Vocational Training of IT-Professionals

Coping with Future Demands

Henrik Schwarz(✉) and Stephanie Conein(✉)

Federal Institute for Vocational Education and Training (BIBB),
Robert-Schuman-Platz 3, 53175 Bonn, Germany
{schwarz,conein}@bibb.de

Abstract. Since their implementation in 1997 the four German training occupations in the field of information and communication technology are writing a success story. Nevertheless they are facing big challenges because of the rapid development of technology and the increasing digitalization of production, service and consumption. The German Federal Institute for Vocational Education and Training (BIBB) has evaluated the existing IT-training occupations. The Results are based on a broad survey conducting interviews in companies with different target groups combined with an online questioning of more than 6,000 participants. Findings suggest that although there is a common contentment among companies, trainers and Trainees, new contents should be included in the training and the training profiles as well as their inner structure should be revised.

Keywords: Information technology · Training occupation · ICT · Training system · Initial training

1 Introduction

Germany's economic success is mainly based on well-trained skilled workers, whose qualification profiles are regularly adapted to new requirements. Within its so-called "Dual System" (see Table 1) annually more than 500,000 school leavers conclude an training contract with a company in currently 327 state recognized occupations.

In the nineties of the last century Germany experienced an intensive debate about the further development of its dual system. The increasing automation and computerization of production coupled with the development of new industries and business models in the service sector necessitated a profound adjustment of the dual training professions. Within the last 20 years, more than 230 training profiles have been modernized and over 60 new training profiles have been developed. Accordingly in 1997 four new IT occupations have been implemented, addressed to suppliers of Information and Communication Technology (ICT) and service as well to companies in other sectors using ICT to run their business and production (see Table 2).

M. Kurosu (Ed.): HCI 2017, Part I, LNCS 10271, pp. 74–85, 2017.
DOI: 10.1007/978-3-319-58071-5_6

Table 1. Characteristics of then German Dual System of initial training

Duality of Training venues	Alternating company- and school-based vocational education and training
Duality of legal jurisdiction	In-Company training is based on federal law (Federal vocational training act) School based training is under federal states law
Duality of funding	Financed by Companies providing training (training allowance, trainers, training workshops, equipment) and (partially) by the government
Shared responsibilities	Common steering and organisation of vocational education and training by the government and the representatives of employer & employee organisations (decisions based on consensus)
Training contracts	Legal relationship between Trainee and Employer (rights and duties for both sides) based on educational laws and labour law
Quality assurance	Occupational standards valid throughout the country, Examination & monitoring standards based on the federal vocational training act

Table 2. IT-Training occupations and main activities

Training occupation	Main activities
IT-Specialist (m/f) with two specializations[a] (a) System integration (b) Application development	(a) Maintenance and administration of IT systems (b) Software development and programming
IT-Systems electronics technician (m/f)	Installation and repair of IT systems
IT-System support specialist (m/f)	Selling hard- and software
IT Officer (m/f)	Buying hard- and software, training of staff

[a]In the German vocational training system, some training occupations have selectable and/or combinable differentiations. If a training occupation has "specializations" it means that one third of the training content & objectives are different. For example: in a three-year training period the third year is split up into different specializations. For more details see Schwarz et al. 2015.

With their introduction in 1997, the IT occupations have embarked on a booming information and communication technology (ICT) sector. Beyond customer and business-process orientation the four IT occupations were developed to fit to rapid technological change and fast-changing market demands. By combining common, broad-based IT core qualifications with profound specialist qualifications, their flexible structure and an audit model oriented to the company's practice, the training occupations met the great needs of the economy.

In the first year of their existence, nearly 5,000 training contracts were concluded, and many new companies could be won for dual training in this area for the first time (see Borch and Schwarz 1999). Now, the number of training contracts signed annually is relatively stable at around 15,000, recently increased up to 16,000. Since their introduction, more than 250,000 skilled IT professionals have been trained in these four occupations (see Fig. 1).

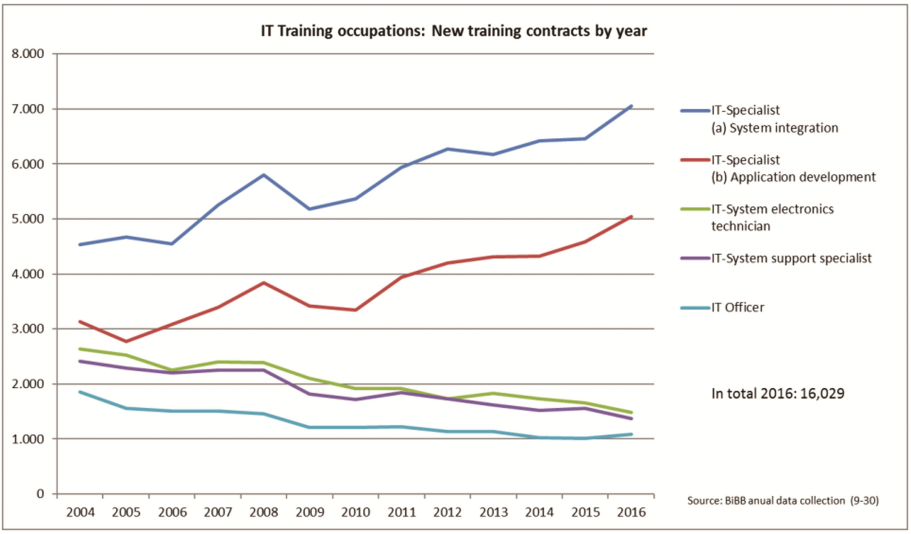

Fig. 1. IT Training occupations: new training contracts by year

The development of the Internet of Things will continue to drive the demand for IT skills in all economic sectors. Since 2008, there are more internet-connected things than humans on Earth. It is assumed that by 2020 the number of internet-capable interacting devices such as smartphones, cars, machine tools, consumer & entertainment devices connected by sensors, software and transmission technology will increase up to more than 200 billion (see Sharma 2014). This requires operating systems, processors, sensors, storage technologies, applications, service and network technology.

"Last year 15% of companies in the business sector hired new employees with IT competences and 15% are planning to do so by the end of 2018. During the same period of time the numbers for the demand for skilled workers in the ICT sector will be 31% and 43% respectively." (BMWi 2016: 14). However, many companies fear that, in particular, the shortage of skilled workers can hinder the advancement of digitalization (BMWi 2016: 69). Estimates on the labor market development are assuming that by 2030 the additional demand for IT professionals will be as much as 3.15 per cent higher per year than without the digitalized industrial production so called as industry 4.0. Beyond that the "additional demand for IT professions will be 37% outside the ICT sector, in the manufacturing sector" (Hall et al. 2016: 6, 18 p.).

The increasing number of networking sensors and actuators in production, software-intensive embedded systems as well as the digitalization of entire business processes will further increase the requirements for stable and safety networks, real-time processing, cyber security and the processing of large amounts of data. Accordingly, topics like software development, cloud computing and big data, as well as IT security as a mega-topic are not fundamentally new, however, complex production & application scenarios lead to new requirements for IT professionals.

These requirements address not only the area of IT skills, but also the personal and social skills. IT professionals are increasingly working in interdisciplinary teams and

dealing with complex cross cutting issues along the whole business process chain. For them, the "key qualifications" such as "willingness to learn, teamwork, flexibility, problem analysis and problem-solving abilities, as well as management and project control competences", will become more important (Aichholzer 2016: 31)

From the point of view of vocational training, the described developments raise the question of the extent to which the existing IT occupations, even considering their flexible and thus also adaptive structure, can cover the current and future needs for IT professionals quantitatively and qualitatively.

2 Evaluation of the IT Occupations

The BIBB evaluation of the IT occupations, which was finished at the end of 2016, aimed at identifying current and foreseeable requirements for IT professionals and at developing proposals for the future design of the IT occupations. Central issues have been:

- contents and objectives;
- required profiles, structure and design;
- further education and permeability between VET and the academic system.

The study, commissioned by the Federal Ministry of Economics and Energy and accompanied by a specialist advisory board, followed a three-step design consisting of an exploratory phase, a phase with qualitative and a phase with quantitative surveys (see Conein and Schwarz 2015).

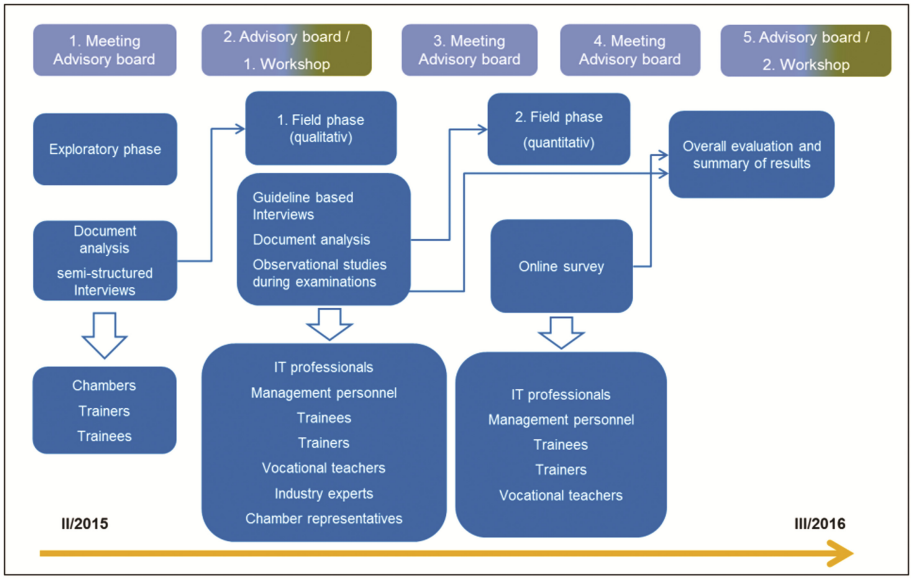

Fig. 2. Research design

The research design (see Fig. 2) allows the triangulation of data and methods. For example: data triangulation is possible because of having asked the same questions to different target groups. Different views on the same topics could be presented in this way. In addition, the same questions were asked both in the qualitative interviews and in the quantitative online survey, whereby a method triangulation was realized.

During the first exploratory phase the field was investigated and the access was prepared. Methods were document analysis and semi-structured, guideline based expert interviews with some target groups (trainees, trainers, representatives from chambers of commerce and industry).

In the second phase, qualitative data were collected. Methods were case studies of ten companies with up to five semi-structured, guideline based expert interviews per company. Nine additional interviews were carried out with industry experts, teachers and representatives from chambers of industry and commerce. In total 54 approx. 60 min interviews were conducted and analyzed by using the qualitative content analysis based on Mayring (2015) (Fig. 3).

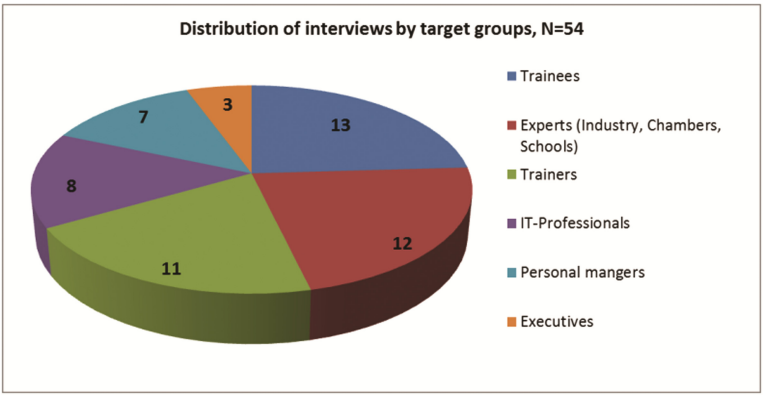

Fig. 3. Interviews by target groups

The results of the qualitative phase served as basis of an online survey which represents the third phase. The online questionnaire was fully answered by more than 6,000 participants (see Table 3).

Table 3. Respondents of the online survey by target group

Target group	N	%
IT-professionals	1,911	31.3%
Traineess	1,767	29.0%
In company Trainers	1,237	20.3%
Management personnel, work council members	748	12.3%
Teachers from vocational schools	438	7.2%
Total	6,101	100.0%

The surveyed IT professionals are working in all economic sectors. They belong for about one-third to the ICT industry, while two-thirds are spread over almost all other economic sectors, including 11% of the manufacturing sector, followed by public administration, other services and financial & insurance services.

In the following, the main focus will be on selected results of the BIBB evaluation study, which refer to the urgent need for change in the current IT training. They concern conceivable changes to the occupational profiles and certain training content (for further results, see the final report at www.bibb.de/voruntersung_itberufe).

3 Findings

3.1 Demarcation of Occupational Profiles

Asked about the relevance of competences in 18 selected fields of occupational requirements, it becomes clear that the various occupational profiles require very different, but in some cases very similar competences. The two specializations of the IT-Specialist (System integration and Application development) are clearly differentiated (see Fig. 2). For example, the areas of software development and databases play an important role for IT-Specialists/Application development. IT-Specialist/System integration mainly require competences in the areas of network engineering, administration & operating systems as well as IT security. The two specializations of the IT-Specialist have proved their worth. From the interviews, there are indications to separate these profiles even more. While 44.4% of the respondents voiced their opinions in favor of maintaining the specializations, 37.8% supported a separation into two independent occupational profiles.

Occupational requirements of the IT-System electronics technician and the IT-Specialist/System integration are overlapping, especially in the fields of network engineering, hardware knowledge, installation and service. Only in the field of electrical engineering/electronics, as a major domain of IT-System electronics technicians, there is a significant demarcation in the requirements. The statement that the two occupations should be put together was supported by 54.2% of the surveyed IT-systems electronics technicians, but only by 22.0% of the IT-Specialists/System integration.

There is even more profile-overlapping between the two business-oriented IT training occupations IT-System support specialist and IT Officer. The occupations only differ in terms of supply & contract management as well as technical marketing, with about 0.4 points (Fig. 4).

Information on whether and how the occupations are differentiated from one another can also be derived from the information about which occupations are trained together in the same company. The data from the online survey result in the following picture: About half of the enterprises (52.9%), who train IT-Specialists/System integration also train IT-Specialists/Application development. From this constellation, it can be deduced that the two IT-Specialists complement each other, because otherwise not so many companies would probably offer both trainings.

IT-System electronics technicians are rarely trained together with IT-Specialists. Just as well IT-System support specialists are rarely trained together with IT Officers

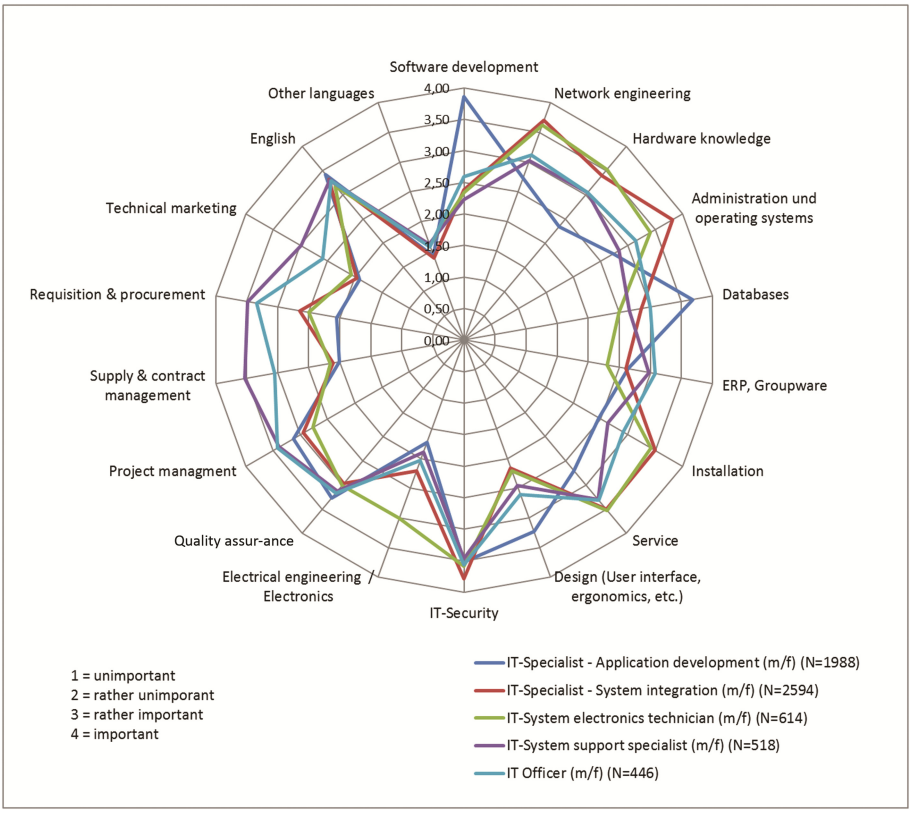

Fig. 4. The Importance of IT competences in some fields of occupational requirements (Based on their own knowledge about the vocational occupations in question (for example by their own training), the respondents in the online survey assessed up to two vocational occupations. An algorithm ensured a distribution of the vocational occupations corresponding to their distribution in the sample. Therefore, the number of cases does not correspond to a person in the present Figure, but to a person's vote for an occupation. Per person, two N could be generated.)

(14.2%), and vice versa (17.6%). This constellation indicates that a company rarely has a need for both business-oriented IT professions.

3.2 Need for Change in Training Contents and Objectives

Overall, there is great satisfaction with the current training content; more than half of all respondents deny the question of missing content. (See Fig. 5).

When missing training content is identified, primarily topics such as virtualization, mobile computing, mobile devices, cloud computing or big data are mentioned. In this respect, there are only marginal differences across all occupations and between different economic sectors.

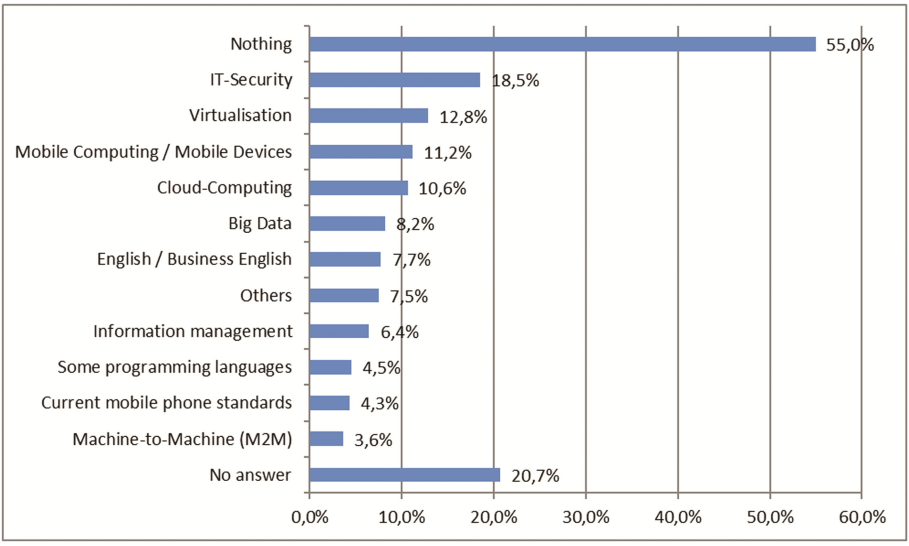

Fig. 5. Which training content are missing? (N = 5,450)

The highest importance regardless of target group, economic sector or company size is attached to IT security. The last finding is underlined by the outcomes of the interviews:

- *"There are, however, topics which are generally not well-established in the market. This includes IT security, since there are already very good experts, but the quality of training is not sufficient"* (Interview 0207_ManagementPersonnel: 55) *["Es gibt aber Themen, die sind generell am Markt noch nicht gut besetzt. Dazu gehört das Thema IT-Sicherheit, da gibt es schon sehr gute Experten, aber die Ausbildungsqualität kommt nicht hinterher."]*[1]
- *"IT security is underestimated"* (0100_ExpertChamber: 114) *["… IT-Sicherheit kommt zur kurz im Moment."]*
- *"The whole topic of cloud computing is, as far as I know, hardly any training content, but is a huge topic for IT operators."* (Interview 0207_ManagementPersonnel: 55) *["Das gesamte Thema Cloud-Computing ist, soweit ich weiß, kaum Ausbildungsinhalt, ist aber ein riesiges Thema für IT-Betreiber."]*
- *"I miss very much mobile device management or generally mobile computing."* (Interview 0307_Trainee: 108) *["Ich vermisse sehr stark Mobile Device Management oder allgemein Mobile Computing."]*

With regard to the topics of industry 4.0 and the internet of things, the interview partners primarily point to the fact that existing specialist's competences and expertise need to be updated continuously and situation-related as the complexity and individualization of the production processes increase.

[1] Translation of interview statements by Schwarz & Conein.

- *"Yes, the requirements have changed, especially in the area of agile software development; (…) the versatility has grown, and has become bigger now. Now I see there also industry 4.0 (…) Before one had learned in a certain programming language, now one learns programming situation-related. I program adequate to the device, which means, I can have both a classic programming language like C, but also a web programming language like PHP, as well as AJAX or Frameworx, there are many frameworx, so there is now a greater variety."* (Interview 08_ExpertIndustry: 65) *["Ja, die Anforderungen haben sich verändert, insbesondere in dem Bereich der agilen Softwareentwicklung, (…) die Vielseitigkeit ist höher, größer geworden inzwischen. Jetzt sehe ich da noch Industrie 4.0 (…) Vorher hatte man in einer Programmiersprache gelernt, inzwischen lernt man programmieren auch situationsbezogen. Also ich programmiere passend fürs Device, ich kann da sowohl eine klassische Programmiersprache wie C haben, dann aber auch eine Web-Programmiersprache wie PHP, wie auch AJAX oder wie Frameworx, es gibt viele Frameworx, die passen müssen, also da ist jetzt eine größere Vielfalt."]*

3.3 Soft Skills Needed

In the online survey the respondents were asked to assess the importance of selected personal and social competences. Almost all competences to be assessed are classified as important or very important by all target groups and across all occupations and regardless of company size or economic sector.

In particular, the competency of learning-readiness is seen as the most important competence with regard to almost all professions. This finding is also supported by the results of the qualitative interviews. Personnel managers and executives who consider further training of IT professionals as important expect learning-readiness from the employees. Being also relevant to all occupations is conscientiousness, self-responsibility and result-oriented action. In addition, the competences for a systematic-methodological approach and problem-solving capacity are considered to be particularly relevant in the two specializations of the IT-Specialist.

The two business-oriented IT occupations emphasize the ability to communicate and the competence for customer & user orientation. As less relevant to all occupations is the ability to resolve conflicts, to make decisions, and, finally, the language.

All of these results are by no means surprising and again support the demand for the provision of personal and social skills, especially in the information technology occupations.

3.4 Implementation of Training in Companies and Vocational Schools

The trainees' appraisal of training in the IT sector is generally positive across all four occupations. Thus, 48.6% of trainees in the online survey rate their training as good, 16.8% even as very good. Differences can be observed with regard to different economic sectors. The IT training in the defense sector is assessed in particular positive, 92% of the trainees designated the training as good or very good. Trainees in companies in the energy sector (78.3%) and financial and insurance services (79.5%) also assess the training very positive. Only in the transport and warehousing sector, less than half of the trainees rate the training very well or well.

Trainees in smaller companies with up to 19 employees are much less likely than in larger companies to grade their current training at least very well or well. Nevertheless, this still amounts to 51.1% or 54.2%. In addition, trainees of older companies are more likely to evaluate their training with good or very good, as trainees of companies that have not existed for so long.

There are great differences in the assessment of the two learning venues, the company and the school. Within the framework of the online survey the trainees were asked the four questions:

- What do you find particularly positive in terms of vocational school training?
- What do you find particularly positive in terms of company training?
- What do you find particularly negative in terms of vocational school training?
- What do you find particularly negative in terms of company training?

Figure 6 shows the frequencies with which the "Nothing" option was selected for all four questions. It is to be noted that with almost the same frequency, with which nothing positive is seen regarding vocational school training, nothing negative is seen in the case of company training, and vice versa. The frequency of "nothing positive" for the company training is comparable to the frequency of "nothing negative" for the vocational school training.

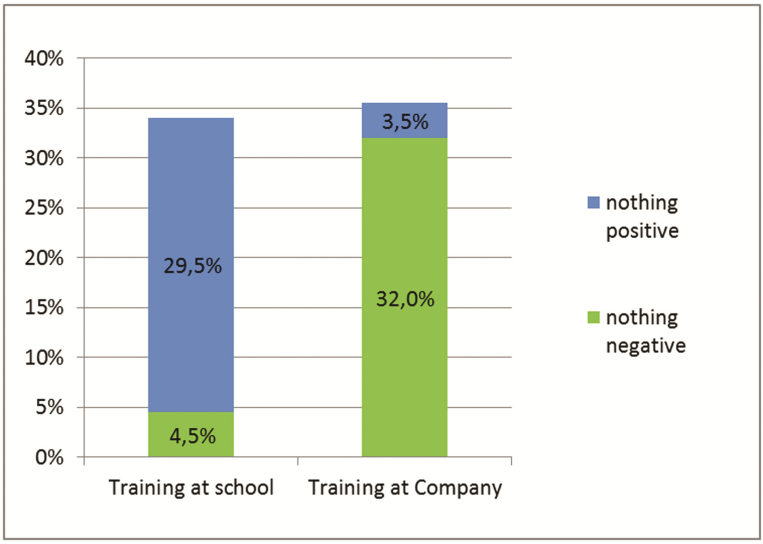

Fig. 6. Distribution of answers to the questions: "What did you see as positive/negative during your training at school/company?" (N = 1703)

Assessment of Company Training

The ability to work independently is the most frequently cited positive aspect of the respondents currently being trained. 82.6% of the trainees represent this view.

Approximately three-quarters (76.5%) of trainees also mention the working atmosphere in their respective training company as a particularly positive aspect. Almost every second trainee (48.2%) has a particularly positive experience with the trainers.

Criticism of the company training mainly refers to the fact that there was not enough guidance (29.9%) and a too company-specific and/or a very one-sided training (27.2%).

Assessment of Vocational School Training

In terms of vocational school training, the good support for the preparation of the examination and the relevant technical content are at the top of the positive aspects. Approx. 30% of the trainees have named these aspects. 28.7% emphasize the commitment of the teachers as a positive aspect.

Especially the non-occupation-related subjects as part of the vocational school curriculum are seen as negative (64.8%). Outdated teaching material is perceived as particularly negative by approximately half of the trainees (50.8%) and outdated teaching methods of 45.3% of the trainees.

4 Conclusions and Recommendations

IT occupations are both, occupations especially related to the manufacturers and suppliers in the ICT sector, as well as occupations for users of ICT services across all economic sectors. In addition, they are interfaces that combine information and communication technology with production technology and business management. The increasing digitalization of all economic sectors will greatly increase the number of networking and interacting systems and thus further increase the complexity of these interface functions. In addition to IT competences, personal and social skills will be even more important in the assessment of the experts surveyed. The present results suggest a substantive and structural revision of the IT professions:

- The two business-oriented IT occupations IT-System support specialist and IT Officer should be merged because main areas of activities are very much overlapping.
- The two specializations of the IT-Specialist should be resolved into separate occupations, since their profiles are clearly different. Beyond that, the numbers of trainees are high and the labor market demand is still increasing for both profiles.
- The issue of IT security (data security, availability, integrity of data and data protection including legal aspects) should be significantly strengthened (e.g. risk analysis, protection of hardware and networks/infrastructure, encryption, authorization, legal requirements, certification, user training, etc.).
- Two-thirds of IT professionals work in sectors outside the ICT industry, including manufacturing. With regard to the topic of industry 4.0, consideration should be given to anchoring contents such as production control, virtualization, and embedded systems in the fields of application development and system administration.
- Within the content of the training, personal competences should be fully taken into account. In particular, it should be reflected in which contexts these training contents can be conveyed as well as be assessed.

- In order to meet the increasing complexity, heterogeneity and speed of change of the requirements, internally differentiation in kind of selectable optional qualifications[2] should be introduced.
- The reorganization of the IT occupations could be a good starting point not only to revise training contents and objectives, but also to improve the cooperation between training companies and vocational schools, e.g. in terms of common training projects and workshops.

With regard to reorganize the IT occupations, these and other proposals are currently under discussion by the stakeholders in the employers 'and employees' associations.

References

Aichholzer, G.: Industrie 4.0: Perspektiven für Arbeit und Beschäftigung. In: TAB-Brief Nr. 47/ Juli 2016, S. 31 (2016). https://www.itas.kit.edu/downloads/tab-brief/tb047_aich16a.pdf Accessed 10 Feb 2017

BMWi - Bundesministerium für Wirtschaft und Energie (Hrsg.): Monitoring-Report, Wirtschaft DIGITAL 2016, Berlin (2016). https://www.bmwi.de/Redaktion/DE/Publikationen/Digitale-Welt/monitoring-report-wirtschaft-digital-2016.pdf?__blob=publicationFile&v=10. Accessed 10 Feb 2017

Borch, H., Schwarz, H.: Zur Konzeption und Entwicklung der neuen IT-Berufe. In: Borch, H., et al. (ed.) Gestaltung der betrieblichen Ausbildung in den neuen IT-Berufen. (S.22). Bertelsmann, Bielefeld (1999)

Conein, S., Schwarz, H.: IT-Berufe auf dem Prüfstand. BWP **2**, 58–59 (2015). ww.bibb.de/bwp-7872. Accessed 10 Feb 2017

Hall, A., et al.: IT-Berufe und IT-Kompetenzen in der Industrie 4.0. BIBB Publikationen (2016). https://www.bibb.de/veroeffentlichungen/de/publication/download/id/7833. Accessed 10 Feb 2017

Mayring, P.: Qualitative Inhaltsanalyse: Grundlagen und Techniken. Beltz, Weinheim (2015)

Schwarz, H., Conein, S., Tutschner, H., u.a.: Voruntersuchung IT-Berufe, Abschlussbericht, Bonn (2017). https://www2.bibb.de/bibbtools/tools/dapro/data/documents/pdf/eb_42497.pdf. Accessed 10 Feb 2017

Schwarz, H., Bretschneider, M., Schröder, J., u.a.: Strukturierung anerkannter Ausbildungsberufe im dualen System: Forschungsprojekt 4.2.381, Bonn, 125 S (2015). https://www2.bibb.de/bibbtools/tools/dapro/data/documents/pdf/eb_42381.pdf. Accessed 10 Feb 2017

Sharma, N.: The Context of Everywhere: The Internet of Things & The Explosion of Data. Pitney Bowes Inc. (Hrsg.) 28 April 2014. http://blogs.pb.com/digital-insights/2014/04/28/internet-things-big-data/. Accessed 10 Feb 2017

[2] For more details about internally differentiations and how to structure the curriculum of training occupations see Schwarz et al. 2015: 67 p.