correct data	Network, partners ('co-operate')	→	Areal mid-term plans and instructions; resolved problems
↑								
Present	Forest operator	ERP 1, IT systems; excels; online & mobile tools	Data in shared systems; digital-ized, online, up-to-date data	Entrepreneurs	Forest operator: short term planning Entrepreneurs: fine tune plans, instruc-tions	Supervision & collaboration ('negotiate')	→	Short-term pre-plans and instructions for quality, amount, destinations
↑								
Past	Harvesting foreman	Excels, notes, face-to-face instructions	Data in dif-ferent forms and sources; forest data; need of mills; contractors and resources	Contractors, in-dividual drivers (harvesters, forwarders)	Harvesting foreman: planning; supervision and preparing instructions Contractors, drivers: harvesting, transporting	Hierarchical supervision ('give orders')	→	Detailed instructions, Supervision

Source: own representation, based on Engeström 1987

Remarks

As the descriptions above show, digitalization has caused several similar changes in both the wood procurement and accounting sectors. Systems, processes and actions are more integrated, and working in networks has increased. Along with the automatization of processes, work tasks have changed as IT systems now perform routine tasks. The roles and responsibilities of clerical workers and employees have expanded because planning and control tasks have shifted down in the hierarchy (Ala-Laurinaho et al. 2009). Changes in job descriptions have raised new requirements in terms of know-how and increased the number of expert tasks. The organizational borders and division of labour are blurred because the tasks and actions of system suppliers, service producers and customers have become more tightly interwoven. Self-management skills are increasingly important as tasks are co-ordinated by integrated IT systems in the network. Perhaps the most essential challenge is the continuous changes caused by renewing IT systems and applications. These changes are part of everyday work.

These changes also challenge well-being at work. Some employees feel that they lose part of their previously meaningful core tasks, and some of the new tasks feel uninteresting or fragmented, or seem to reduce their leeway in decision-making concerning timing and organizing their work. Yet some of the tasks require completely new skills and competencies. While some experience fear and uncertainty in the face of these changes, others welcome new inspiring tasks and opportunities to develop in their work. Overall, employees need to rethink the meaning of their work and build a new personal relationship with their changing tasks (Mäkitalo 1995; Bean/Eisenberg 2006).

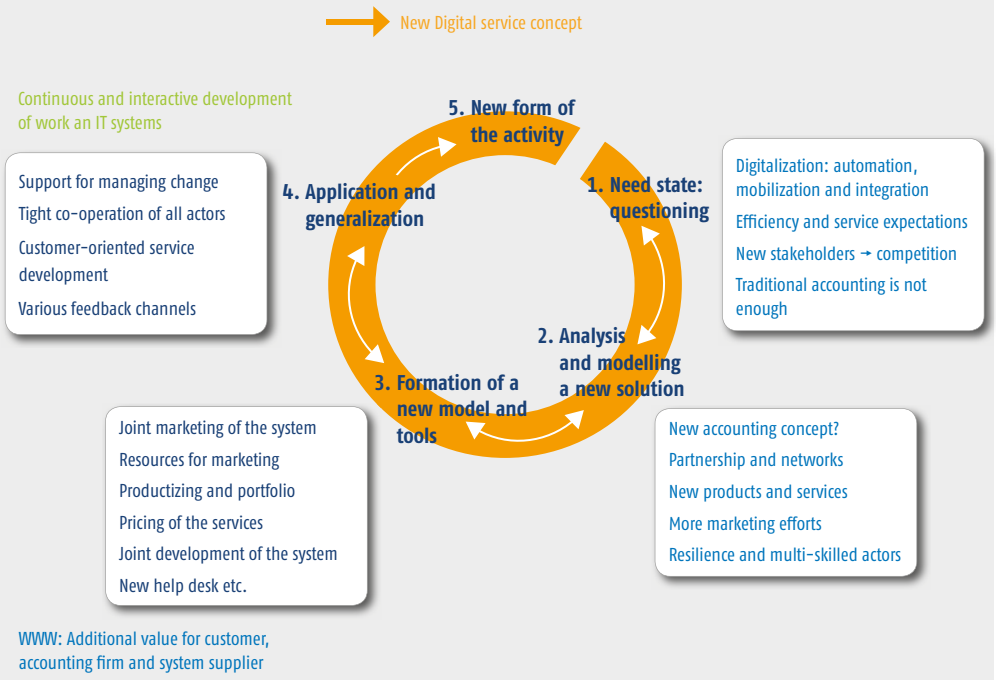
While tools, systems and practices change, these changes also influence occupational safety. Unless they are well-planned and organized, changes may cause confusion among employees and diminish the fluency of their work. This increases time pressure if tasks are unclear, and the management of work suffers. In addition to reduced well-being at work, time pressure may also result in occupational accidents (Salminen et al. 2017). Risk assessment after changes in work is essential in order to prevent excessive workload. However, changes often also have the positive effect of diminishing workload, and these characteristics should be further supported.

5. The development of a new service concept

As the previous analysis and description show, IT systems change work, tasks and processes and provide a central tool for implementing networked operational logic in service and production processes. Next, using the expansive development cycle (Engeström 1987; Virkkunen/Newham 2013) we explain the phases of transformation and illustrate how the development of a new service and business logic has emerged in the accounting case.

The expansive development cycle of the case accounting enterprises began when they were faced with rapid changes in the operational environment, i.e. when automation, mobilization and integration led to the need for efficiency, competition and acknowledgement of customer's expectations. The old way of serving was no longer applicable (Figure 3).

Figure 3: Expansive development cycle of the case accounting enterprises and network



Source: own representation, based on Engeström 1987

This transformation builds on a collaborative, participative process of analysis of the situation. New operational logic should enhance the role of all parties as actors in development and service and promote taking small steps of practical improvement, as well as more radical leaps in the context of entire organizational and network changes. Resilient and multi-skilled actors and structures are also needed in this service concept. Marketing also requires more effort.

The formation of a new service concept requires many practical experiments and evaluations of the results by system suppliers in collaboration with the accounting enterprises and their customers. In this example, the system supplier involved the accounting enterprises in the marketing process of the accounting system. The supplier also produced marketing material and delivered this and other resources to the accounting enterprises, aiming to help them with their marketing. A help desk was included in the service. The accounting enterprises focused on their portfolio and the use of the system by productizing their services. This caused changes in pricing and the principles of invoicing. Thus, the resulting new service and business concept was based on a partnership of different IT and accounting service suppliers and on the exchange of products and services.

The formulation of a new kind of service concept concerned the network of actors rather than focusing on developing only the accounting enterprise's own inner processes and practices. The new digital service concept's main idea concerning ongoing customer-oriented service development was to produce additional value for the accounting enterprises and their customers as well as for the system suppliers. An important shared task was thus to identify the targets of the system's development and the evaluation of the outcomes. The various feedback channels from accounting enterprises and their customers to the supplier made evaluation feasible. The main idea behind the development was that the end customer's experience of the accounting services was to be smooth. In our case example, the system supplier had taken a strong role in managing and promoting the change. In the next chapter, we focus on the continuous, interdependent development process of work practices and processes with IT systems.

6. Continuous, interdependent development through IT reinvention

The IT reinvention model is used to analyse the processes of developing a system, its use, and its interrelated work practices and processes, and to enhance well-being and safety at work. Nevo, Nevo and Pinsonneault (2016) distinguished between IT adaptation and IT reinvention as separate processes in IT adoption due to the importance of users' temporal orientation and in order to differentiate and classify post-adoption behaviours. Their model emphasizes IT adoption as future-oriented, self-determined and self-motivated action. It also contributes to practice by helping managers understand the process of IT adoption and provides better tools for enhancing the use of IT in organizations. The model expands the viewpoint of the success of IT adoption to the development process of the IT system and its use in the post-adoption phase. It situates actors in the flow of time and identifies the key processes of IT reinvention, explaining how the present and the past influence the adoption of IT.

IT adaptation has been widely investigated, and research has focused on new IT implementation and the success of this process. The adaptation of an activity system begins when a change alters the users' environmental and/or internal state so that it reduces the efficiency to achieve existing goals. After this, the users, by changing their own state and/or environment, improve the fit with the current context and efficiency to achieve the goal they have set (Beaudry/Pinsonneault 2005). For example, in the field of accounting, the implementation of a new accounting system can change the accountant's work practices of posting a sale receipt. However, it does not necessarily change the existing goal of posting or the ultimate process, i.e. accounting.

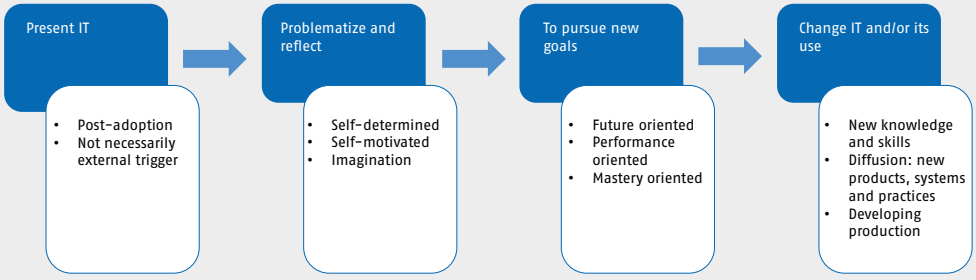
In IT adaptation, system implementation is seen as an external trigger and users as reactive actors who respond to it according to their past experiences. The trigger challenges existing structures, routines, habits and goals. Because users are considered reactive, they primarily adapt to IT to keep up their efficiency. Users try to attain their existing goals and

alter their routines as little as possible in order to succeed in their work. The primary target is to maintain ongoing production, fulfil present needs, and continue past practices.

IT reinvention

IT adaptation focuses on the outcome of the implementation process (e.g. Rice/Rogers 1980), whereas IT reinvention also takes into account the user's intention (Nevo et al. 2016). The main idea is to find new ways of applying IT to attain new goals (see Figure 4). The driver of the change is not IT or its implementation as an external trigger, but the user's own formulation of the imaginable future that informs the actions of users reinventing IT. Whereas IT adaptation is determined and shaped by users' present needs and past experiences, IT reinvention uses IT in a new way and aims towards new goals.

Figure 4: IT reinvention's definition



Source: own representation based on the description of Nevo et al. 2016

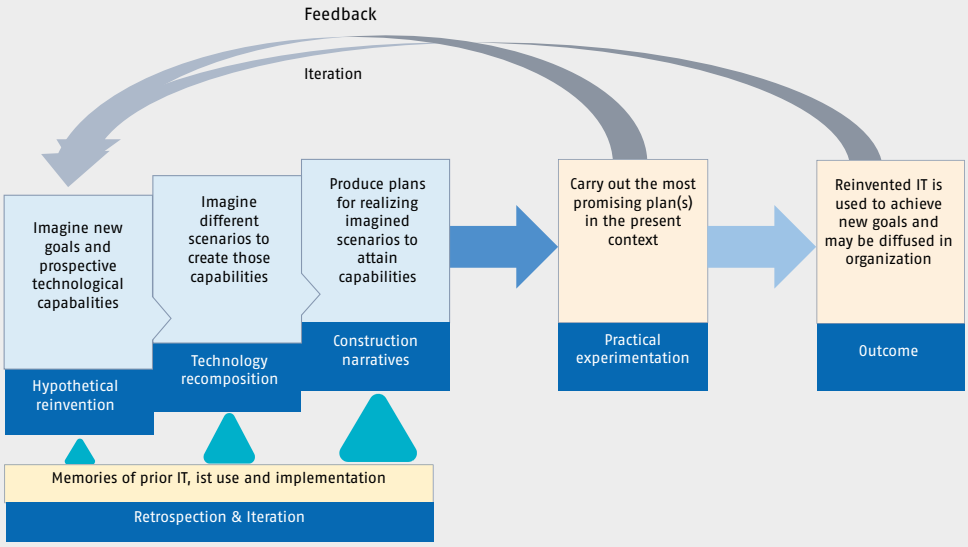
IT reinvention can focus on the change of use of IT or the change of the system itself. For example, a medical document management system is also used as a training and teaching tool (Goh/Gao/Agarwal 2011). Or, users envision changing the code of a system to produce a capability of digitized drawings that would also allow the production of a visually appealing newsletter (Leonardi 2011). These users were not reactive to the change in IT and its constrains or demands: they were oriented to the future and focused on renewing and reformulating the goals of IT (i.e. training tool/newsletter).

Future-oriented action is divided into two aspects: performance-oriented and mastery-oriented IT reinvention. The core of the performance aspect is to achieve better work results, whereas the mastery aspect involves better understanding and controlling of the tasks and thus searching for continuous development at work. The process of reinvention gives rise to new knowledge and skills. In an optimal situation, the reinvented IT will diffuse new practices in the organization and in production development, or will enable new products. Through the development and use of IT, new personal and shared technological capabilities can be achieved.

7. IT reinvention process in accounting and wood procurement processes

We analysed our interview and observational data via the IT reinvention process model to determine the developmental aspects of IT systems. The model enables us to understand the phases users develop in their work related to IT and, here, related to integrating IT systems. The IT reinvention process, in accordance with Nevo et al. (2016), in organizational, social and technological contexts, consists of phases such as ideation and imagination, planning, testing and dissemination (Figure 5).

Figure 5: Process of IT reinvention in organizational, social and technological contexts



Source: modified from model of Nevo et al. 2016

First, in the hypothetical reinvention phase, new goal and prospective technological capabilities are imagined. After this, in the technology recomposition phase, users envision different scenarios for attaining these capabilities, and in the phase of reinvention narratives they construct and create concrete plans for realizing these scenarios. The most promising plan is chosen and the proposed capabilities are tested in the present context in the practical experimentation phase. Finally, as the outcome, the reinvented IT and/or its use is applied to achieve new goals. The reinvented IT may be diffused throughout the organization.

The changes in work, IT systems and their use described in the previous sections were analysed using the IT reinvention process model (Table 1). Both the accountant and the forest operator presented self-determined and self-motivated developmental actions when developing work tasks and processes interrelated with IT systems – in doing so, reinventing the use or features of the IT system.

Accounting case

The accountant faced the challenge of wanting to work more fluently when taking care of clients' payment transactions based on client's financial liquidity. The IT system's reinvention began when the accountant imagined how it would ease work pressure if the system could somehow help in the timing of payment transactions. In this and the next phases, the client was also able to participate in contemplating the problem that they faced in the accounting service process and using the present accounting IT system. The phase of technology composition, and also partly the phase of reinvention narrative construction, took place in the developmental workshop arranged by the system supplier. Accounting entrepreneurs and the system supplier's product owner, sales co-ordinators and service co-ordinators took part in the workshop. Together they defined the proposed new technological capability more precisely and found answers to their questions: what information was needed, where the information could be obtained and how the process was to proceed. They imagined different scenarios to create these capabilities. The product owner presented some possible scenarios for solutions to develop the technological capabilities from the system development perspective.

Based on the interview data of the supplier's representatives, after prioritizing the required technological capabilities, the system's development process began, thus forming the narratives' construction phase. The new features that the system needed were agreed on, and the product owner and the development team constructed different narratives for attaining these features. The evolutionarily, economically and practically best solutions of the narratives were selected and the new features of the system were coded. Next followed several tests at the technological functionality level. In the practical experimental phase, pilot users in the accounting enterprises tested the updated system in their everyday practice. Iterations of the system solutions were made according to the feedback gathered from various channels. The system supplier released a new version of the updated system after piloting it with the other accountants in the network. As an outcome, thanks to the new version of the system, the accounting enterprises were able to develop their payment timing process and offer a new, efficient and more automated service to their customers. This meant better, timely services for customers with fluent, better controlled work processes.

Table 1: Examples of IT reinvention processes in the work of accountants and forest operators

Phase of IT reinvention/Target of development	Hypothetical reinvention	Technology recomposition	Reinvention narrative construction	Practical experiments	Outcome of technological capabilities
Modification of system's characteristics	Accountant – (client): 'It would be nice if the system helped in payment timing.'	Accounting enterprise –system supplier: ▶ What information is needed? ▶ Who will produce the information? ▶ Different ways to enter the information? ▶ How the information is stored and used?	System supplier – accounting enterprise: ▶ New features needed in the system ▶ Different ways to develop those features ▶ Coding those features ▶ Economic aspects	System supplier – accountant – client: Updating the system ▶ Spreading and wide use ▶ Gathering clients' and accountants' experiences ▶ Iteration	Altered system and process: ▶ New features in the system ▶ Client prioritizes ▶ Accountant support and finish the timing ▶ Better service for the client ▶ Fluent and efficient work ▶ Better control ▶ Attractive system
Change in use of system	Operator: 'How can I exploit IT systems to obtain an overall picture of my whole operating region?'	Operator: ▶ What should the overall picture be like? ▶ What information is needed to formulate it? ▶ How must the information be reported?	Operator: ▶ Where are the data received? ▶ How and in what form are the data transferred between systems? ▶ In what way are the data presented?	Operator: ▶ Iterative process to develop Excel macros ▶ Update and merge data from different systems ▶ Report and present information ▶ Update reports and presentations	New personalized integrating forest system: ▶ New overall picture ▶ Sharpening monthly figures and schemes for contractor, i.e. better service ▶ Better control over own work ▶ Share with co-workers

Source: own representation, based on the categories of Nevo et al. 2016

Wood procurement case

In the case of wood procurement, the forest operator imagined new features for technology capability by analysing what the overall picture of the operating region should be and what information was needed. In the present forest IT system, reports are presented for larger areas but not for single operating regions. It was essential to gather information from many different locations and to use self-assembled Excel sheets to formulate the overall picture when exploring the long-term situation. The operator combined information on the stands marked for cutting, the raw material needs of the mills, locations, the amount and quality of raw material, the status and quality of cutting, the distance of transportation, the conditions

of forest roads, and the contractors' capacity in order to make plans and instructions for cutting and logistical operations and to follow up and steer the contractors.

In this case, several operators made their own Excel sheets and layouts when integrating the data from different systems to form a personalized forest IT system. The data came mainly from the present forest IT system, but also from other planning systems and even via email and phone. The data were manually transferred between the systems, as was the recording of information from other sources. The development of a personalized system was an iterative process in which the forest operator tried out different ways to transfer, shape and present the data. Using Excel macros, the operator was able to automatize the integration of the data and presentation of the information. The main target, along with an overall picture of the operating region, was understandable information regarding the situation that could be disseminated to the contractors and their employees. This management process can be interpreted as a change in the use of systems and their information.

The personalized system solutions were discussed and shared with the other forest operators and thus spread throughout the organization. With a better understanding of the overall and timely situation in the operating region, it was possible to achieve a better service for all stakeholders. The quality of the operators' work also increased, and they experienced less workload and better control over their own work.

To conclude, although Nevo et al. (2016) emphasize self-determined and self-motivated action as a driving force for reinvention, in our case, the need for the change emerged in practical work situations when users came across an obstacle to carrying out their work tasks in a satisfactory way from both their own perspective and that of the organization. The solutions looked forward to find renewed answers to the questions of fluent, meaningful and efficient work practices by re-evaluating work processes, tasks and goals, and represented changes in knowledge use and practices in using the systems.

8. Discussion

In this article we introduced an analysis framework that enables a more practical understanding of the continuous, interdependent development of work, processes and IT systems as work tools. Our framework consists of three viewpoints: the activity system model, the expansive development cycle and the IT reinvention model. These describe changes in work practices, services and production logic, as well as the continuous developmental premises interrelated to IT. In order to foster the human aspects of digitalization, a multifaceted understanding of the adoption of IT work tools and new ways of working, as well as their interrelated development, is needed. By demonstrating the use of the framework in the fields of accounting and wood procurement, we showed how the development of everyday work practices and IT systems are and should be tightly interconnected, and that they are also dependent on the broader change of production logic.

Work change description

Digitalization offers new possibilities for organizing and developing work on both a personal level and within networks. It has already caused several changes, both intended and unintended, in the wood procurement and accounting sectors. Using the activity system model, we illustrated how the work of accountants and forest operators has changed and is continuously changing along with technological development. In both fields, the information needed at work has been digitalized, is now derived from shared systems, and is online, up to date and mobile. The integration of systems and processes has increased working in networks and, thanks to automation, employee's work tasks have changed on every organizational level. Some tasks, typically the routine ones, have disappeared and others have been replaced, i.e. shifted to other actors in the network. New requirements for expertise have arisen when employees' tasks have changed from routine to expert. In terms of an accountant's tasks, the share of revision, business monitoring, economic consulting and IT systems guidance has increased and is expected to gain even more importance in the future. In the forest operator's work, integrative tasks such as planning, monitoring and problem-solving will gain even more emphasis. The tasks are co-ordinated by integrated IT systems in the networks. Thus, the organizational borders, hierarchy and distribution of work may change or even dissolve when working in networks. The renewing of technology and work tasks is a part of everyday work and fosters continuous development, for which employees' self-management skills are ever more important.

Here, we concentrated on the changes in work tasks and processes, tools, co-operation, division of labour, and the object of work. However, the change model also helped us focus on the subjects' experiences of the impacts of digitalization. The thematic interviews showed that continuous change can be experienced as either positive or negative in terms of well-being and safety at work. Aspects that arose, depending on the situation, context and individual, were the meaningfulness of core tasks, being able to make decisions regarding the timing and organization of work, the acquiring of new skills and competencies, transparency, and automation. In some cases, the change caused confusion among employees and diminished the fluency of their work, but in others the situation was inspiring and included new possibilities and challenges. As we have seen, technology-mediated communication has set new standards for confidentiality from personal relationships to formal and transparent information in databases. During change, employees need to rethink the meaning of their work and build a new personal relationship with it. Thus, good change management and proper tools are needed to create a shared understanding of ongoing changes. In this way, excessive workload caused by changes can be avoided and a positive effect can be attained. In an optimal situation, IT technology provides possibilities for individual employees working in the network to improve their effectiveness and control their work flow.

Service and production concept change

Behind the pressure for continuous development there is a changing operational environment and emerging new business concepts, as described here among the SME accounting enterprises. Using the expansive development cycle model, we analysed how a new digital service concept arose from co-operation between the accounting enterprise, its customers and system supplier when facing the need to develop accounting processes due to progressive digitalization. In our example, many little experimentations and reformulations helped revise the accounting system, partnership, co-operation, distribution of work and responsibilities between stakeholders. It seems that the tasks and actions of the system suppliers, service producers and customers were interwoven more tightly and became an essential success factor in the new SME accounting concept. Thus, the accounting enterprise, its customer and system supplier all gained additional value. Furthermore, iterative development cycles occurred on different levels of the activity, i.e. concerning the person's use of IT system, the IT system's development and marketing processes, and service and business process reformulation. This required joint understanding of the goal, and accepted methods of the continuous, interdependent development of work, processes and IT systems. Customer-oriented thinking is at the core of joint development.

The change in service and business logic serves as a framework for the developmental actions that occur at the micro level in organizations and in their employees' work (Ala-Laurinaho et al. 2017). The developmental actions should be in line with the new, emerging service logic. A shared understanding of the new operational logic and business tie together the small development steps taking place in everyday work in different organizations in the network.

Reinventive developmental actions

We analysed developmental cycles and the actions within them through the IT reinvention model and presented two examples of reinventive processes (Nevo et al. 2016). The examples illustrated two different developmental targets of reinvention: modification of the system's characteristics (accounting case), and a change in the use of the system and its data (wood procurement case). Both were based on self-determinate and self-motivated actions to improve the employees' own ongoing work processes and task performance. Successful IT reinvention in the accountant's work required direct, open and ongoing interaction with the network of stakeholders in the accounting process. The product owner and the renewed coding of the programme played a key role in this process. In contrast, the forest operator's IT reinvention was based on applying several IT systems and other information sources and on the renewed use of the information from them.

In the case of the accountant's IT reinvention, the starting point was, as assumed by the framework (Nevo et al. 2016), current IT use in the post-adoption phase. However, the trigger for development actions came from the accountant's customary work process, which was experienced as fractured and lacking in fluency. The problematizing of this service block and

the imagining of innovative solutions was based mainly on the current accounting process and the accountant's experiences of its problems. Therefore, the new goals of the accounting process were not actually pursued, but when applying the renewed IT system in the co-operation between the accountant and his/her customer, new ways in which to act and conduct the service were born, i.e. new technological capabilities were created. The reinvention process has led to new features in the accounting IT system and has made it possible to disseminate this solution among system suppliers' customers in the field of accounting.

The example describes how the integration of the accounting system's revision occurred through mass tailoring in the network consisting of the accountant, the customer, accounting entrepreneur and system supplier (the IT product owner). To realize the imagined technological capability, tight, continuous interaction between different stakeholders was required, as well as an outspoken will to find technological and functional solutions that would serve the different sides. The new technological capability will streamline accountants' work tasks, provide better services for the customer, increase the probability of keeping the customer and improve the accounting system's attractiveness. With this solution, the accountant can serve the client more efficiently. This is one key factor of experiencing work as meaningful and increasing well-being at work (e.g. Tuomivaara et al. 2016; Tuomivaara et al. 2017).

The forest operator's IT reinvention process also emerged from the needs of everyday work practices. The present use of IT in the post-adoption phase was problematized on the basis of the large amount of data and complex information flow in the planning and controlling of the wood procurement process. The target in this iterative and ongoing development process was to gain a better overall picture of the operating region by integrating data and presenting necessary information in an understandable way. In this case, new knowledge and skills for performing the operator's job were attained via new technological capabilities. Although the development process was self-motivated and self-determined at the beginning, the organization recognized the process and its outcomes. Thus, in the development and implementation of a next-generation ERP, these needs and solutions must also be taken into account.

9. Conclusions

In this article, we have shown how the use of IT systems lays the ground for the reform of individual work and co-operation in networks. Working with IT in the network requires changes and provokes the need to develop work practices, work division and processes. Knowledge regarding these changes and the ways in which they are achieved is essential for understanding what kind of possibilities both new and old tools offer for the innovative, sustainable organization of work. In this article we have shown the importance of a more practical understanding of methods for implementing new systems and reinventing uses for the old ones in order to benefit from the potential innovativeness of digitalization. The multilevel analysis presented here enabled us to understand the manifold process in which IT is being adopted.

The activity system model helped us to see the historical change in IT-mediated work and to predict future changes as employees anticipate them. The expansive development cycle helped us to illustrate the emergence of a new digital service concept. Finally, the ideas of IT reinvention proved to be a good process model for analysing continuous development of IT systems and their use on the level of networks, organizations and employees. The analysis as such provided a basis for a profound understanding of continuous and interdependent development of work processes and IT systems and their use. The profound understanding of the systemic connections in turn provided a basis for creating practical guidelines for IT adoption and the promotion of IT reinvention.

The previously described developmental process requires data and constructed information and knowledge to be available to all parties in the organization, even in the network of organizations. Such open information creates preconditions for the innovative development of processes and products by employees, contractors, customers and other actors in the network (Kesting/Ulhøi 2010). There is also a need to create a collective understanding of the systemic interconnections between changes in the everyday work of the different actors and the activity of the entire network in order to enhance participative development of the new operating logics and practices (Ala-Laurinaho et al. 2017; Virkkunen 2007). This resembles the ideas of employee-driven innovation and workplace learning that emphasize the importance of collective reflection and inquiry about work situations (Høyrup 2010).

From the viewpoint of well-being and safety at work, in both cases the IT reinvention process focused on increasing the fluency of work and therefore on decreasing disruptions at work. These operations and improvements reduced workload and strain and promoted control over work. As we can see, the practices raised by the theoretical model of IT reinvention can support innovativeness, the new application of an IT system, along with meaningful work goals and well-being and safety at work. These developmental practices establish opportunities for the improved integration of work processes and IT systems during the post-adoption phase. Focusing on these practices is essential because we increasingly live in a continuous post-adoption phase. More research is needed on practical ways to support reinvention, and to describe the practical tools that make it possible to achieve an effective IT reinvention process.

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Digital Work Tools and Tasks: Firm-Level Evidence from Germany

Abstract

The ongoing computerization of our economy is transforming the world of work. New technologies and new working requirements are leading to changes in employees' task composition.
This paper analyses the influence of digital work tools on routine, manual, interactive and cognitive tasks, based on German establishment data (BIBB Establishment Panel on Training and Competence Development). A distinction is drawn between groups of employees with different skill requirements (employees performing simple, qualified and highly qualified tasks). We show that the usage rate of work tools increases with rising skill requirement level in routine, manual and non-routine tasks. Software is the most important work tool among all skill groups and tasks. Our results show that software substitutes for human labour in performing routine and manual tasks and complements for human labour in performing non-routine tasks. Work tools in the category "Measurement Devices and Diagnostic Tools" complement for human labour in performing non-routine tasks.

1. Introduction

The introduction of new communication and production technologies is usually accompanied by new work processes and operating procedures, leading to changes in the way certain jobs are performed. In order to evaluate this impact of technological change on jobs, Autor, Levy and Murnane (2003) introduced the so-called "task-based approach". Whereas computers substitute for workers' skills in performing routine tasks, they are complementary in performing non-routine tasks, such as problem-solving. Consequently, a "new division of labor" (Levy/Murnane 2005) between workers and machines creates new jobs, while existing jobs might disappear over time. Following this approach Goos/Manning (2007) provide evidence of a polarization of jobs in the UK, where medium-skill jobs are most strongly affected by computerization. Frey and Osborne (2013) confirm these findings for the US and at the same time predict that 47 percent of jobs are at risk of computerization. In Germany, the literature on tasks reflects the employees' (Spitz-Oener 2006; Rohrbach-Schmidt; Tiemann

2011; Dengler/Matthes 2015/2018; Pfeiffer/Suphan 2015) as well as the employers' perspective (Mohr/Troltsch/Gerhards 2016). A comprehensive analysis by Helmrich et al. (2017) indicates an upgrading of qualifications rather than job market polarization. The study also shows accelerated structural change and more job switching due to technological change. Furthermore, it provides a first analysis of usage of employees' work tools depending on different qualification requirements. The results reveal that higher qualification requirements for employees go along with more frequent usage of digital work tools.

The concept of work tools was introduced to the recent debate on technological change by Güntürk-Kuhl, Lewalder and Martin (2017). Their concept extends a taxonomy initially developed by Troll (2002). Work tools essentially define how workers perform their job. Hence, they are an insightful instrument for observing technological change. This paper uses work tools as an indicator of technological change and thereby extends Autor, Levy and Murnane's framework by allowing a more differentiated view on employees' tasks. It also allows account to be taken of the frequency of use of digital technologies. Research work within the scope of "skill-biased technological change" adopts the central hypothesis that the main tasks and task clusters to be substituted because of increasing computerization will be those which exhibit a high proportion of routine. For this reason companies will substitute such tasks by making investments in digital technologies (Autor/Levy/Murnane 2003). Accordingly, tasks involving communication, creativity and problem-solving come to the fore. So far little is known about the relationship between specific work tools and workers' tasks. If – following Autor, Levy and Murnane's line of thought – technological progress makes workers perform more non-routine tasks, one should be able to observe workers having less routine tasks the more technologically advanced their work tools are and the more often they are used. This leads to the following hypotheses:

(1) Digital work tools substitute for human labour in performing routine and manual tasks.
(2) Digital work tools complement for human labour in performing non-routine tasks.

The paper is organized into four sections. The next section describes the data set, the variables and the derivation of the multivariate models. Section 3 investigates the influence of digital work tools on tasks within employee groups with different occupational skill requirements. Section 4 presents the conclusions.

2. Methodology

Data

The following analyses are conducted on the basis of the BIBB Establishment Panel on Training and Competence Development (BIBB Training Panel) (Gerhards/Mohr/Troltsch 2013; Troltsch/Mohr 2017; Troltsch/Gerhards 2017). The BIBB Training Panel is an annual survey which collects representative longitudinal data on the training activities of companies in Germany. It has been conducted since 2011, and around 3,500 establishments participate every year. Selection takes place via a disproportionately stratified sample of the statistical population of all companies with one or more employees subject to mandatory social insurance contributions. Hence, the basic population consists of every establishment in Germany with at least one insurable employee.[1] The data is collected via computer-assisted personal interviews (CAPI) and web-based interviews (CAWI). As the digital work tools were collected in detail in the 2017 wave, we will use that year as the database for our analysis. We will match the information on tasks of employees from the BIBB Training Panel 2016, assuming that they did not change significantly within one year.

Implementation of the task-based approach

In order to measure the tasks of employees at company level, eight items were incorporated into the BIBB Training Panel 2016.[2] Companies were asked to make evaluations of their employees based on task requirements (employees with simple, skilled and highly skilled tasks).

Different strategies are used in the literature for classifying activities into task domains (Rohrbach-Schmidt/Tiemann 2013). We choose a classification based on existing theory and research practice with the aim of mapping the task dimensions of "routine", "cognition", "interactivity/subject relation" and "manuality/object relation" (Autor/Levy/Murnane 2003; Spitz-Oener 2006; Gathmann/Schoenberg 2010). Following Antoncyk et al. (2009), the share of a certain task-group g is defined as the number of activities in group g performed by an individual i divided by the total number of tasks performed by the same individual, i.e.

$$\text{Task}_{ig} = \frac{number\ of\ activities\ in\ group\ g\ performed\ by\ i}{total\ number\ of\ activities\ in\ all\ groups\ performed\ by\ i} * 100$$

Table 1 illustrates the assignment of activities to the four categories for each employment group. The tasks contain ordinal information about whether these are performed 1 – never, 2/3 – relatively/very seldom or 4/5 – relatively/very often.

1 Business addresses are provided by the Federal Employment Agency, the Federal Ministry for Labour and Social Affairs and the Institute for Employment Research.

2 Response categories: task performed (1) never, (2) very seldom, (3) relatively seldom, (4) relatively often, (5) very often.

Table 1: Definition of TASKS in the BIBB Training Panel 2016

		Employees performing simple tasks[1]	Employees performing skilled tasks[2]	Employees performing highly skilled tasks[3]
TASKS categories	Routine TASKS	▶ Sequences are repeated in every detail ▶ All details are pre-stipulated		
	Manual TASKS	▶ Tools or machines such as control or computer systems are used ▶ Dexterity and craft trade skills are used		
	Interactive TASKS	▶ Information or advice is provided to customers or patients ▶ Involves persuading others and negotiating compromises		
	Cognitive TASKS	▶ Involves organizing or researching sequences ▶ Procedures and processes are improved or piloted		

[1] These usually do not require vocational education and training. Simple tasks are, for example: tasks which encompass simple cleaning, waste removal, warehousing and transport work or simple sales activities; they can, for instance, be performed by unskilled and semi-skilled workers.

[2] These usually require completion of vocational education and training or relevant occupational experience. Skilled tasks encompass, for example: tasks in which products and goods are manufactured, tasks in which repair and maintenance work is carried out in a qualified manner, or tasks which involve qualified services such as commercial activities or IT work and which usually, although not necessarily always, require completion of company-based or school-based VET or relevant occupational experience and are carried out by staff such as skilled workers, journeymen or specialist commercial clerks.

[3] These usually require a degree from an institute of higher education/university of applied sciences or a master craftsman, technician or comparable qualification. Highly skilled tasks are understood to mean, for example: tasks which encompass research, development, analytical and construction work or management, training and organizational responsibilities and which are carried out by employees such as master craftsmen, certified senior clerks, group leaders, scientists or managers.

Source: own representation

Categorization of digital work tools in the BIBB Training Panel

The operationalization of digital tools in the BIBB Training Panel 2017 is based on the BIBB taxonomy of work tools (Güntürk-Kuhl/Lewalder/Martin 2017). This concept was developed within the scope of analyses of job advertisements and defines work tools as follows:[3]

> *"Work tools are material and immaterial objects required to perform occupational tasks and activities. Work tools may be used by persons as well as machines. Using a work tool requires specific abilities and skills, which are part of the description of a workplace as well as occupational tasks and activities to be performed and are closely linked to work tools. Work tools are not raw materials, building materials or substances being worked on, but rather what is used to work on these materials. Software, information (such as legal texts), standards, models or concepts and what is used to perform services can thus also be work tools."* (Güntürk-Kuhl/Martin/Lewalder, p. 11 in this book)

3 The BIBB taxonomy of work tools was developed in stages. First, words found in the job advertisements were qualified according to specific criteria (for example nouns in a particular section of the advertisement). The second phase of the process then involved qualifying a further noun occurring after a noun which had already been qualified as a tool or as a non-tool and so forth (Güntürk-Kuhl/Lewalder/Martin 2017).

However, the BIBB Training Panel 2017 solely focuses on digital work tools. Therefore, we have no information on the use of other work tools (e.g. vehicles, office/communication tools, other ancillary equipment).

Table 2: Summary of explanatory variables

	Variables	Response categories
Measurement devices, diagnostic tools[1]	▶ Measurement devices, diagnostic tools ▶ Computer-controlled analysis systems, diagnostic devices with data/image storage and results print-out	1 = (very) frequently used at workplace 0 = never/ (very) seldom used at workplace
Machines, installations[2]	▶ Automated machines ▶ Additive manufacturing (e.g. 3-D printer)	1 = (very) frequently used at workplace 0 = never/ (very) seldom used at workplace
Software-related tools[3]	▶ Administrative software (e.g. bookkeeping, business processes, tendering software) ▶ Computer integrated production (e.g. B. CAD, PPS, CAQ, CAE, CAM) ▶ Standard office applications/packages (word processing, spreadsheet programs, e-mail clients, presentation programs, Internet browsers) ▶ Graphic/multimedia software (e.g. image and video processing) ▶ Planning and management of company resources (e.g. Enterprise Resource Planning (ERP)) ▶ Management of customer relations (e.g. Customer Relationship Management (CRM)) ▶ Recording and management of flows of goods (e.g. inventory management system, procurement) ▶ Content management systems/editing systems (e.g. administration of websites, document management) ▶ Software development (e.g. programming languages) ▶ Analysis software, mathematical software (e.g. statistics software)	1 = (very) frequently used at workplace 0 = never/ (very) seldom used at workplace
Company-related variables	Company size	1 to 19 employees[4] 20 to 99 employees 100 to 199 employees 200 and more employees
	Region	0 = East Germany 1 = West Germany
	Sector	0 = Manufacturing[5] 1 = Services[6]
	Training company	0 = not a training company 1 = Training company

[1] In each case for employees performing simple/skilled/highly skilled tasks.
[2] In each case for employees performing simple/skilled/highly skilled tasks.
[3] In each case for employees performing simple/skilled/highly skilled tasks.
[4] Employees subject to mandatory social insurance contributions (MSC). The following remarks refer to employees. This abbreviated term is used to refer to the number of employees subject to mandatory social insurance contributions.
[5] Agriculture/mining/energy; manufacturing sector; construction industry; trade/repair.
[6] Corporate services; other personal services; medical services; public services and education.

Source: own representation

In the BIBB Training Panel 2017 companies were asked about the frequency of use of digital software and hardware components in the workplace for different skill levels (employees carrying out simple, skilled and highly qualified tasks) (see Table 2). In line with the theoretical concept put forward by Güntürk-Kuhl/Martin/Lewalder (2019), we aggregate the work tools given in the data to the categories "Machines and Installations", "Measurement Devices and Diagnostic Tools" and "Software".

Derivation of the model

As stated, tasks were surveyed in an ordinal manner. However, for an analysis with more heterogeneous results, these tasks were recoded into a binary variable. This dummy contains the categories (1) "frequent task performance" (relatively/very often performed) and (0) "infrequent task performance" (never/relatively/very seldom). Therefore, a binary logistic regression approach is used. Major criteria for this form of regression is that the independent variables do not show strong multicollinarity. This is prevented by not including computer and EDP devices. Another precondition which is met with the data set is a large enough sample (Andress/Hagenaars/Kühnel 1997; Windzio 2013). For each of the skill groups (employees performing simple tasks; employees performing skilled tasks; and employees performing highly skilled tasks) we run binary logistic regressions, with separate models for manual, routine, interactive and cognitive tasks as dependent variables (in sum twelve models). Besides the digital work tools, further variables describing the company (company size, branch, region etc.) are taken into account. As coefficients depend both on effect sizes and the magnitude of unobserved heterogeneity, we cannot straightforwardly interpret and compare the coefficients (e.g. Wooldridge 2002). Therefore, we report Average Marginal Effects (AME) which measure the change in the expected value of y as one independent variable increases by unity while all other variables are kept constant. Moreover, AMEs are not biased by uncorrelated and unobserved heterogeneity (Auspurg/Hinz 2011).

3. Digital work tools, tasks and skill requirements

In this section we test the hypotheses described in the introduction. First, we give a descriptive overview of the use of digital work tools by employees with different skill requirements and by task categories. Then, in a second step, we analyse the effects of digitalization on tasks.

Overview of the use of digital work tools by company task groups

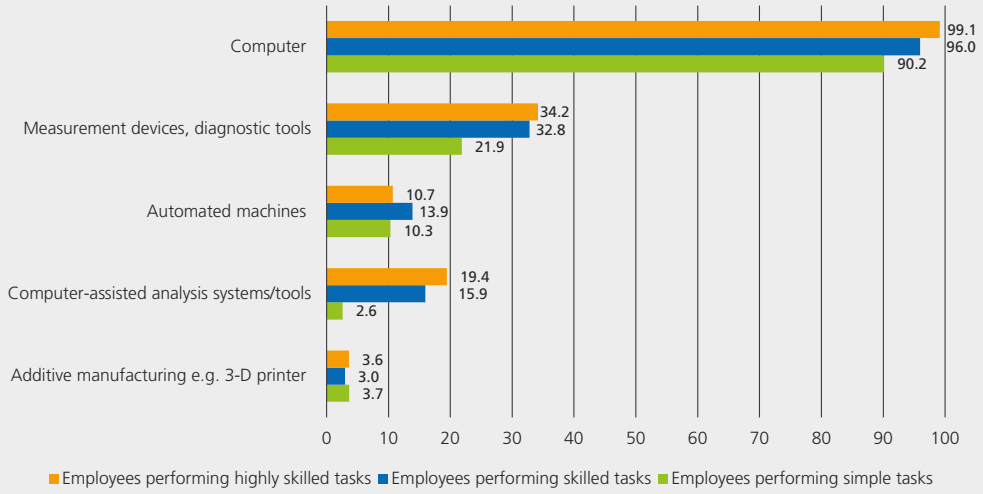
The tools used by employees form the basis for analysing which changes are occurring in the requirements profiles of various employee groups. In 2016 half of the companies (46.5%) employed staff to perform simple tasks (which usually do not require vocational education and training). Within this employee group, on average about three quarters use digital tech-

nologies (75.6%). In turn, 91 percent of these use computers, of which two thirds use standard office applications such as office packages (62.65%).

The proportion of users of digital technologies rises in line with increasing task requirements (employees performing skilled tasks: 83.7%; employees performing highly skilled tasks: 94.1%). In addition, the proportion of computer users and users of office applications also rises among users of digital technologies to reach a level of almost 100 percent.

In order to gain a deeper insight into the employees' tools, it is important to consider other software and hardware work tools used beyond computers and office applications. Figure 1 provides an overview of digital hardware components by employee groups in 2016. Looking at these reveals that the most often used tools, across all three employee groups, after computers are electronic measurement devices and diagnostic tools. With rising skill requirement level the usage rate of these kinds of tools increases. The same is true for computer-assisted analysis systems/tools. Qualified task workers use automated machines more often (around 14%) than highly skilled and simple ones (around 10%). This leads to the conclusion that the operation of automated machines needs to be ascribed to the area of skilled tasks. This offers especially those employees with a vocational education the opportunity to benefit from digitalization. Additive manufacturing tools are least often used among all employee groups (about 3%). The differences between the groups are marginal.

Figure 1: Use profiles of digital hardware components by employee groups 2016 (in %)

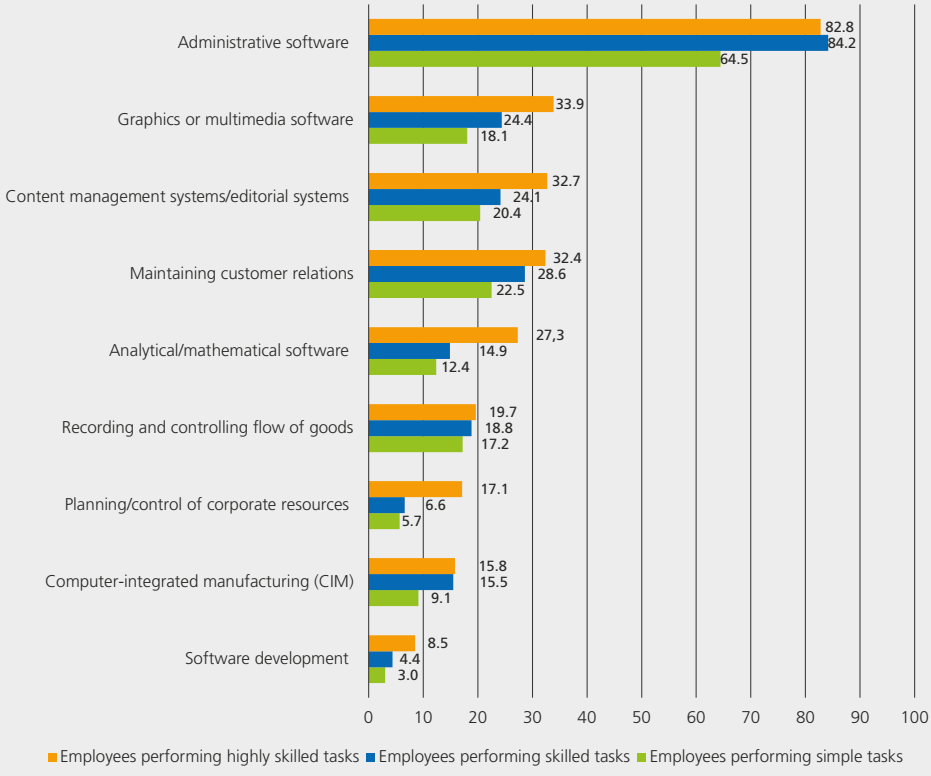


Source: BIBB Training Panel 2017, n = 3,727 (weighted data), multiple answers by cases. Computer use is not considered. (Very) frequently used work tools are reported

As stated, the majority of employees uses computers in their everyday work. Therefore, it is important to identify the task requirements of employees with the used software com-

ponents as well. Figure 2 shows usage profiles of digital software components by employee groups in the year 2016. Comparable to hardware, the usage rate of these tools increases with rising work requirement level. The most frequently used tool on all requirement levels is administrative software, which is used around three times more often than the second most frequently used tool (graphics or multimedia software). The least used software are components for software development, which are used by 9 percent of the highly skilled and by only 3 percent of the low skilled employees. Also, software components for planning/controlling of corporate resources and computer-integrated manufacturing (CIM) are only seldom used. It has to be noted that the hugest difference between the employee groups can be found where the usage rate of low skilled employees is considerably smaller than the usage rate of highly qualified employees.

Figure 2: Use profiles of digital software components by employee groups 2016 (in %)



Source: BIBB Training Panel 2017, n = 3,727 (weighted data), multiple answers by cases, office applications are not considered. (Very) frequently used work tools are reported

According to the task approach (Autor/Levy/Murnane 2003), the analysed employee groups differ with regard to tasks performed at work. Routine tasks are mostly performed by employees with low skill requirements (79.3%), manual tasks by employees which usually require completion of vocational education and training or relevant occupational experience (48.1%), and the proportion of cognitive tasks is highest within the group of employees who require a degree from an institute of higher education/university of applied sciences or a master craftsman, technician or comparable qualification (81.5%). Whereas the proportion of employees performing routine tasks declines with higher skill requirements, it increases with regard to interactive and cognitive tasks.

The analysed employee groups also differ with regard to the tasks performed and work tools used (Table 3). The frequency of use of all the analysed work tools increases the higher the skill requirements in (nearly) every task category. Every group of employees performing routine, manual or non-routine (interactive or cognitive) tasks mostly makes use of "Software" tools. "Machines and Installations" are the least often used work tools among all skill levels and task categories.

The usage rate of "Software" is lower in every skill category for employees performing routine and manual tasks than for employees performing non-routine (interactive and cognitive) tasks. Within the group of employees performing highly skilled tasks, we see that the frequency of usage of "Machines and Installations" and "Measurement Devices and Diagnostic Tools" is lower for non-routine tasks. This is also true for interactive tasks performed by skilled employees.

The descriptive analyses show that the usage rate of work tools increases with rising skill requirement level in routine, manual and non-routine tasks. Software is the most important work tool among all skill groups and tasks. With higher skill requirements "Machines and Installations" and "Measurement Devices and Diagnostic Tools" become less significant for employees performing non-routine tasks.

Table 3: TASKS by employee groups and work tools (in %)

	Employees performing simple tasks			
	routine	manual	interactive	cognitive
2 Machines, Installations	63.9	32.7	*8.1*	*8.8*
3 Measurement devices, Diagnostic tools	59.4	40.4	7.9	*3.6*
4 Computer, EDP-devices	61.9	29.0	13.8	*5.8*
5 Software	59.5	26.6	11.3	6.7
n	2562	1191	426	233
	Employees performing skilled tasks			
	routine	manual	interactive	cognitive
2 Machines, Installations	42.6	67.6	42.7	5.4
3 Measurement devices, Diagnostic tools	43.2	62.4	41.6	5.6
4 Computer, EDP-devices	38.9	36.5	47.8	3.4
5 Software	37.8	36.1	49.0	3.3
n	2113	2715	3495	233
	Employees performing highly skilled tasks			
	routine	manual	interactive	cognitive
2 Machines, Installations	25.8	48.8	78.9	67.2
3 Measurement devices, Diagnostic tools	32.0	50.7	74.8	62.2
4 Computer, EDP-devices	22.9	31.4	81.5	66.3
5 Software	22.8	31.2	82.4	67.5
n	763	1036	4873	4534

Source: BIBB Training Panel 2016/2017, weighted data. In italics: n < 50 (it is likely that these results are unreliable). (Very) frequently used work tools for (very) frequently performed tasks are reported. n=3705

Effects of digitalization on tasks

The following analysis investigates the substitution and complementarity hypothesis for the task categories within the three employee groups. For this purpose, we examine the relationship between digital work tools and (relatively/very often performed) tasks.

Tables 4 to 6 show the relationship between digital work tools and tasks separately for each employee group. Each column represents a separate binary logistic regression of different task categories on work tools. We interpret positive effects of digital work tools as complementary effects and negative effects as substitution.

For all employee groups the effects of software are consistent with the routinization hypothesis. We find substitutive effects on routine and manual tasks and complementary effects on interactive and analytical tasks.

The effects of work tools in the category "Machines and Installations" are in most cases not consistent with the routinization hypothesis. We find positive effects on routine and manual tasks for all employee groups and negative effects on interactive tasks. The effects of machines and installations on analytical tasks are not consistent across the employee groups. However, these effects are not significant for most specifications. Interestingly, for all groups we find complementary effects of measurement devices and diagnostic tools on routine, manual and non-routine (interactive and analytical) tasks.

Table 4: Logistic regressions: Influence of work tools on tasks of employees performing simple tasks (in Average Marginal Effects/AME)

	routine	manual	interactive	analytical
Software	0.023	-0.02	0.073**	0.139**
	(1.78)	(1.44)	(2.83)	(5.34)
Machines, Installations	0	0.057	-0.102*	-0.009
		(1.75)	(2.75)	(0.24)
Measurement devices, Diagnostic tools	0.003	0.018	0.152**	0.058
	(0.18)	(0.91)	(4.71)	(1.81)
West Germany (Reference: East Germany)	-0.029**	0.007	0.021	0.021
	(3.45)	(0.45)	(0.77)	(0.79)
Services (Reference: manufacturing)	-0,024*	-0.072**	0.145**	0.018
	(2.54)	(6.34)	(5.36)	(0.67)
Company size: 1 to 19 employees (reference category)				
Company size: 20 to 99 employees	-0.017	0.037	0.142**	0,07*
	(1.29)	(1.79)	(4.20)	(2.04)
Company size: 100 to 199 employees	0.003	0.049	0.089*	0.023
	(0.2)	(2.09)*	(2.28)	(0.59)
Company size: 200 and more employees	0.006	0.067**	0,091**	0.037
	-0.48	(3.24)	(2.62)	(1.04)
Training company (reference: no training company)	0.023*	-0.002	-0.05*	-0.069**
	(2.25)	(0.12)	(1.98)	(2.76)
n	1.930	1.970	1.970	1.970

Source: BIBB Training Panel 2016/2017. Dependent variables: Tasks with response categories 0 never/relatively/very seldom and 1 relatively/very often performed. The task items are matched from the BIBB Training Panel 2016. *p<0.1, **p<0.05 ***p<0.01. Standard errors in parentheses. Computer, EDP devices are not considered because of collinearity effects

Table 5: Logistic regressions: Work tools on tasks of employees performing skilled tasks (in Average Marginal Effects/AME)

	routine	manual	interactive	analytical
Software	-0.007	-0.14**	0.008	0,002
	(0.35)	(4.57)	(0.95)	(0,22)
Machines, Installations	0.032	0.12**	-0.01	0,004
	(2.19)*	(4.62)	(1.38)	(0,34)
Measurement devices, Diagnostic tools	0.011	0.136**	0.011	0.007
	(0.98)	(8.46)	(1.73)	(1.11)
West Germany (Reference: East Germany)	0.004	-0.009	0.008	0.004
	(0.34)	(0.84)	(1.23)	(0.53)
Services (Reference: manufacturing)	-0.004	-0.084**	0.038**	-0.003
	(0.29)	(8.36)	(3.79)	(0.39)
Company size: 1 to 19 employees (reference category)				
Company size: 20 to 99 employees	-0.026*	0.003	0	-0.006
	(1.99)	(0.24)	(0.06)	(0.64)
Company size: 100 to 199 employees	-0.01	-0.012	0.001	0.011
	(0.61)	(0.72)	(0.06)	(1.21)
Company size: 200 and more employees	-0.021	-0.003	0.014	0.009
	(1.45)	(0.18)	(1.77)	(1.04)
Training company (reference: no training company)	0.016	-0.002	0.009	-0.004
	(1.39)	(0.21)	(1.36)	(0.7)
n	3.391	3.393	3.395	2.315

Source: BIBB Training Panel 2016/2017. Dependent variables: Tasks with response categories 0 never/relatively/ very seldom and 1 relatively/ very often performed. The task items are matched from the BIBB Training Panel 2016. *p<0.1, **p<0.05 ***p<0.01. Standard errors in parentheses. Computer, EDP devices are not considered because of collinearity effects

Table 6: Logistic regressions: Work tools on tasks of employees performing highly skilled tasks (in Average Marginal Effects/AME)

	routine	manual	interactive	analytical
Software	-0.051	-0.084	0.009*	0.015**
	(0.87)	(1.6)	(2.07)	(2.80)
Machines, Installations	0.038	0.043	-0.002	0
	(1.52)	(1.67)	(0.56)	
Measurement devices, Diagnostic tools	0.071**	0.154**	0.001	0.005
	(3.57)	(7.90)	(0.36)	(0.92)
West Germany (Reference: East Germany)	-0.008	-0.017	0.006	0
	(0.41)	(1.05)	(1.69)	(0.74)
Services (Reference: manufacturing)	0.031	-0.123**	-0.003	0
	(1.48)	(8.14)	(1.19)	(0.49)
Company size: 1 to 19 employees (reference category)				
Company size: 20 to 99 employees	-0.059*	-0.033	0.001	0.004
	(2.53)	(1.73)	(0.16)	(0.76)
Company size: 100 to 199 employees	-0.07*	-0.048*	0.001	0.004
	(2.46)	(1.99)	(0.2)	(0.58)
Company size: 200 and more employees	-0.141**	-0.035	0.004	0.005
	(5.55)	(1.67)	(1.27)	(0.85)
Training company (reference: no training company)	-0.03	0.015	0.001	0
	(1.53)	(0.92)	(0.24)	(0.26)
n	2.846	2.847	2.849	2.318

Source: BIBB Training Panel 2016/2017. Dependent variables: Tasks with response categories 0 never/ relatively/ very seldom and 1 relatively/ very often performed. The task items are matched from the BIBB Training Panel 2016. *p<0.1, **p<0.05 ***p<0.01. Standard errors in parentheses. Computer, EDP devices are not considered because of collinearity effects

All in all, the results show that we get different effects of working tools on the tasks performed by employees performing simple, qualified and highly qualified tasks. Whereas the routinization hypothesis holds for software for all employee groups, it does not hold for machines and installations. As for measurement devices and diagnostic tools, our results show complementary effects on the different tasks categories for all employee groups.

Based on our results, we can confirm the hypothesis that software substitutes for human labour in performing routine and manual tasks and complements for human labour in performing non-routine tasks. Also, for working tools in the category "Measurement Devices and Diagnostic Tools", the hypothesis that they complement for human labour in performing non-routine tasks can be confirmed. For machines and installations we cannot confirm our hypothesis.

4. Conclusion

Technological progress is greatly affecting our working environment and significantly changing the nature of many jobs. To evaluate technological change within jobs, Autor, Levy and Murnane (2003) introduced the task-based approach to considering employees' performance of work tasks. This paper analyses the substitution and complementarity hypothesis of digital work tools on different task categories based on firm-level data (BIBB Training Panel). It extends Autor, Levy and Murnane's framework by taking different digital work tools into account. As technological progress evolves, employees' work tools evolve accordingly. We analyse the effects of employees performing simple, qualified and highly qualified tasks.

The results show that the usage rate of work tools increases with rising skill requirement level in routine, manual and non-routine tasks. We find that software is the most important work tool among all skill groups and tasks. With higher skill requirements, "Machines and Installations" and "Measurement Devices and Diagnostic Tools" become less significant for employees performing non-routine tasks. Hence, digital works tools are more often used by employees performing tasks with higher skill requirements and software tools are more frequently used for tasks with complex cognitive and interactive requirements. Our multivariate results indicate that the influence of digital work tools differs between tasks and employee groups. Software complements for non-routine tasks and substitutives on both routine and manual tasks. Working tools in the category "Measurement Devices and Diagnostic Tools" have complementary effects on all task categories analysed. For workings tools in the category "Machines and Installations" our results do not provide a clear picture of the effects of technology as postulated in the task-based approach.

The results suggest that the task-based approach has to be analysed in a differentiated manner to capture the effects of computerization. Our definition of digital work tools goes beyond computer use and is therefore suitable for a differentiated analysis of the effects of technologization on labour.

We suggest that further research should focus on the differentiation of work tools and their varying effect on tasks. For this purpose, it might be necessary to extend the selection of relevant work tools used in this study. Also, it should be kept in mind that the results presented rely on aggregated firm-level information. The scientific community would benefit greatly from individual data on employees' work tools which would allow for a more differentiated analysis on an individual level.

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Information Literacy in the Digital Workplace

Abstract

Today's workplace is increasingly digital, with many new information technology tools and digitalization processes. This means there are a number of challenges that are related to constantly learning new technology, re-organizing work, and the fact that there is often too much information in various forms and sources. The ability to handle information overload and fragmentation as well as the demand for new skills in relation to work tools is crucial. This ability is called *information literacy* and in this chapter we will define and explain what information literacy is about and how it can be a supportive set of skills in today's digital workplace. The literature underlines that there is a wide variety of definitions of the concept of information literacy. Also, the digital workplace is an emerging concept and therefore difficult to clearly define. Despite these conceptual challenges, this chapter will explain workplace information literacy as a set of skills and abilities that are increasingly needed to be able to handle different kinds of work tools. The workplace demands solutions to open-ended problems. The ability to synthesize multiple sources is important in a workplace context. These activities involve understanding the information need, identifying appropriate sources and evaluating the information before using it for subsequent purposes. These expectations involve more than just searching for information on Google because evaluating authentic sources and information is a critical component of information literacy. The contextual factors are also highlighted; information literacy must be defined in the sociocultural context of each workplace.

1. Introduction

The use of information in workplaces has increased exponentially over the years and the variety of information and knowledge that is being processed takes up an increasing amount of employees' time and effort. The ability to fluently deal with information and information flows is becoming a key asset in the digital workplace. In today's workplace there are very many different kinds of work tools for information handling. It is, therefore, important to

focus on the digital workplace from this perspective, while the digital environment changes quickly and is connected to challenges like fragmentation and information overload. We need to have an understanding of the information practices that are created around tools and technologies and the information literacy skills needed in order to effectively handle the information landscape in the digital workplace. In this chapter we consider work tools as information practices and we are interested in studying the information literacy skills needed in order to effectively handle the information landscape in the digital workplace.

While information literacy has mainly been developed within education and in connection to learning, there exists a gap in knowledge about how to concretely support and develop information literacy in a workplace context. Focusing on the workplace, information is often valued as a resource, but seldom given attention from an information literacy point of view. There are some early studies, more on a theoretical level, like Bruce's (1999) study of workplace experiences of information literacy. She identifies seven different ways of experiencing information literacy. These are closely related to key processes in the workplace such as environmental scanning, information management, corporate memory, and research and development, confirming that information literacy should be considered a significant part of the character of learning organizations.

However, there are also a number of challenges connected to the implementation of information literacy in an organizational context. Traditional workplaces are transforming into digital workplaces where new technologies are implemented and adopted to keep employees connected and to ensure a more collaborative approach is applied to extracting information and using it efficiently with a view to reaching organizational goals. These new practices have forced a change in the culture, structure, and the work processes of those workplaces. Progress towards new technologies has exposed workplaces to a virtually unlimited amount of information that is the key success factor for almost all types of organizations irrespective of the industry to which they belong.

There is a growing interest in looking into how information literacy in a workplace context can support organizations in achieving their goals. In this chapter we will present a literature review in order to explore in more depth how information literacy has been studied in a workplace context so far. The digital workplace as a context will be explained, the impact of digitalized work tools will be discussed, as will how information literacy can support employees in effectively managing those tools. This is a complex picture and there are no easy solutions to dealing with new work tools, digital processes, and information fragmentation and overload. We will focus on the importance of information literacy in the digital workplace when it comes to supporting information practices (work tools) in different contexts. Although we have technologies and tools we need humans to work well with technology to tap into the benefits of digital work tool. It is a question of interaction with individual information skills, technology, and the workplace culture, that is how information is valued in the organization. This chapter is based on our literature review of workplace information literacy. The theoretical framework strives to define the concept of information literacy and

how the concept has progressed to become a matter of concern in the workplace. Finally, we discuss what kind of information literacy is needed in the workplace context and how it can support the efficient management of work tools.

2. Methodology

A literature review was conducted to define the concept of information literacy. A set of 1,800 articles that discuss information literacy was collected. A total of 102 review articles were collected to discuss the core of information literacy and its relevance in the digital workplace. A content analysis of these articles was then conducted, and this chapter focuses on the importance of information literacy in the digital workplace when it comes to supporting information practices (work tools) in different contexts.

3. The digital workplace

> *"A digital workplace enables any employee to complete a task, information and work as a member of a team with other employees in the organization and in any partner organization on a totally location-independent basis for all the parties concerned."* (White 2012)

The digital workplace is an emerging concept and therefore challenging to clearly define. The above definition emphasizes that the digital workplace is totally location independent. White also underlines some of the advantages of a digital workplace, such as being adaptive to change, compliant with laws and regulation, attractive, and predictive because of rapid change. However, most work contexts are not totally location independent but have many digital elements in their work processes. In our chapter we will not try to define what the digital workplace is, but to highlight the fact that people interact with a lot of digital work tools and processes in today's workplaces, which again brings with it a need for workers to acquire new competencies. Today's digitalization has a profound impact on work tools. Digitalization of work tools has created an increasingly fragmented working culture and has also helped challenges such as information overload to surface. Therefore, it is important to reflect on what the increasingly digitalized workplace entails in order to be able to discuss what the information literacy skills needed in this context are.

The digital information landscape has certainly brought with it a rapidly growing amount of information which employees are required to manage. Information exists in various forms and sources. *Information overload* happens when information becomes a hindrance rather than a help. This phenomenon is most recognized in business and commercial sectors as well as in science and healthcare. It is not only the quantity of information that creates overload, it is also the diversity of information that comes from varying perspectives of the same thing and in different formats. New information technology, which aims to provide easy access to information and effective information management, is at the same time responsible for

the overload effect (Bawden/Robinson 2009). Information overload has implications on the personal level and on an individual's ability to cope with decision-making and problem-solving. It also has implications for organizations and management because the volumes of information are too big. The dilemma is that there is too much information but not enough relevant information (Edmunds/Morris 2000). In the digital workplace there is clearly a need for better knowledge organization, such as personal taxonomies, and better categorization of e-documents in personal collections (Chaudhrym/Rehman/Al-Sughair 2015).

Focusing on the impact of digitalization on work tools, we can see the same phenomenon that there is an increasingly fragmented working culture and also the challenges of information overload. If digitalization is planned well, there are of course a lot of benefits in more efficient work processes. But again, as has been stated many times before in regard to new information systems and tools, the added value does not come without the need for workers'engagement, skills, and motivation.

How can we then support a workplace with fragmented information and work tools as well as too much information? Information literacy and promoting competences and attitudes that are needed to avoid information failure is important. We need to better understand human information behaviour to actually be able to deal with increasing information overload. We cannot decrease the volumes and diversity of information, but we can probably better understand how people deal with and react to overload to be able to support their information literacy to cope with fragmented information (Bawden/Robinson 2009). The literature emphasizes that information literacy as well as personal information management might be a way to tackle this dilemma (Edmunds/Morris 2000). Information literacy training with the appropriate integration of personal information management skills will improve information finding and re-finding in order to manage digital information more efficiently (Kirtson/Barham 2005; Chaudhrym/Rehman/Al-Sughair 2015).

4. Information literacy

Information literacy is related to the ability to purposefully handle information and information practices in an information-intensive society, it is multifaceted and shaped by the context in which these abilities are to be applied (Limberg/Sundin/Talja 2012). The concept was first developed within higher education to support students in their studies. There are a number of library instructions that define information literacy as the ability to identify your information needs, the ability to search for, select, critically evaluate, and use information for various purposes, and that take economic and legal issues in the use of information into account (Sconul 1999; ACRL 2000). The emergence and development of this concept was supposed to enlighten and guide students to understand the need for and the source and use of authentic information.

An information literate individual is able to (ACRL 2000)

- Determine the extent of information needed
- Access the needed information effectively and efficiently
- Evaluate information and its sources critically
- Incorporate selected information into one's knowledge base
- Use information effectively to accomplish a specific purpose
- Understand the economic, legal, and social issues surrounding the use of information and access and use information ethically and legally

As the information society has developed, the need for skills to manage information in various ways has been increasingly highlighted. It is not only in an educational context that this is important. What we can see from the literature is that the literacy landscape is very varied, and even in a workplace context the challenge is what to focus on. Information literacy is an ambiguous concept (Bawden 2001; Saranto/Hovenga 2004; Sproles/Detmering/Johnson 2013; Stordy 2015), with the additional challenge that information literacy skills are different in different contexts.

In an extensive literature review, Bawden (2001) identifies six different terms related to information literacy. In addition to information literacy there is computer literacy (IT literacy), library literacy, media literacy, network literacy (Internet literacy), and digital literacy. Information literacy is the most frequently used term, followed by computer literacy. Media literacy has gained attention over the last few years. These literacy concepts have been divided further to specific areas of literacies, which creates the challenge of clearly defining information literacy. Information literacy can also be divided into more skill-based literacies to meet the needs of the complex information environment, but it is also used in connection with learning and knowledge, meaning that information literacy is more than seeking and evaluating skills, for example understanding the power of information in a democratic society. Information literacy is often associated with information overload, lifelong learning, knowledge management, and the information society. The number of literacies that are described, defined, and studied shows that today information literacy skills are important not only in education but also in all other areas of society. A concept of metaliteracy has even been developed as a comprehensive model for different literacies to support critical thinking and reflection in contexts such as social media, open learning, and online communities (Jacobson/Mackey 2013).

Is the emerging information landscape, with its overload and fragmentation, new technologies, and tools, the only reason why we have this ambiguous situation in relation to information literacy? Stordy (2015) argues that one challenge has been that scholars and organizations have developed their understanding of information literacy without reference to others. This has led to the wide variety of definitions of information literacy. Besides the

different definitions of the concept, information literacy has been developed through standards and instructions. A review by Sproles, Detmering and Johnson (2013) identifies three main lines of development. First, there is a strand of literature that focuses on *information literacy standards* developed by different library associations, what is needed to be an information literate person (student). Further, there is literature that focuses on how to educate and train information literacy skills, that is *information literacy instructions*. Finally, there are a number of attempts to develop *assessment tools and techniques* to evaluate the impact of information literacy. It has been said that the impact is difficult to measure, especially in a workplace context where sociocultural factors must be taken into account. This is, however, a crucial area for development, otherwise we will go no further than noting that information literacy is important.

The variety of definitions of information literacy or the variety of literacies needed in today's information society is not the only challenge. The importance of looking at information literacy in context has also been emphasized, demanding a level of flexibility in the information literacy instructions and standards. Stordy (2015) summarizes that the literacies can be thought of as *"[t]he abilities a person or social group draws upon when interacting with digital technologies to derive or produce meaning, and the social, learning and work-related practices that theses abilities are applied to."* His definition underlines the nature of literacy as a combination of cognitive ability and social practice. Information literacy should be understood as a critical information practice rather than as a set of information skills (Lloyd 2010). Tuominen, Savolainen, and Talja (2005) also define information literacy as socio-technical practice, that is how individuals interact with other people and technical artefacts in their information environments. In recent years, workplaces have faced many different kinds of digitalization processes with new work tools and changed work routines. Digital literacy is highlighted in this context. Digital literacy is the ability to use a variety of sources and tools in combination with critical thinking (Weiner 2011). Digital literacy is also about effective communication skills, ICT skills, and social skills. In the workplace, tasks are context-specific and digital literacy can be described as a socio-cultural practice that informs learning in the workplace (Bawden 2008; Weiner 2011).

Although information literacy has gained more attention in a workplace context in recent years, there are of course also barriers to information literacy. These might be related to the fact that literacies are not well understood, there is little knowledge about information literacy in jobs that do not require university degrees, and it is not clear who is responsible for educating the workforce in the area of information literacy (Weiner 2011). However, information literacy is relevant in all kinds of organizations and work tasks today and will need more attention, especially while information literacy is influenced by external changes, and it will be important for information literate people to be able to fluently use their diverse information literacy skills in different and new situations. Information literacy must be adaptable to changes throughout life. This is probably an important asset, especially in today's workplace where new digital tools are introduced frequently (Webber/Johnston 2000).

To sum up our review of information literacy, we can conclude that a broad form of literacy is required in today's society, in all parts of life, including working life. However, it is perhaps not necessary to focus on what the concept is called but on the skills needed in a complex information environment.

5. Information literacy in the digital workplace

In the workplace, information seeking, evaluation, assessment, organizing, presenting, and engaging is nothing new, and information literacy does not mean anything to knowledge workers although they act upon it every day (Cheuk 2017). This is a clear challenge when talking about the role of information literacy in a workplace context. It is an active part of everyone's work practice but it is seldom acknowledged as an ability that can be actively supported by the management. Digital workplaces have improved the technological framework and they have more tools for collecting and sharing information than ever before. New digital tools possess the potential to stay connected and collaborate to make the best use of the information it extracts. However, to use information effectively, a set of new skills are required and an awareness of information and digital literacy is needed.

Context and culture

As we have stated in the above, there are many information-related challenges in today's digital workplace, such as information overload, leading to information stress and negatively affecting employees' well-being. Also, several generations are now working together in the workplace. We know that younger generations have a different approach to information technology and ways to communicate than the older generation does. The information literacy of different age groups might become of key importance in an organization's overall information and knowledge management. However, this area of research is still in its infancy and it is difficult to predict how big a role the individual information literacy skills of different generations will actually have in a workplace context. In a study by Widén, Ahmad, and Huvila (2017), the generational differences were not a straightforward predictor of differences in information-sharing practices, although some differences were found in information consciousness and activities in information sending. It seems that organizational culture and work practices still overrule individual preferences in information work which supports Lloyd's (2005) statement that information literacy in the workplace is a broader term than it's original meaning in the educational context, focusing textual information sources. In workplace context information literacy includes both tangible and intangible practices and is hidden in different business activities, roles, and functions. Information literacy is not only a set of individual skills, but in a range of locations in a landscape. There is a lot of social information as well as embodied knowledge and practice. Information literacy in the workplace means connecting all these different sources of information and knowing how to navigate this landscape (Bawden 2001; Lloyd 2005; Cheuk 2017). A company needs to

embrace a culture that uses information to add value to work. Information literacy should be a company-wide strategy for creating a knowledge-driven organization (Cheuk 2017; Forster 2017).

So, when looking at information literacy in the digital workplace, the most important starting point is the *context and culture*. An information culture perspective could add the following insight to the discussion around workplace information literacy: workplace information literacy is not an individual attribute or set of activities, but a collective attempt at performing tasks in workplaces. There are multiple social and cultural factors that influence information literacy activities. In addition to the individual skills of information handling, workplace information literacy should be about navigating the organizational level of information awareness. It is of course important to be able to identify relevant information sources and critically evaluate information needed for problem-solving, but in a workplace context information literacy should also focus on aspects like attitudes and values to information, social interaction for knowledge creation, and information use outcomes. An information culture perspective gives a more holistic approach to information literacy in the workplace, supporting more efficient information management and leadership in relation to information handling, too. Acknowledging the cultural aspect in relation to workplace information literacy helps us also design more concrete implementation and assessment frameworks (Widén/Karim 2018).

Collaboration

As we have stated above, the traditional view that information derives from electronic and printed sources is not valid in a workplace context. *People as sources* of information must be included. It is important to emphasize the role of human relationships in the development of information literacy in the workplace. A skill- and qualifications-based agenda is an important pre-condition, but in a workplace setting information literacy must move beyond the traditional view (Crawford/Irving 2009). Also, the information landscape has changed, and both technological and *social competencies* are crucial when managing information and knowledge in the workplace. The information literacy skills that recent graduates have are not enough in the workplace. Tasks and assignments are not as structured in the workplace as they are at school. More interactive and social information-seeking is needed in the workplace, something students do not put into practice enough in their studies (Head et al. 2013). Employees work in distributed teams and share expertise and knowledge in wide networks. Workplaces are in need of people who are good at collaborating and sharing knowledge. It is increasingly important not to only focus on individual information skills but information literacy in collaboration with others and technological artefacts and with a practice-based approach. Information literacy is embedded in the activities of particular groups and communities and information skills and therefore abilities developed in context. It is an ongoing interaction on an individual-collective dimension (Tuominen/Savolainen/Talja 2005; Head et al. 2013; Lloyd 2017).

The collaborative dimension is also very important to make tacit knowledge effective in a workplace context. We know that most of the knowledge resources in an organization are tacit and the management of tacit knowledge is a crucial ability for any organization (Davenport/Prusak 1998). Workplace information literacy is an important addition to managing tacit knowledge, focusing on people as sources of information and with that the set of skills in being able to search, evaluate, understand, and use that information.

Impact

The literature review clearly underlines the importance of information literacy skills in the digitally oriented workplace. Both the quantity and diversity of information as well as the changing information environment and information practices need a good level of information literacy skills. The list of skills is long, and in addition to traditional information literacy skills such as information retrieval, information evaluation, and critical thinking (ACRL 2000), we can clearly see that visual and digital skills, social skills, and communication skills are highly important (Tuominen/Savolainen/Talja 2005; Head et al. 2013; Lloyd 2017). Also, leadership engagement and the role of information culture are shown to be important. Additionally, the digitalization of work tools has created requirements in terms of the cognitive abilities to perform tasks. In our view, the information literacy framework highlights the requirements well, including information-seeking strategy skills, critical thinking, the ability to manage different kinds of information sources. But there are few attempts to bring hard evidence to the discussion to assess the *impact* of information literacy in the workplace (Williams/Cooper/Wavell 2014). We need to develop measures to study the impact of workplace information literacy to raise awareness of its importance. We need to bridge the gap in research on workplace information literacy, that is looking at workplace learning in a wider context, including information-seeking skills, information evaluation, information use, information-sharing with others, and knowledge creation in a social context.

6. Conclusions

The focus on improving employees' information literacy in today's workplaces is important. Digital workplaces are adopting new technologies, but they are often found to be less attentive towards developing employees' information literacy that is vital in the optimal use of those abilities. In order to ensure strong collaboration between employees and the technological framework, developing information literacies in the digital workplaces is imperative. Information literacy was primarily a concept that was defined and implemented within academia to assist students in higher education. However, the mass use of information and communication technologies within workplaces has forced the emphasis to be placed on the development of information literacy in workplaces as well. An awareness of information literacy in digital workplaces has emerged, but has not yet been studied to a large extent. Therefore, we still need to develop the theory and models related to workplace information

literacy. The literature on information literacy provides a relatively nuanced picture of what information literacy is, as well as a number of clear standards and instructions on how to improve someone's information literacy. One challenge is probably the rapidly changing information environment and the need for new literacy skills that is emerging. Further, we need to work together as a community by engaging stakeholders in information literacy. That is librarians and researchers who have worked on developing information literacy instructions as well as knowledge managers and business people engaged in workplace learning while information literacy contributes heavily in the construction of a learning organization that has the ability to use information as a resource. Most importantly, we need to *develop measures to study the impact of workplace information literacy.* This could be done by developing different relational models to see how information literacy is affected by, for example, leadership styles and then how it affects different working outcomes or by developing a so-called information literacy self-efficacy scale (ILSES). These results could then help in establishing explicit policies about information literacy expectations to support workplaces where new digital work tools and processes are frequently introduced and employees need to have relevant information literacy skills to adapt to these changes.

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Abstract

Change in the world of work, be it in the form of digitalisation or other, is often discussed in broad terms of possible losses of jobs or huge restructurings of whole branches. Seldom do we look at what workers actually do at their workplaces – and how. But obviously technological change will affect the things we work with, our work tools.

This reader combines empirically grounded insights into how changes in work tools affect our work and how we react to it. In this sense it is a "hands-on" approach to find out more about the impacts digitalisation might have on qualification and the labour market. Work tools can be used to link analytical perspectives to investigate the effects of digitalisation on workplaces and employment, to understand the demand for specific competences within occupations and also to arrive at a workspace-specific understanding of said changes.

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