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Diffusion of the "Internet of Things" on the world of skilled work and resulting consequences for the man–machine interaction

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Abstract

Background: The vision of an "Internet of Things" seems to capture numerous application fields at present, especially in the field of logistics. Despite the undisputed advantages the implementation of the "Internet of Things" also exerts a crucial influence on the social and economic forms of organization and on the organization of work. The implementation of the "Internet of Things" marks a new level of the division of work in the field of man–machine interaction. This article concentrates on the current level of application of the "Internet of Things" in the logistic sector and presents the resulting consequences with respect to skilled workers.

Methods: Within the framework of an empirical research qualitative vocational educational scientific instruments of early recognition were used to analyze the impact of the "Internet of Things" on skilled work. A literature and document analysis as well as expert interviews were conducted in order to analyze the current development status of the "Internet of Things' within the field of logistics. Within a next step innovative companies and research projects were analyzed for the implementation and realization of the "Internet of Things" in skilled work and companies for case studies were selected. Following the case studies expert interviews were conducted for a deepening qualitative analyses.

Results: The application of the "Internet of Things" appears to be a creeping process. Although it emerged that companies are increasingly dealing with the "Internet of Things", the grade of diffusion was mostly comparatively low. But despite this low level of diffusion, some companies could be identified that are already witnessing sustainable changes in their workflow due to the technological changes based on the implementation of the "Internet of Things".

Conclusion: Depending on the aim that is pursued by the companies the "Internet of Things" can be applied in different ways and with different consequences for skilled work. Two major development strands could be identified:

1. the development of expert systems as a tool for qualified skilled workers;
2. limitation of the autonomy of accomplished skilled workers by the emergence of advanced technology in plants and machines (automation scenario).

Keywords: "Internet of Things", Man–machine interaction, Skilled work, Early recognition research

Background

The ongoing development of information technology in the world of work

The introduction of IT-systems has led to fundamental changes in numerous fields in the world of work in recent years. Above all the networking with the aid of IT-applications has created many possibilities to monitor complex systems and processes and to control them more and more without human interference. Weyer (2007) comments this development as follows: “Ein besonderes Merkmal der jüngsten Entwicklung ist zudem das scheinbar unaufhörliche Vordringen autonomer technischer Systeme, die immer mehr zu Mitspielern in derartigen Netzwerken geworden sind. (“Translation”: A specific characteristic of this recent development is the apparently continuous permeation of autonomous technical systems which have increasingly become players in such networks.)”. The emergence of “hybrid constellations, permeated by human actors and (semi)autonomous machines” (cf. ibid.) is one of the consequences of this development. The autonomy of IT-systems seems to increase while the role of the human actors is taking a back seat.

The implementation of the “Internet of Things” is considered to be one of the main triggers of this development. The term “Internet of Things” was first introduced in the year 1999 by the Massachusetts Institute of Technology (MIT). It was defined as a “[…] information-technologically networked system of autonomously interacting things and processes, characterized by an increasing self-organization and leading to a merger of physical things with the digital world of the Internet” (Brand et al. 2009). As for the field of logistics, the Institut für Materialfluss und Logistik—IML—(Institute for Material Flow and Logistics) defines the “Internet of Things” as the autonomous, self-controlled transport of logistic objects from the sender to the consignee (cf. Ten Hompel 2005).

What does this exactly mean for corporate processes in the field of logistics? A parcel in a logistic process would no longer be a simple item to be transported from A to B. Instead it exerts direct influence on its own path. Based on the approach of the “Internet of Things”, the parcel is equipped with “intelligence”. By using e.g. RFID-labels, it recognizes its destination within the logistic system by itself. All means of transportation integrated into a logistic process are equipped with RFID-Readers[1] and are thus able to read out the parcel’s label. The information stored on the RFID-label can now be used to control the logistic process. The decision on the exact path of the parcel is no longer made by a central control system or a human being but by the means of transport in cooperation with the parcel.

With the aid of the “Internet of Things”, every object can be enhanced or equipped with digital information from the Internet and thus be guided and controlled. This process does not only create new economic values, it also increases the value of the information available in the Internet. Companies will finally depend on accessing these new value potentials and to master the resulting challenges (cf. Schmidt et al. 2008).

[1] RFID-Reader: A special electronic device which can emit and receive electro-magnetic waves of a specific frequency and range in order to read out the contents of RFID-TAGs (Zahn 2007). RFID-TAG: A very tiny microchip with an integrated antenna. When prompted by the receipt of specific radio waves, the chip sends out stored data via radio waves.

Development status of the "Internet of Things"

The fields of application of the "Internet of Things" are diverse. First approaches can be found in the sectors healthcare, smart home, transport, logistics and industrial production. Especially the logistics sector seems to be very interesting in this context because the meaning of the field of logistics increases dramatically at the moment. Outsourcing, distributed production processes in different areas, the reduction of inventory, Just-in-Time production etc. lead to a key role of the logistic processes (cf. Botthof and Bovenschulte 2009). The technologies of the "Internet of Things" can be used to fulfill this key role and to cope with the increasing dynamic of logistical processes as well as to help to stabilize and to speed up the flow of goods and the flow of information.

The equipment of objects, rooms and machines with different technologies for the perception of the environment, data storage, communication and autonomous acting forms the technological basis of the "Internet of Things" (cf. Dworschak et al. 2011). Above all RFID is increasingly applied and it is considered to be a key technology in the context of the "Internet of Things". RFID-systems can read out data contactless and without intervisibility. These devices consist of a scanner and a transponder and/or a "tag", i.e. a chip with an antenna. The object equipped with the device can thus be unambiguously identified and the exact path of the individual products can be tracked. RFID-systems can be combined with a set of sensors that can be embedded in the products themselves. These sensor data can be automatically updated with the aid of RFID. Due to increased demands with respect to flexibility and mobility, the development of the RFID-systems and sensors tends to wireless systems that require a radio-based transmission of information.

Digital product memories,[2] the intelligent networking of products and the autonomous acting with the aid of special software agents and assistant systems are considered to be the potential application spectrum of the "Internet of Things" in the field of logistics. Further fields of application are logistic control and tracking systems as well as the self-organized transport of logistic objects by in-firm and external transport networks (cf. Ten Hompel and Bullinger 2007).

Obviously the application possibilities of the "Internet of Things" in the field of logistics are diverse. And they all seem to have a positive and long-term influence on the efficiency and effectiveness of logistics processes.

Moreover a considerable number of research projects have been implemented for the promotion of these application possibilities. "IKT (Informations- und Kommunikationstechnologien; Translation: Information and communication technologies)[3] for Logistics and Service Tasks" represents an important focus within the program IKT 2020 of the BMBF (Bundesministerium für Bildung und Forschung; Translation: German Federal Ministry of Education an Research) with a target-oriented promotion of the aspect of the "Internet of Things". But also other fields of promotion offer relevant activities, e.g. the Federal Ministry for Economy and Technology (BMWi). Projects with emphasis on "convergent IKT" (Next Generation Media) are promoted within the field of logistics.

[2] In this case objects are equipped with "Smart Labels" combining radio frequency identification (RFID) with their own power supply and a set of various sensors. Thus the products are able to compile data from their environment. The state of the goods, the state of freshness, storage temperature, origin etc. can be controlled and read out at any time (Brand et al. 2009).

[3] IKT: Information- and communication technologies.

Regarding these developments it seems very likely that the implementation of the "Internet of Things" will be further promoted.

However this development will lead to an increased complexity of technical structures of information and communication technologies. This new level of technical development exerts a crucial influence on the social and economic forms of organization and on the organization of work. Contrary to machines which carry out tasks and processes determined and controlled by human beings, the networked systems in the "Internet of Things" are able to make their own decisions. The implementation of the "Internet of Things" therefore marks a new level of the division of work in the field of man–machine interaction.

This interaction between man and machine is a crucial factor and has so far played a subordinate or even no role at all in the development of the individual technologies and products. On the one hand these technology-based developments are dominated by a technology-centered automation strategy, i.e. the ambition to develop and implement zero-defect systems and to eliminate the human being as a possible error source. On the other hand experts do not tire to emphasize the significant role of human.

Thus it remains to be clarified how the cooperation of man and machine will look like when machines gain more and more intelligence and the authority to make their own decisions within the running process. What are the consequences for skilled work that accompany this development?

Leading questions for the diffusion of the "Internet of Things"

There are first activities in Germany dealing with the concrete effects of the technological developments towards an "Internet of Things" in the world of work and in skilled work. They are embedded in initiatives of early recognition and the research network FreQueNz,[4] funded by the Federal Ministry for Education and Research. The main objective of early recognition research is to identify future, new or changing qualification requirements in the world of occupations and work at a very early stage and to swiftly integrate them into the shaping processes of vocational education and training.

Altogether three studies with emphasis on the "Internet of Things" are being funded in the following application fields:

- Logistics,[5]
- Industrial production and
- Smart House.

The present article concentrates above all on the transfer of the "Internet of Things" into the real work processes at skilled worker level in the fields of logistics. Based on the leading questions within the so-called FreQueNz study the survey focussed on following questions:

[4] FreQueNz is a research network in Germany, funded by the Federal Ministry for Education and Research. Various institutions are contributing to the early recognition of qualification requirements with their project work.

[5] Georg Spöttl and Lars Windelband kindly supported this article with the results of their research activities in the field of logistics within the framework of the study on early recognition FreQueNz (Windelband et al. 2011).

- To which extent is skilled work in the field of logistics already confronted with the "Internet of Things" and
- what are the consequences for the organization of skilled work?

Apart from the technical development of the "Internet of Things" in both research and practice, the article shall discuss the various consequences for skilled work and make statements on the possible changes of business processes and work cycles up to work tasks within the companies.

Methods

Research design of the study on the "Internet of Things"

In order to answer the research questions, three research steps[6] were selected which apply the qualitative vocational educational scientific instruments of early recognition (Becker and Spöttl 2008; Windelband 2006; Windelband and Spöttl 2003):

1. Within the first step literature and document analysis as well as expert interviews were conducted in order to analyze the current development status of the "Internet of Things" within the field of logistics in the sectors Foods and Automobile Industry.[7] A second purpose was to identify key persons and innovative companies as well as research projects in order to find experts and interesting cases for further steps.
2. The second step of the survey included the implementation of case studies in order to allow first conclusion to be drawn regarding possible implementation scenarios of the "Internet of Things" as well as consequences for the world of work that accompany this development.
3. In the last step the results of the case studies were discussed in deepening qualitative analysis (expert interviews) in order to identify consequences for skilled work as well as possible changes in qualification requirements.

Literature and document analysis

With the help of the literature and document analysis the current status of the technological development in science and research could be identified. The results of the first step also permitted an overview of current research and development projects. The analysis focussed on following questions:

- What is the vision of the "Internet of Things"?
- Which technologies are combined within the idea of the "Internet of Things" and how does the current state of development look like?
- What kind of prototypical applications and pilot projects can be found within the field of logistics?
- Are there any information about already known consequences of these technologies regarding the world of work, skilled workers and changes in qualification requirements?

[6] The instrument of the future expert workshops was applied as a fourth instrument for possible and changing needs for qualification. This leading question will not be discussed in detail in this article.

[7] These two sectors were selected during a preliminary study. The identification of the practice areas concentrated on those already applying the "Internet of Things".

In order to analyze the current state of research qualitative expert interviews with technology developers and employees of research institutes were conducted. Five experts out of the fields of cold chain logistics, sensor technology, RFID development and application and telematics in logistics were questioned in the form of guided interviews. For the documentation of the interviews different methods were used. Some conversations were recorded on tape, others were documented by memos or minutes by memory.

With the help of the experts, different companies were identified that make use of technologies of the "Internet of Things" in the fields of application.

Case studies

Within the framework of case studies six innovative companies and two research institutes were surveyed that were either part of development activities of the "Internet of Things" or already using it within their processes.

Within the company case studies different target groups were questioned in the form of half-structured interviews in order to gain information about the latest technologies in the framework of the "Internet of Things" that are implemented in practice and the consequences for skilled work that come along with them. In order to gain information out of several perspectives, members of the management were conducted as well as employees out of the development department and skilled workers that are actually working with the new technologies. Within the interviews different questions were asked regarding the details of the specific case (employees, sector, products etc.) as well as technological changes in the last years. The focus of the case studies was the recording of changes in work tasks and the resulting consequences for changing or new qualification requirements. Besides the interviews further instruments were used during the case studies including work observations and company presentations. These instruments have been put in place in order to gain an overview of the whole company and to be able to interpret the work processes as well as to get a better understanding of the process structure.

The aim of the research institutes case studies was to analyze new developments regarding the "Internet of things". Current research and development activities should be identified in order to provide a basis for better assessing the further developments in this field in the next 3–5 years.

Similar to the documentation within the literature and document analysis different methods were used for the documentation of the results. Besides the recording of interviews on tape and the use of minutes by memory, memos were mainly used to report the impressions that were gained during the case studies. The analysis of the case studies was proceeded in two stages. In the first stage case documentation were generated based on the structure of the interview guideline for each individual case. In the second stage all cases were classified within a standardized structure in order analyze the leading questions.

Expert interviews

Within the third research step, the results from the first two steps were intensified with the help of qualitative interviews in order to gain more information on emerging development trends. The target group encompassed selected representatives of companies and sector experts. Apart from the prerequisite to be an expert for the "Internet of Things", the selection of experts was based on further parameters: high practice orientation, cooperation in future-oriented projects as well as a focus on one of the two application areas—foods and/or the automobile industry. In the framework of the interviews four experts were questioned. The interviews were documented in form of tape recordings, memos and minutes by memory.

Results and discussion

Level of diffusion of the "Internet of Things" within the surveyed cases

In order to make a statement on the level of diffusion of the "Internet of Things" within logistical processes an instrument for the measurement of the "depth of diffusion" was developed. The instrument is based on two models to classify intelligent products and objects. On a model by Meyer and Främling (cf. 2009) which classifies intelligent products and on the classification approach for intelligent objects that was developed within a project named PROMISE (cf. Promise Consortium 2008). In combination of these existing models with the results of the literature and document analysis and expert interviews the following instrument was developed (cf. Table 1). It encompasses six characteristics which help to identify the depth of diffusion, i.e.: technology, energy supply, connectivity, information processing, aggregation level and location of the intelligence. In more detail:

- With regard to "technology", Level 0 indicates that no technology at all is in use (therefore no indication in the table—this applies for all characteristics of Level 0). Level 1 makes use of an auto-ID (identification), e.g. a RFID or barcode system. Level 2 describes the use of sensors, i.e. for example a sensor network. Level 3 eventually applies embedded systems, i.e. equipment with decision-making components.
- The characteristic of "energy supply" is completely neglected at Level 0, i.e. no energy is supplied. Information is e.g. read out manually. Level 1 comprises systems which make use of induction for their energy supply, e.g. the reading out and description of passive RFID-transponders. Level 2 is characterized by systems that are supplied with energy from an accumulator and by using active RFID-transponders. Systems of Level 3 have a self-sustaining energy supply.
- The characteristic "connectivity" is again inexistent at Level 0, i.e. the system does not communicate. Level 1 describes the manual reading out of information, i.e. the system communicates only passively. At Level 2 the system communicates on demand,

Table 1 Characteristics of the "Internet of Things" in the field of logistics

Level	1	2	3
Technology	Auto ID	Sensors	Embedded system
Energy supply	Induction	Accumulator	Self-sustained
Connectivity	Manual readout	On demand	Continuously
Capacity to process information	Storage	Message	Decision-making
Aggregation level	Packing level	Object level	Component
Location of intelligence	Network	Object	Distributed

e.g. in case of a signal sent to the control centre or a supervisor during a certain event, e.g. if a measuring value is exceeded. Level 3 systems continuously communicate with other systems and are "online" at all times.

- The characteristic "information processing" indicates how the object deals with information. At Level 0 no information is processed. For most of the systems this also means at the same time that no data at all are compiled by the object. At Level 1, information is both compiled and stored, however, not further processed as e.g. in a temperature logger. At Level 2 information may be relayed to other instances without being processed by the object itself. These applies e.g. for telematics systems which can emit a status message in case of certain events. At Level 3 the object is capable to make a decision. This applies e.g. for embedded systems.
- The "level of aggregation" of a technology at Level 0 is inexistent. At Level 1 the technology is placed on the packing, for example on a cardboard box or a container. Level 2 describes a technology at object level, i.e. at the level of a finished product. In terms of vehicles, this technology would be applied per car. Level 3 systems are applied at component level, in vehicles e.g. on a seat.
- The "location of intelligence" at Level 0 is inexistent. At Level 1, the intelligent systems are distributed within a network. A possible application scenario would be the already described sensor network. Level 2 is marked by intelligence at object level, i.e. on the final product, whereas Level 3 describes various locations for intelligence, i.e. different sub-systems are used at different levels. They are, however, interlinked into a system.

Although it was obvious that companies are increasingly dealing with the "Internet of Things", the grade of diffusion was mostly comparatively low. The evaluation of the case studies showed that hardly any company had reached the second or even the third level. Above all the objects are so-far not autonomously communicating with each other and do not exert any direct influence on the flows of commodity. With regard to the surveyed fields of practice in the companies, i.e. the concrete fields of application of the "Internet of Things", only a low diffusion of the "Internet of Things"-technologies could be identified, mostly just reaching Level 1 according to Table 1.

In spite of this generally relevant result, some companies in the field of automobile and food logistics could be identified that already had basic technologies available which are required for the implementation of the "Internet of Things".

In the field of automobile logistics these companies apply at least barcodes or make use of RFID. The data are mainly read out manually with an adequate (mobile or stationary) barcode reader. Only in companies with RFID-technology the data readout took place automatically. In this case the objects carried a data storage unit, a prerequisite for networking as stipulated by the "Internet of Things". In the majority of cases a company-specific IT-system is customized for the purposes of the company. In most cases this system was specially developed for the designated objective. No company at all makes comprehensive use of this technology or leaves decisions to an algorithm receiving the required data from integrated objects. The data are used for the optimization of the logistics chain (often just up to the company gate). They help to monitor and optimize processes and to control product flow paths and inventories. The information and communication systems are being used in a variety of forms. They support the employees of the operative area in all companies. The work steps, the required objects etc. are shown in a display and the operation is mostly confined to simple data entries (number of parts, barcodes etc.) in predefined fields.

In the field of foods logistics/foods distribution the application of this technology was highly divergent. Today, all companies use telematics systems which keep dispatchers and drivers in constant contact via a network. The dispatchers' computers are connected with the onboard PDA or notebooks in the vehicles. These onboard computers mostly have a variety of integrated functions. They are used for the organization of the tours and can also be applied for sending e-mails, as a mobile phone or as navigation systems. The complex tools (fleet management systems) which are applied by the dispatchers are also used for tour planning, organization and control and to determine the exact position of the transport vehicles and goods. The basic technologies required for the "Internet of Things" are only marginally applied. One of the three surveyed companies uses RFID internally in order to start-up the correct cleaning program for the transport containers. Another company applies sensors for the control of the temperature in cooling containers. As soon as the temperature rises, the dispatcher receives a message via SMS on his mobile phone. He or she must then take a decision on what should happen to the container. So far, both companies do not plan a further development of the system or to base it on a self-controlled algorithm.

Figure 1 shows a radial diagram of the characteristics of the six case study companies with respect to their application of technology. As the figure illustrates hardly any company has reached the second or even the third level. As for the field of application of logistics it is underpinned that "Internet of Things"-technologies are so-far mainly used within a company ("Intranet of Goods").

It cannot be excluded that more characteristics will emerge in the future. The three levels reveal how far the diffusion can proceed if the development for the implementation follows the "vision" of the "Internet of Things". However, this does not mean that Level 3 stands for the "ideal level" for a logistics chain across several companies. This strongly depends on the conditions of the logistics process. On Level 3 and across all six criteria the process would proceed automatedly and with an autonomous decision-making. This level comes very close to the "Internet of Things" with an autonomous and self-controlled transport. It is, however, not necessarily desirable for every company.

Consequences of the implementation of the "Internet of Things" for skilled work

In spite of the so-far minor diffusion of the "Internet of Things" into logistic processes, some companies could be identified that are in fact witnessing sustainable changes in their workflow due to this technology. Also the employees' work tasks were subject to changes. These companies mainly focus on the automation of work cycles and the digitalization of information. A technology mix consisting of digitalized documents, the detection of geographic positions via telematics, special onboard terminals for status monitoring and an integrated flow of information via the Internet support these companies in delivering more efficient services. Two major development strands could be identified:

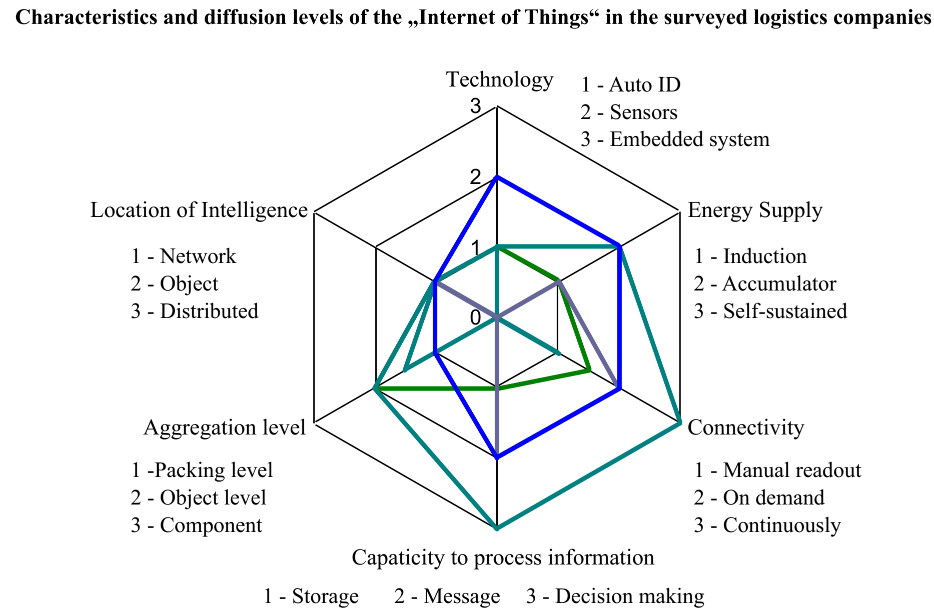

Fig. 1 Characteristics and diffusion levels of the "Internet of Things" in the surveyed logistics companies

1. On the one hand the technology was applied in order to automate processes and to reduce the error frequency during work processes. The work tasks and the respective requirement profile at the level of skilled work thus have often been simplified. This resulted in the fact that lower qualified personnel could be quickly deployed at lesser wages and without an extended on-the-job training.
2. On the other hand technologies for the "Internet of Things" were used to optimize work cycles. At the same time this has changed the fields of tasks for the employees. As the implementation freed up capacities of the employees, they could take over other tasks instead. This resulted in the fact that the fields of tasks became more comprehensive and above all more diverse. Such companies normally relied on very well trained skilled workers and reacted to the change of tasks with further qualification measures.

While the first development strand mainly affects the unskilled and semi-skilled workforce in the companies, the second strand aims at the group of skilled workers. The sketched development strands lead to different work-organizational solutions and thus have a different impact on the affected groups of skilled workers.

If the development strand aims at an automation of the processes, technology takes over decision-making processes and carries out technologically predefined work routines via program-controlled cycles. In this case the operative tasks of skilled workers are simplified with the exception of malfunctions and other problems within the system itself. Thus on the one hand routine tasks are increasingly simplified and more and more decisions are made by the system itself but on the other hand the employees must be able to intervene in the process in the case of malfunction. The surveyed companies showed no uniform strategy for the shaping of work organization in order to cope with these contrarian tasks.

With respect to the development strand to optimize the work processes with the aid of the "Internet of Things", the companies always aimed at taking their employees' strong points into consideration. This resulted in the fact that decision-making processes were not left to the system but to human beings. As a rule the employees got supporting information on process optimization but were given the chance to co-shape the processes. The skilled workers must have a high process-specific knowledge in order to be able to intervene in case of problems or to make decisions. This development strand offers skilled workers the chance to make use of the technologies as assistance systems.

Conclusions

Conclusions on the interaction between man and machine

The development towards autonomously acting systems will turn the relationship of man and machine upside down. An implementation of this technology will have a considerable impact on the world of work. The survey shows that first approaches of the "Internet of Things" can already have an positive impact on the flow of goods and it is probable that these development will continue to proceed if the application of the "Internet of Things" will be intensified in the field of logistics. But there is still a long way to go towards the automation of entire processes or process steps. Here and there partly automated processes can be identified. Two major development strands for the future are already emerging:

1. The development of expert systems as a tool for qualified skilled workers (tool scenario);
2. Limitation of the autonomy of accomplished skilled workers by the emergence of advanced technology in plants and machines in the field of logistics (automation scenario).

Should the development proceed in the direction of the tool scenario and should human beings keep their freedom to shape, this technology could be employed as a kind of assistance system. One example for this development is the simplification of the planning activities for dispatchers in forwarding companies. The application of technologies according to the "Internet of Things" could result in the fact that the vehicle driver takes over some selected tasks from the dispatcher. Man and machine thus interact as authorized acting units that control each other reciprocally. The driver could carry out the dispatcher's tasks directly at the customer's or en route in his or her vehicle. The technology provides the driver with adequate aids on site (data forms, selection of driving jobs). He or she would not simply work off his or her jobs but could even intervene in the order sequence according to the particular situation. The driver could thus directly react to traffic imponderabilities or customer wishes and could shape his or her tour in an optimal way. At the same time the technology could offer support with the autonomous acquisition of new orders.

These considerations are opposed by the statement that "the driver should above all be functional": "He or she should not hit any obstacle, he or she should be nice to customers, he or she should adhere to his or her driving schedule." (Statement of a company manager). Drivers should adhere to specifications given by the dispatchers or by respective technical systems. A critical reflection or discussion is not desirable. This would mean a development towards the automation scenario. In this case the technology or the “Internet of Things” guides the skilled workers and the work of the “Internet of Things” is entirely controlled by the technology. Skilled workers are not provided with information and do not have any responsibilities. The resulting competency gap entails that a shaping of work processes is only purposeful if guided by the “Internet of Things”.

Consequently one of the central questions remains: How will the future profile of skilled work in logistics develop as soon as technologies such as the “Internet of Things” are entering the scene? The results from the case study do not yet show an unambiguous trend, even if a development towards a (semi)automation of the processes is above all favored by the research institutes. According to experts, the technologization of the work place will lead to clearly more complicated work tasks. A semi-automated support of the work can even trigger acceptance problems in the employees. For example: Technology often sets too tight limits or gives instructions on e.g. where the driver is allowed to fill up his truck. The drivers often neglect—or have to neglect—these directions for different reasons. The manual recording of conditions (e.g. waiting at the loading ramp) requires a highly disciplined behavior of vehicle drivers. Employees often feel constricted in their ability to act as soon as the cycles are determined by technology. The acceptance and the motivation of the drivers may then decrease.

So-far neither the employees nor the companies are prepared for these entirely different technological structures which excel by new information and communication structures.

Assuming that there will be a development towards more (semi)automation in the short- and medium term, the field of tasks of employees is likely to change. Routine tasks will decline and more (difficult) special cases will take their place. This phenomenon is derived from the so-called automation paradox. In an automated system, the employees only have to interfere in case of difficult malfunctions. These problems, however, often call for a higher qualification which the employees are no longer able to develop. This situation, which can already be witnessed in so-called high-tech-fields (e.g. airplane maintenance), is likely to spread out to all employment fields along with the possibilities of comprehensive networking. The so far open question which must still be clarified by upcoming research work is how vocational education and training should react to this scenario and which strategies or concepts could be an answer to such developments.

Abbreviations

BMBF: German Federal Ministry of Education and Research; BMWi: Ministry for Economy and Technology; IKT: information and communication technologies; IML: Institue for Material Flow and Logistics; ITB: Institut Technology and Education; MIT: Massachusetts Institute of Technology; RFID: radio frequency identification.

Compliance with ethical guidelines

Competing interests

The author declares that he has no competing interests.

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