Data from and for work

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1. Introduction

Datafication penetrates all areas of life including the workplace. Both large corporations as well as small and medium-sized enterprises (SME) are affected by changes in the workplace and in production that are caused by automation and digitization.

Companies which wish to remain competitive are forced to adapt their technical equipment, organizational structures and cultures as well as the competences of their employees to this technological transition.
New socio-technical systems, e.g. the use of tablet or smartphone apps, are supposed to shape the image of the future. By implementing data-management-driven, simplified and accelerated communication processes mediating between the different organizational units of a company, it is possible to e.g. handle and distribute incoming orders faster and with more resource efficiency. All information that was previously communicated by paper can now be processed using new information and communication technologies in the workplace.

The term "Arbeit 4.0" depicts a datafied/digitized work environment and its actors. Until now, mainly the sociology of work (e.g. Pfeiffer 2016) and the sociology of industry as well as economic sociology (e.g. Hirsch-Kreinsen 2014) have studied the fields of "Arbeit 4.0" and "Industrie 4.0".

The five analytical moments of data technology enable a relational techno-sociological perspective on the smallest socio-technical couplings of the datafied workplace and on the emerging virtureality[1] of work.

In order to explain the five analytical moments of data technology in practical terms, we will refer to the research project "SozioTex- Neue soziotechnische Systeme für die

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[1] Virtureality is a german term coined in Häußling & Lemm et. al. 2017 representing a mixture of *physical reality* and *digitally calculated reality*

Textilbranche"[2], funded by BMBF and carried out by the Institute of Textile Technology and Sociology of Technology and Organization at RWTH Aachen University. SozioTex develops new socio-technical systems (here: assistance systems) for the textile industry.

The use of an app as an assistance system in order to improve the usability of weaving machines (e.g. with the help of tutorials) and for optimizing communication between the weaving mill and administration serves as application of the five analytical moments of data technology to the subject area of *work*.

2. The five analytical moments of data technology of work

(1) Production of data

In the workplace, data can primarily be gained from three different sources: The employees, the machines used and the assistance systems that stand between man and machine. All data producers are interconnected and produce different kinds of data as explained in this first phase of the model.

Regarding the *production of data,* there is a differentiation between *usage data* and *meta data*. Data that is generated by employees who directly interact with machines is called usage data. This category can be further subdivided three times:

a) Configuration data
   Configuration data refers to data which is generated during the (initial) setup of a machine. Additionally, processes such as the factory adjustment or the product-specific setup of a machine can also be categorized as configuration data. Configuration data arises while configuring a machine for the production of a specific product. A specific fabric in textile manufacturing is an example of such a product. Configuration data are the basic parameters based on the inherent basic properties of a machine, which are predefined by the factory settings of machine developers. Furthermore, configuration data also includes the adjustable settings of machines, e.g. weaving machines, that must be utilizable with respect to multiple products and therefore must provide a certain variety of configurations.

b) Data through the usage of devices

A second class of usage data is created during the actual use of devices. By this, we mean the data that objectively describes and protocols the production process and hence makes it reconstructible. This kind of data is generated by various sensor and actuator elements that are specifically set up for the read-out of the individual machines. Data such as temperature or running speed of weaving machines describe the actual machine usage since these parameters affect the quality of the end product.

c) Data through user input

The third class of usage-data consists of actual user input. Such data is obtained from the input of necessary production data into the machine by the employees via an operator control module. By design, the different operator control modules are equipped with sensor elements which capture the usage of the machine as well as the environment, granting deep insights into everyday work.

The usage of machines does not only create usage data, but simultaneously generates another kind of data called meta data. Over the course of the entire work process, data is generated showing how frequently machines and assistance systems are used while, at the same time, employees unconsciously produce data about their work behavior. Viewed closely, meta data provides insights into employees' break habits, working speeds, or even more abstract values such as their expertise regarding machine usage (e.g. via error rates or revisions of input). On the part of machines and assistance systems, data concerning the frequency of malfunctions in work processes can be gathered and analyzed.

Different types of data creation form another aspect of analysis, which can be categorized as follows:

- Data is generated when (digital) services are used by employees who, e.g., use tools to request process-relevant elements.
- Sensor-data is gained with help of sensor and actuator elements. This refers mainly to data that is exchanged between interconnected machines.
- Furthermore, data is generated through the self-measurement of entities that can be further broken down into self-measurement of machines and (self/foreign) measurement of employee entities.

Through the process of self-measurement on the side of machines, data is filed that later provides ground for an optimization analysis. The term (self/foreign) measurement of the

entity *employee* is based on the term Quantified Self. In this sense, an assistance system such as a smartwatch (with heart rate monitor) or a health-monitoring shirt is used to assess the health and stress levels of employees, which can be useful for employees (health protection) as well as for employers (assessment of the performance capabilities of employees). Additionally, foreign/external measurement of the workforce is possible – e.g. by means of a meta data analysis concerning the frequency of use of (health-related) in-house services such as back therapy trainings and nutrition advice or by analyzing the loss of working hours due to sick leave.

(2) Structuring of data

Modern algorithms and software products enable the purposeful structuring and evaluation of data gained in phase 1. For example, the efficiency of a specifically configured production process or the quality of the manufactured product can be determined. By interlinking different machines, their data can be juxtaposed in order to compare, e.g., two machines regarding the efficiency of the different production methods utilized. While machines are analyzed using configuration and usage data, people can be analyzed with help of his or her input data. By working with machines (e.g. via controls or assistance systems), employees produce data that can grant insights into their work behavior: How often do employees use tutorials showing how to operate specific machines? How long do breaks have to be? How much time do employees need to complete specific work steps? Resulting from the identification of patterns as exemplified, exact error predictions can be deduced, showing breakpoints in the workflow and allowing the person in charge to decide accordingly.

(3) Distribution of data

Concerning the distribution of data, the following central questions arise: Who has access to these structured sets of data and what are his or her aims in accessing them? In this context, different levels of hierarchy in organizations can be categorized. The different hierarchical ranks have varying levels of authority and 'necessities' regarding the production and access of specific data. The subdivision of all employees of a company into the categories of *producers*, *owners*, and *end users* of data shows a difference in authorization concerning/in dealing with data. Consequently, work data is inherently exclusive or inclusive, meaning that data either shuts employees out of certain company-internal discourses or integrates them, which is an indicator of the obvious power of data. Through the potential of data analysis, positions of power on higher levels of hierarchy are possibly strengthened and, accordingly, the structures of organizations are decisive for the distribution of data.

The distribution of data can not only be exclusive or inclusive, but is subject to another dichotomous differentiation: the differentiation between active and passive distribution. In

concrete terms, it is either data that employees must read/submit, or it is data that he or she *can* but *do not have to* retrieve/provide. Using the example of SozioTex, this can be exemplified referring to the use of assistance systems by shop floor employees: For example, the shop floor employees make process data available in the database of the assistance system. At the same time, throughout all work stages, the employees produce passive and automatically saved data on the work process. An example of *inclusive* factors of data can be seen in the way employees can (or have to) call up the operating numbers of their shift after the structuring of data in order to initiate an optimization process. An excluding factor of data can be seen in the way employees are not able to access business data or the data of other shifts as both are reserved for the management level or respectively the other shift (exclusively).

(4) Visualization of data

Structured source data is processed under particular aspects (e.g. purpose of task) in order to make the data accessible. Different options of visualization of data represent another form of exclusion (via technical access) that results in another form of hierarchy because certain forms of visualizations require task specific understanding that might have to be acquired first. For the levels of production or general management, data is illustrated in form of check values or estimated values/diagrams. On the shop floor level, data can be provided as tutorials (e.g. in the form of video or audio instructions). In the context of SozioTex, knowledge can be loaded into these tutorial-apps by experienced employees in order to pass it on to trainees (cf. fig. 1)
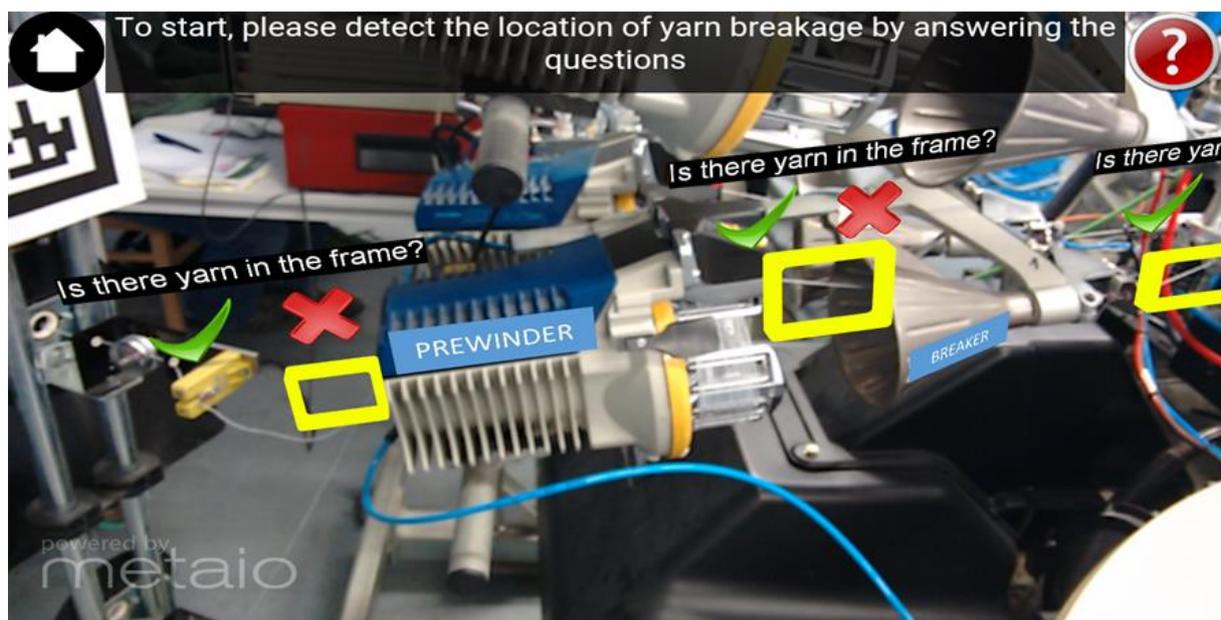

Figure 1 Visualization of an assistance system in SozioTex

The tutorial-app assists trainees, e.g., in setting up a weaving machine by themselves for the first time, or the app acts as a reminder for more experienced employees who are supposed to carry out a specific process they have not performed for a while. However, the aim is to ensure that employees can carry out highly complex work processes by themselves after learning them and also that assistance systems facilitate an improvement of competencies instead of reducing or replacing them.

(5) Control through data

Control through data is divided into two different aspects: Control through visualized 'in-situ' data and control through simulated 'in-silicio' data.

When data has proliferated a work process, an intervention in the real-time processes can take place through an analysis of production-data, which can result in a change in the organizational processes or the process architecture. The aim is to prevent errors and to avoid inefficient actions. That way, the analysis of data directly affects the stream of actions in an organization. The consequences of this analysis are, e.g., the general relief or support of employees, which results in an increase of (resource) efficiency. This process represents control through "in-situ"-data. Regarding time efficiency, SozioTex offers the possibility of comparing two shifts with different workflows within the same process with the help of measured data.

By simulating production processes, the optimal utilization of a set of machines within a work process can be calculated. Hence, employees can adjust their work cycles to those parameters. This synthesis of analogue work cycles ("in-situ") and simulation ("in-silicio") represents a first approach to virtureality.

3. Outlook on the changes of datafication in the workplace of tomorrow

In the depiction of the five analytical moments of data technology, a form of virtureality is outlined that results from the last phase: control through data.

This phase describes organizational changes of current structures caused by the effects of progressing datafication of the workplace. The improvement of production and value creating processes are of central importance for companies and can be attained by the synthesis of social and technological aspects and by considering both aspects as mutually interdependent. In transforming an organization, both production and process optimizations are implemented and also changes regarding the socio-technical fabric are realized. The organization following the vision of a successful virtureality is controlled via the implementation of data, which has extensive consequences regarding the flattening of hierarchies and which is essentially renewing the notion of work.

A form of virtureality that gives insights into the changes in the workplace caused by control through data becomes obvious with regard to the effects of datafication on organizational structures in the course of Industrie 4.0. These organizational transitions display the control of organizations or work in general through the implications of data.

On the one hand, there are social factors of work – in form of structural levels – that must adapt to technological change. "*Functional access points" is a term that could expand the construct of structural levels from a relational point of view. This approach focusses various kinds of positions within the socio-technical constellations in an organization.* These positions have access to data that concerns their co-workers within the corporation, that enables them to gain a knowledge-advantage. These functional access points could be of sociological interest especially in the context of self and external measurement. With an increase in the measurement of the workforce (by themselves or others) comes the potential for higher degrees of transparency of the employees, which can enable people in key positions a gain in power/control. Who has the right to use data that is generated during work processes for specific purposes and how much say will be granted to the employees at the shop floor level?

On the other hand, there are technological aspects which - represented by the datafication and digitization of machines - are adapted by all organizations to fit their specific operational circumstances. Only by following this approach of social constructionism concerning the implementation of technology, virtureality can be achieved with means of datafication.

4. Literature

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