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Jonas Gebhardt (Europa-Universität Flensburg)

Axel Grimm (Europa-Universität Flensburg)

Laura Maria Neugebauer (Fachhochschule Flensburg)

Developments 4.0 Prospects on future requirements and impacts on work and vocational education

Herausgeber

Bernd Zinn

Ralf Tenberg

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Jonas Gebhardt (Europe-University of Flensburg)
Axel Grimm (Europe-University of Flensburg)
Laura Maria Neugebauer (Fachhochschule of Flensburg)

Developments 4.0 - Prospects on future requirements and impacts on work and vocational education

Abstract

Where are we heading to in the future, and how will the future working world look like? Technological innovations and rearrangements, for example the digitization and networking of value chains, experienced by the future object "Industry 4.0" (by German government) enjoys increasing attention. The target is economic nature: the economy has to be strengthened. The need to answer the initial question for politics, business, research and education increases parallel to the need of a strengthened economy. It is to draw out and estimate the current workers and their know-how, in terms of the ability to work in the digital work environment. This article has designed a perspective on requirements for future work 4.0 and displays the effects on the German system of the vocational education of skilled workers.

vocational education, future scenarios, Industry 4.0, digitalization/digitization, competences

Entwicklungen 4.0 – Ausblicke auf zukünftige Anforderungen an und Auswirkungen auf Arbeit und Ausbildung

Zusammenfassung

Wo geht es hin und wie könnte die zukünftige Arbeitswelt aussehen und wie ist darauf vorzubereiten? Technische Innovationen und Neuanordnungen, z. B. die Digitalisierung und Vernetzung von Wertschöpfungsketten, erfahren durch die Zukunftsvision „Industrie 4.0“ im zunehmenden Maße Aufmerksamkeit. Das Ziel ist ökonomischer Natur: Die Wirtschaft soll nachhaltig gestärkt werden. Parallel steigt die Notwendigkeit für Politik, Wirtschaft, Forschung und Bildung die Eingangsfragen zu beantworten. Es gilt gegenwärtige Arbeitnehmer/-innen und ihr Know-How, in Bezug auf die Arbeitsfähigkeit in der digitalisierten Arbeitswelt, herauszuzeichnen und einzuschätzen. Dieser Beitrag gestaltet eine Vorausschau auf Anforderungen an die zukünftige Arbeit 4.0 und Wirkungen auf die Aus- und Weiterbildung von Facharbeitern.

Berufsausbildung, Zukunftsszenarien, Industrie 4.0, Digitalisierung, Kompetenzen

Prolog: Scenario 4.0

A customer sends photos of his new building, which he took with his smartphone -via the app (application software) created by the kitchen producer. The customer marked the location from the supplying lines on the images and sends as well, by attaching the building plan to the image, the exact dimensions for the planed kitchen island. The customer designed his "dream kitchen" through an online simulator and co-ordinates the planning with the kitchen producer online.

The process takes its course: machinery and products communicate with each other, notice their environment by reading and identifying information's on RFID tags (radio frequency transponder) or QR-codes (Quick Response Code) which are located on the material support or on materials themselves. They give feedback to their robotic production environment, respond in real time to the current inventory, take resource-dependent decisions and send the human employees optional instructions on how to proceed. The employee gets the information about the process status on the display of his supporting smart glasses and can directly intervene on the tablet in the process. Parallel he disposes another job. At the end of his workday, he legitimizes through its tablet the subsequent layer for access to appropriate production protocols and machine accesses. At the same time the customer can observe the progress of the order, similar to the tracking of parcel companies, with the company's app. It is possible that the customer can make changes on his order to a certain development progress.

The individualized kitchen leaves as terminates the factory and is delivered to the customer. The customer commissioned in advance his local carpenter of trust to start with the installation and the set up of the product. The carpenter just has to read the QR code with the camera of the smartphone from the delivery to get all the images, dimensions and assembly send on their synchronized tablet. Before they even begin to set up the product, they are standing directly in the center of the kitchen and they orientate themselves on the one hand by the transmitted blueprint files on their tablet and on the other hand by an already experienced 360 degree swivel with the camera of the tablet. The display shows a digital blueprint of the kitchen and simulates their installation in the existing room. It supports the carpenter visually in the positioning of the devices; a projection via a mobile 3D-projector increases the illustration, while installing. In according to bring simulation and planning in harmony with the reality, the craftswoman measures again.

The batch size of one - the individual product in mass production - reached with the assistance of digitized processes and associated service management functions, starting from the customer`s order through production, delivery and installation of the craft, the customer and all of it with the cost of a mass product.

This is already Industry 4.0? Yes, even if the example, which is chosen here, is an abstract matter of Industry 4.0 and illustrates the idea too compact. For research representatives and industry partners of federal political excellence initiatives and technology clusters, this scenario might lead to various irritations. This practical example might already be Industry 4.0 and is partially already practiced in real businesses in comparable technical/digital interfusions.

A compact introduction to Industry 4.0

The high-tech strategy of the Federal Government of Industry 4.0 aims to provide the enterprises in the high-wage country Germany in global competition a locational advantage, through flexible production with high quality individual products. In an integral manner with respect to SMEs and the craft, one can also speak of economy 4.0. The reference to industrial 4.0 and predominant use of that term in this article refers primarily to technological change in all businesses and to the general high-tech strategy of the Federal Government. It is thus no contempt to nonindustrial enterprises. Industry 4.0 means that processes and products must be largely digitized and automated. Information-infrastructure and production are to operate as a unit.

The aim is efficiency gains through transparent real-time communication in the value-added networks (see Hengsbach 2015 & Veit 2015) to respond rapidly to supply and demand. These individual mass production means that the customer takes a more active position as a "prosumer" (see Sattelberger 2015). The technological innovation capability of enterprises and the development of new processes and models are considered to be key factors for the future economic prosperity and employability of workers (see Temple 2015).

Renowned German and global industrial companies and pilot projects in peak and research clusters are considered high gloss examples of an implementation of 4.0 technologies in the operating process. Representatives of these companies push together with research institutions and ministerial support measures actively the implementation and shaping of the digitized world of work.

Also criticism arises:

- German companies and their structures are too sedate for Industry 4.0 and the development of industrial standards for machine language; one had already been displaced to the global backroom (see Rinke 2015 p. 9ff.).
- It`s a kind of misperception, that the German economy, along with the local education system and its present structures, ensure furthers the very best basis for a leading economic position (see ibid.).
- Existing problems and fears with regard to the acquisition of information from a cross-company networking of machines and materials need to be solved because innovation should never be done at the expense of safety (see Liggesmeyer & Trapp 2014).
- Higher quality jobs can be created, but the digitalization may also lead to the displacement of work (see Hoffmann 2015).

To date in the public perception, it seems only few SMEs outside ministerial funding's to give that represent their work as concrete Industry 4.0. In a study of more than 500 companies, the Fraunhofer Institute for Work and Organization identified, meanwhile, 29% than those in which an Industry 4.0 strategy exists (see Ingenics 2014, p. 6f.).

Effects on technology and influence on work

The common operational field devices or BUS-systems contained in machines for manufacture or logistical tasks receive an addition or a replacement by cyber-physic components. The qualifications (RFID-chips, decentralized BUS-systems, touch terminal device, sensitive robots) already exist. From now on this range of technology is seen and used in another context and configuration.

The path of the smart-factory is leading to the stage where things and machines communicate and switch information's with each other and with the employees in real time. This concept "internet of things" refers to the idea from a cross-company infrastructure created by Kevin Ashton from the Massachusetts Institute of Technology (MIT). The machines and materials receive a digital and programmable identity, called IP address. With this IP address the computer can source information's and react demand-orientated in form from algorithmic independent from the human influence. The digital and real world does now experience from their parallel existents a joining on an operational level. Exactly this way of digital connection is the next step in the evolution of the internal and intra-operational nervous system of the value chain and a leading element of the intelligent manufacturing from the Industry 4.0 (see Kagermann 2015). In this intelligent company the employees supervise the flexible manufacturing process with devices for the computer based reality perception (augmented reality devices like tablets or smart glasses), the employees immediately react if problems or process changes appear and the employees are assisted by fine sensory robot units. The direct impact is probably inevitable and will happen with the introduction of industry 4.0 rearrangements, because *"als eine zentrale Schnittstelle der Veränderungen erweist sich die Arbeit. Wenn wir über Arbeiten 4.0 sprechen, reden wir nicht nur über die Technikwelten der Industrie 4.0. Wir reden über die Arbeit der Zukunft in ihrer ganzen Breite und Vielfalt"* (Quote by Nahles 2015 (German secretary of labour and social affairs), see BMAS 2015, p. 6-7).

Technological development and innovation does in usual have an impact to the workflow and with that an impact to the concrete skilled work. The aim is to create a network that reaches from the development to the order acceptance, manufacturing and delivery etc. without the classic barriers from local separation like company- country- or language barriers.

Image 1 Clivot (2015): What kind of information and tools does the production staff need?

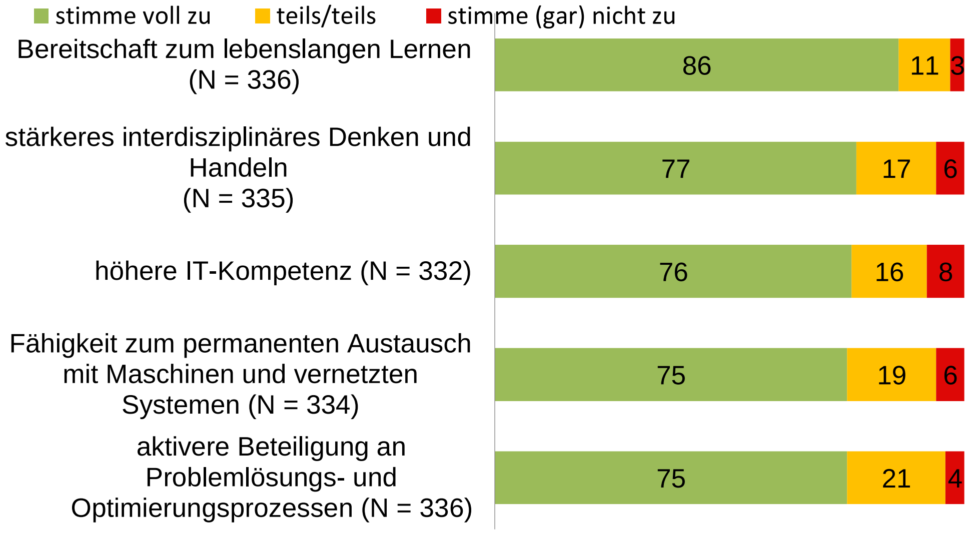
The new arrangement of digital technics from decentralized applications or controls become more users friendly and create as well a deeper process- and contextual understanding and a kind of "net-competence/Netzkompetenz" from the employees, which is more than necessary. Federal secretary for education and research Johanna Wanka talked about the humanization of the work at the BMBF-congress (of the ministry of education) "work in the digitalized world/Arbeit in der digitalisierten Welt". She mentioned that the human being and employees should always stay in focus of every aimed technical innovation and change and that the human being always will be the most flexible element in every process. That is a renewing awareness, because the production staffs are the ones who must interact directly with every innovation on the hall floor.

As a result the requirements to the employees can increase because the processes are getting more interconnected und more complex, especially in the area of the technical, organizational and social operations and work processes in the company (Image. 1, Clivot 2015). Michael Clivot refers in this case to the production staff of the future and illustrates that these should be strengthened to be able to connect employee-information with professional knowledge as well as company- and real-time machine information. New forms (non-standard employment) of distributed and outsourced commissioned work can increasingly finding their way, in Persona of crowd- and click worker (freelancer) The balance from flexibility, ongoing employment and social plus financial safety and pay scale classification (Gastbeitrag 2015) is going to be more and more important and will be emerged in the future. At the present time this is also one of the key points of current dialogues of representatives of workers, employers, policy research and quite controversial (cf. BMAS 2015 & BMBF 2015, Initiative Neue Qualität der Arbeit, Kompetenzmanagement im demographischen Wandel etc.). Professional and working scientific studies are prerequisites for a constructive approach to the future developments in work processes (see AHRENS & SPÖTTL 2015, p. 201).

The requirements for the digitized skilled work will rise because the processes are interconnected and more complex, particularly with reference to the overlap of technical, organizational and social spheres of activity and the work processes in the company. Fields of operation from different regulated professions and gainful occupations will change continually, with the result of generating synergies between different fields of operations according to the requirement and innovation for the purpose of a flexible interdisciplinary and related ability to act of the employees. To increase the affectivity of in-company communication and the necessity of that transparence and decryption are from now on even more linked to the skill of reading, understanding and interpretation of information. The competitiveness of companies to what extent more from the future functionality of new process trekking and automated systems or from the human employees themselves generate, particularly in terms of their analytical and creative ability to think, their technical knowledge, experience and overview knowledge and the ability to link new technological contexts and localization of their action in the professional field as well as overarching social interfaces - still remains a foresight. This new level of division of labor between man and machine applies increasingly to investigate it and to estimate (see automation and assistant scenario; Windelband & Spöttl 2011 p. 12).

The basis for the employability for nearly every qualified profession will be more dominated by a field of professional action and cross-industry application knowledge and experience and goes hand in hand with the necessarily of an always developing IT understanding. (see Zeller 2010, p. 79ff.). The longtime learning and developing of IT competences and the skill of the interdisciplinary thinking will be in the present and in the future a longtime task and will be one of the basic requirements on the specialized workers from different educational biography,

Image 2: Required competences in Industry 4.0 for the production staff (in %; Ingenics 2014, p. 26)



beyond the pure IT-professions. The Fraunhofer Institute prognosticates in a study of the human engineering and organization for work structuring in the production from the Industry 4.0 for the Ingenics AG, for the 518 representatives of German companies – from that 33% and 60% large concerns of the evaluated industry- have been asked. According to that is the willingness from an employee in the manufacturing for a long time learning (86%), a stronger interdisciplinary thinking and acting (77%) and a higher IT competence (76%) more and more important in the future. (see Image 2). In varying degrees and at different levels of IT operations demand the development of IT skills in all occupations and industries will need to increase sharply as a partial or core competence in order, inter alia to ensure the employability of workers (see. Hall et al 2015, S. 30f.). Based on initial estimates, and based on our own empirical findings, funded as part of a BMBF project (see. PROKOM 4.0 2015) were collected, developments for a work 4.0 can be outlined today. Due to the penetration of the professional qualified workers with transversal skills in the field of information technology and data processing, can be assumed that "more" or "other" respectively "more complex" knowledge, skills and abilities in the professional qualified work of the future are to be expected. This could mean that employee segments will move. Higher qualified staff for example, of higher vocational education (Fachschulabsolventen) and university graduates are more in demand and this for example at the expense of employees with lower qualifications. Already today vocational education in the company a qualification sees it serves as a procedural learning to cope with operational tasks. These highly customized and lasting competence development through learning in operational contexts should be institutionalized to thereby give an operational answer to the "more needs" and increasing "complexity". New forms of work are going to be practiced, which are characteristic for shedding classic hierarchical thinking. Thus, it was found that non-academic but qualified vocational workers in software development already get early transfer project responsibility and academically staff in team does legwork for them.

Education and vocational education – Where could we head to?

Growing networking and digitalization of technology, production, trade and service area caused by inference an incontrovertible expansion of educational facilities in the mainstream school. Raising a corresponding information technology orientation and reflectivity of the individual, through the mediation of theoretical knowledge and the experience of practical and problem-oriented applications, will henceforth even greater significance - first in the school, following equally in all measures of vocational education, in the individual readiness or commitment to training "OnTheJob" and beyond. The continuous development of an interdisciplinary and multi-perspective understanding of classical professions addition, in the current dual system of vocational training, from the perspective of technology -savvy companies, is not yet strong enough (see Niggemann 2015). New requirements and qualification requirements to employees just also demand increasingly process-oriented curricula, career field overarching professional understanding and direct interaction with the real world of operational action (see Acatech 2013, p. 59ff).

Key qualifications, action orientation, competence orientation and learning field concepts promise a curricular framework, which can be reacted in the flexibly to the new demands of a digitized world of work. This is just possible for already existing job profiles. If a wide break trough would happen in the educational strong KMU it could create a new arrangement. The traditional separation from metal-, electrical- and information profession could switch into the new fields of the putting into operation, operation and maintenance. In the advanced trainings, there is also necessity for hybrid professional profiles. Findings from the surveys of the project PROKOM 4.0 show that for the higher vocational education in the non-academic advanced trainings for technicians segment has created new fields of professional action, towards the progress -to Industry 4.0. The here so far oriented traditional technologies of the technician training, e.g. electrical engineering, information technology, mechatronics, mechanical engineering - will have to respond to the diffusion of career fields. Former structures of professionalism merge into a new idea, owed by industrial requirements. The dynamics of the requirements for the professional jobs of the future requires less a fixed qualification profile, but rather an applied on competency development professional life - from vocational education up to retirement. Lifelong learning can therefore be considered as a prerequisite for a long lasting employment history, with respect to the short half-life coming unstuck digital information and communication technologies in the anticipated 4.0 developments.

Impact on the education for the training of school and company training staff

Domains with specific allocation problems already do exist, for the regulated profession of mechatronics. Caught in the “gap” between the professional fields of electrical and metal technology, it is the commitment and own technical affinity of teachers and trainers and trainers due to be able to make teaching-learning arrangements in the field of mechatronic systems. If we add information technical perspectives – for example the programming from a sensitive robot with Java- it is necessary to at least refer to three disciplines from the occupation didactical references. On the increasing complexity of digitization in the wake of Industry 4.0, which is caused, among other things due to the diffusion formerly isolated areas of competencies and qualifications, must be curricular reacts on the dual training courses, the full-time school vocational training and technical schools also. As well as for the company instructors, the inter-company training centers and teachers education for vocational schools is a shift of paradigm necessary. Organizational structures of training workshops and vocational schools are as questionable as the previous definition of vocational subjects for teacher training. Especially in industrial training companies a (spatial) separation between the metal and electrical technical professions is still living, whose authorization is traditional and curricular founded. To respond adequately to the requirements, for example in maintenance, i.e. during maintenance, inspection, repair and optimization of production, prepare, should take catchment interdisciplinary approaches. Instructors and teachers will therefore continue to open from their original domain and have to give space to the interdisciplinary as well in terms of IT skills. Forms of work, working methods, work routines and working strategies are increasingly backed in vocational training at the center of co-operative, competency-based and autonomous learning and teaching arrangement, to ensure sustainable the work ability of future qualified professionals in an increasingly interconnected and possibly collaborative operational environment. To set a great value upon the education and training of teachers and trainers and trainer’s professional methodical and –didactic, for example with a methodical way of self-experience, is more in the focus than before (see. „pädagogischer Doppeldecker“, Wahl 2006).

Impact on the level of education and instructional design

In vocational schools and the vocational operational education in companies itself will enforce project-like forms of learning. As a possible scenario for a future-oriented interdisciplinary professional education for industry 4.0 may be mentioned a project-oriented vocational school instruction. Vocational trainees of the third year of their vocational education[1], after first own estimates, industry 4.0 affine professions, work on a common project and gain their own close work experience. Mechatronics of the third year of their vocational education, electronics technicians of industrial technology, media designer and industrial clerks professional, work together on a project on work field and year linking. Their assignment contains to create a value chain to everyday life to design and simulate. They create an app in this partial project. The app should control and monitor the production chain with the batch size of one, which to the PLC

[1] At this point, the third year of vocational education is called, since we, after interviews with teachers and by reference to the respective regulations governing the vocational training, estimate that of current occupations, the potential complexity of 4.0 developments, rather already experienced trainees should be recorded.

a learning factory and associated programmable RFID tags (radio frequency transponder) and model-like base materials is coupled. The purpose is to generate a service like and flexible production process in this way in the abstracted scale. The mechatronics and electronics rely on the programming skills of the lower secondary level. In the general education they have already developed their IT skills by designing algorithms in reduced Java programming environments such as Scratch or Greenfoot (see image 3).The app, which has to be developed, exists already as an extensible program block. This further development of the IT competence could be even placed in the still current learning fields of the vocational education of mechatronics. An extension of the current learning environment 5 *”Kommunizieren mit Hilfe von Datenverarbeitungssystemen“* would be conceivable, in terms of developing an app as a control element for a production chain (see KMK 1998). Vocational trainees of various regulated professions and fields of professions interact with each other in this project, similar to the heterogeneous staff spectra in real life operational processes. Work processes are the professional field across simulated by the learners in the project to communicate, operate and market. A cross- faculty supports them and cross-professions are teaching team. Such a scenario could be the groundwork for vocational training lessons of professional competence development of prospective qualified professionals in the rearranged work fields of Industry 4.0. One development goal can be that learners deepening the skills and competences to act creatively and locate themselves in the digitized and networked operating environments

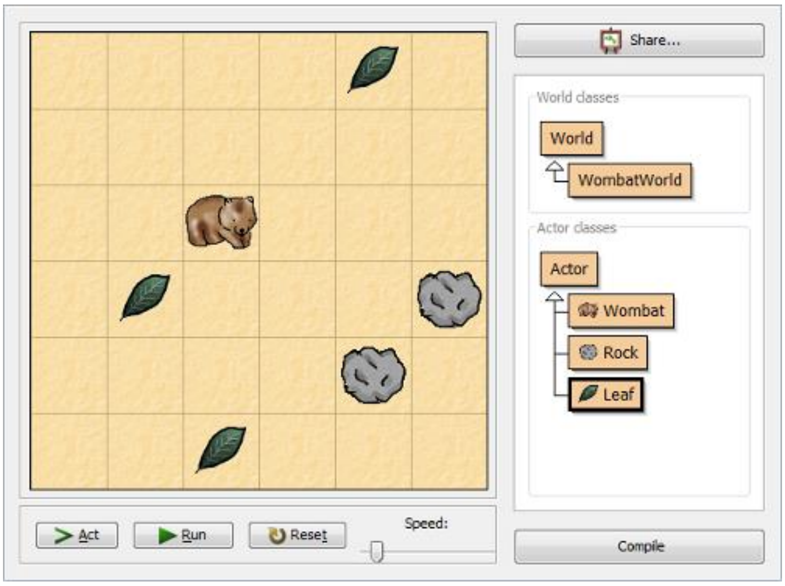


Image 3: Example of the surface of an interactive program-tool (Greenfoot 2015)

Controversy can arise that with the changes towards a digitized world of work a higher proportion of IT competence will be connected. The broad diffusion of IT into traditional job descriptions of the industry craft professions and inside work processes in designing a broader understanding of skills development and training in the vocational education and further education training The digital network - as always, it is now or in the future called (Internet, Web 3.0, etc.) - remains the technical requirement of all modern forms of communication (see Ceruzzi 1998). Learners and teachers should understand how a digital network works. This reflected a critical approach is developed especially in matters of data and system security. These, of professional didactic perspective yet to be analyzed “net- competence/ Netzkompetenz” is, form a foundation for both artisanal and for industrial trades in industrial and technical fields in the future.

New forms of learning will establish the medium term both in school as well as in operational contexts. What can be regarded as a normal form of learning in the work process or to cope with tasks in the IT sector already, will win for the metal and electrical industry is becoming increasingly important. In contrast to traditional ideas of knowledge transfer and knowledge acquisition objectives of cooperative knowledge communication and sharing are creative - productive justified and aligned. The activities serve, even if a group jointly elaborated results, in the final analysis, the learning and knowledge of individuals on its road to lifelong learning. Especially the media-based knowledge communication in groups also contributes to the fact that the learners prosaically, (meta-) practice communicative and socio-technical competencies and qualifications deepen. The individual creation and sharing of knowledge is taking on a new importance even beyond the IT industry in professional and private life. Forums and chats like wikis, YouTube and other social platforms are already a knowledge store for current generations, which are used for vocational teaching-learning purposes already in approaches (e.g. as for "Inverted Classroom"), their potentials and risks are still not reached and realized.

It is expectable that enabling professional competences can be developed in a sustainable complex of real-world learning environments with operating close to everyday problems in the operational fields of companies (see. Zinn 2014, p. 26). A similar school education, referring to the future-oriented example with crossed-professional projects, already finds support in the program Industrie4.0@School, which is funded by the German Electrical and Electronic Manufacturers' e. V. (ZVEI). Vocational trainees/students from the “David-Roentgen-Schule Neuwied” already experience Industry 4.0 since 2014, by planning and installing automatized and intelligent linked production processes together with their vocational teachers. This is done in interdisciplinary learning modules, whereby the trainees of different apprenticeships develop broad and generic competences and skills for the future world of work, e.g. as in the fields of robotics, PLC technology, network security app design and 3D Pressures (see ZVEI 2014).

3 Scenarios for the future in Industry4.0

At this point are imaginable and disputatious future scenarios for the Work 4.0 outlined - comparable to the trends of the "Internet of Things" for the qualification requirements in logistics (see Windelband 2012, p. 184f.). The following scenarios are based on estimates and anticipation and do not claim absolute validity. Rather, they are intended as compressed striking synopsis to serve as thought- and discourse-provoking impulse.

Scenario 1 – The loss of jobs of “low”-qualified and “low”-skilled workers

Former monotonous and physically stressful manual work will be eliminated through the use of automated robotics or assistance systems. At the same time the requirements increase on the level of qualification of the staff and their willingness to do professional developments. Untrained workers, regardless of their existing skills and proficiencies or informally developed competences, henceforth will have got even worse chances to compete in the employment market. Their current and in past done routine activities in production or service perhaps will fall victim of the efficiency to a "triumvirate" of digitization, automation and robotics. Although complex and creative matters from now on continue to be mainly achieved by the humans and the "ghost" of the unpeopled factory will not absolutely occur, the streamlining of the workforce contains, accompanied by flexible working models, always deprived areas and fear for their own existence - comparable to the doubts of the automation in the 60s and 70s of the 20th century.

Scenario 2- Reduced proficiencies

In the course of user-centric, clearly arranged simpler user interfaces of digital devices, the future operators will not need the whole variety of proficiencies, skills and qualifications of well trained and qualified employees. The operation of the software is done by fast taught future production-assistants. Only qualified and trained professionals or engineers monitor, as head of a work team, the IT-supported work processes in real time and only intervenes with complex problems. The risk is that the more assistance systems are integrated into the workflow, the greater is the threat of a disqualifying characteristic of future work 4.0. If decisions of qualified professionals are no longer required, but for example, be made by CPS systems, so just threatens the loss of competence of the skilled worker (see Windelband & Dworschak 2015, p. 83f.).

Scenario 3 – Reinforcement of the dual vocational education and higher vocational education and training

Adolescents will increasingly experience digitization and the development of their IT-understanding in educational system and in private. Society, politics and enterprises up value qualified professionals of the dual vocational educational system. The recent initiatives of academization opposed to a broad alliance for the attractiveness of dual vocational education. Vocational trainees are already transmitted more radius of operation and responsibility during the educational training. Concerns, who take part in this dual education, continue to benefit from the increased life- and work relating teaching-contents of the vocational schools. In the vocational school education, the upcoming qualified professionals henceforth work together in heterogeneous groups. They run operating practice-simulated projects and production-processes - with vocational trainees of different regulated professions and education vintages. Through this kind of interdisciplinary dialogue and the collective designing of intelligently networked production-processes, e.g. to practical Industry4.0 learning-modules, identification with the profession and the own certainty it will be accomplished. A close integration of already realized "on-the-floor solutions" of industry with the vocational schools in the certain regions would be a sustainable benefit. This design of the dual vocational training is comparable to the best practice models for the Industry 4.0 of the ZVEI flagship project “Industrie4.0@school” in vocational schools (see ZVEI 2015).

In higher vocational education (e.g. nonacademic master technician examinations) the specialist professional schools for technology provide its graduates the further development of necessary competences in the field of Industry 4.0. These specialist professional schools for technology do offer shaped modules that are interdisciplinary, basing on the forward teaching design of the dual vocational schools. The economy participates through waivers for works for professional development sand continuing education.

Scenario 4 - Academization

Dual vocational trainees can no longer meet the complexity of the digital work. Businesses want to promptly respond to demographic and technical changes as well as the market and follow the “principle of agility/ Agilitätsprinzip” (quick adaptation to changing conditions; see Schwuchow & Gutmann 2014), so as not to miss the boat. From an operational perspective, the dual vocational education system will be judged in the future to be too rigid, too conservative and lacking adaptable. This may arrive especially for occupations in the industrial and technical area, whose schooling at vocational schools has got no forward-looking, appear (see Niggemann 2015). Shifting of interests among potential vocational trainees, in terms of career choice and the aging society, raising the difficulty of individual businesses to fill apprenticeship places in an adequate manner with the desired personnel. In the future production processes are controlled decentralized, are digitally networked and correspondence with suppliers abroad will increase exponentially. The companies cumulatively demand interdisciplinary understanding, communication competences, multidisciplinary practical capacity and a wider understanding of the own junior staff. Then why not cooperate directly with a local university and focus on a dual study program, to deploy "practical professional academics/berufspraktische Akademiker" from operational fields of development to maintenance, instead of relying to the dual vocational education of vocational trainees. The demands for academic graduates (master of engineering etc.) will rise sharply and could be displace the need of qualified professionals with completed vocational educations (see Art. IAB 2015, p. 49).

Scenario 5 – Professional development

In the near future it not only will turn on the qualification and the skills, proficiencies and competences of young professionals. In terms of demographic change (aging population) mainly longstanding older staff and their potential to experience and knowledge need to be effectively integrated appreciative into future technical and work-political restructuring. Their competences and experience are to make sustainable and transparent accessible by allowing them to enter into the cooperative and collaborative dialogue as experts. Both, experience and multiple heterogeneous work teams on the operating floor of enterprises as well as in-house or external digital forums of the respective value chain, by using smart glasses or board-threads in digital semantic glossaries (ontologies), they apply themselves sustainable about issues and questions on action-specific work process. Particularly with regard to the flexibility of qualified professionals in production and fabrication, respectively in crafts, these workers prove themselves as particularly adaptable, referring to technical innovations and rearrangements in the workflow. They are the ones that need to be "picked up" by means of individually tailored on work training courses according to continue to ensure their employability. E-learning concepts seem in the wake of Industry 4.0 again increasingly becoming trendy and require not only the technology of a smart-app, but also purposeful teaching and didactics, especially in relation to suggestion increasingly complex CPS environments (cyber physical environment) in the everyday operation. Employees should be given more opportunities in company-internal and -external ways of professional development, to evolve as informed decisions in the operational process, regardless of level of education, qualification and age of the people. Special and individual continuing developments and trainings, in the field of IT (digital media) and the "net-competence/Netzkompetenz", ensure sustainable employability - in the spirit of lifelong learning and learning on the job.

Lookout

With regard to these possible scenarios and along with this, that technical changes generally attract modifications in work and therefore in the vocational education and training by themselves. Today it cannot be estimated yet that the politically motivated technical revolution Industry 4.0, in fact will have this character. Deserted factories we will probably and hopefully never see, although this vision already shook the Industry 3.0 (automation in the early 70`s of the 20th century). It probably will not even move tall production sites abroad and only the "think tank" stays in Germany. The recent report by the Institute for Labor and Employment Research (IAB - Institut für Arbeit- und Berufsforschung) at the possible consequences of Industry 4.0 for the German labor market assumes a structural change, including to a strengthening of the services sector and walks of professionals between traditional occupations and fields of work. Should Germany not be able to skill workers and future professionals with foresight and does not invest to develop competences of already qualified professionals to prepare for the implementation of technologies of Industry 4.0, decline in production and the rise in unemployment could be expectable (see IAB 2015 p.63f.). Also it is estimated that Industry 4.0 just according to the "usual" changes in the numbers of employed persons prior to the introduction of 4.0-technologies (in time we're still), could only affect moderate or temperate on the number of jobs (ibid. p. 49). Whether we will certify the revolutionary character in an review or not, in terms of vocational education and training need to be pursued on the integration of IT competences in the width of the industrial-technical vocational schools and all educational courses all over the whole educational school system. The managing of interdisciplinary professional work tasks - be it in the development, commissioning, operation or maintenance - requires a curricular fusion of traditional forms of organization. The question of whether the current occupations will continue to be sufficient to be prepared for future requirements surely cannot be answered yet. New job profiles or regulated professions, such as “keeper maintenance 4.0” (Instandhalter/-in 4.0) certainly are possible responses to the anticipated changes in the digitized world of work. The possible creation of such a qualified profession could be a result from the available broad-based knowledge in connection with practical operational fields of mechanics, fluid, electrical and information technology capable of acting to tread and to manage the interaction of virtual and real machines, controls and tune (see. Zinke, Schenk & Vasilyev 2014, p .39f.), although projected in the IAB in a scenario that the demand for labor force in controlling and maintenance jobs will fall around ten percent until 2030 (see IAB 2015, p. 58)

The outlined scenarios in the article are never redeemed solitary, but always can occur only as mixed forms. Preceding and all foreseeing requirements to Work 4.0 are to verify through empirical evidences (such as, discoveries from sector analyzes and observations of qualified professionals working in opposition to the possible 4.0-competences), taking into account different educational- and corporate sectors (see Kärcher 2015, p. 55). The fear of a digital heteronomy by the machines must be counteracted by development of multiple perspectives, critical reflection and IT-expertise. People must continue to process rather be able to purposeful interpret and critically reflect on the commodity information, because only digitization and applying smart-tablets not represent Industry 4.0 yet. The digital transformation of Industry 4.0 is the networking and the allowing of human-machine interfaces and especially the vocational training system constitutes a successful qualification-base to meet future digital requirements successfully.

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Authors

Dipl. Päd. Jonas Gebhardt

Europa-Universität Flensburg – Berufsbildungsinstitut Arbeit und Technik (biat)

Auf dem Campus 1, Deutschland, 24043 Flensburg

jonas.gebhardt@uni-flensburg.de

Prof. Dr. Axel Grimm

Europa-Universität Flensburg – Berufsbildungsinstitut Arbeit und Technik (biat)

Auf dem Campus 1, Deutschland, 24043 Flensburg

axel.grimm@biat.uni-flensburg.de

Laura Maria Neugebauer

Fachhochschule Flensburg - Internationale Fachkommunikation

Kanzleistrasse 91-93, Deutschland, 24943 Flensburg

laura.neugebauer@fh-flensburg.de

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