Industrie 4.0 – Qualification 2025 (Management Summary)

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**Study and data**

**Objective and focus**

The study investigates the effects of Industrie 4.0 on skills development in the mechanical engineering industry. The focus is on the demands placed on vocational education and training (VET), specifically in the industrial/technical occupations and in academic education in the STEM fields.

In the debates and developments around Industrie 4.0, it is assumed that mechanical engineering, as a key supplier and user industry, is facing major changes, which will bring definite consequences for qualification and training. The precise nature of these consequences is still largely unknown, however, and is the subject of vigorous debate. The aim of the study is to capture the current view prevailing in workplace practice. To do so, it surveys the current situation in the workplace, and the views of those working in the industry about likely developments up to 2025.

By combining qualitative and quantitative methods, the study offers both an exploratory in-depth approach, and an idea of the extent of the development. The study presents the perspective of in-company experts on qualification and training, and of companies playing a pioneering role in Industrie 4.0.

**Brief information on the data used**

The study combines qualitative and quantitative methods. The presentation of the results is organized thematically, with the different data sets and survey methods complementing each other.

The data consists of three major components:

- our own analyses of the representative BIBB/BAuA Employment Survey of the Working Population on Qualification and Working Conditions in Germany 2012, for the mechanical engineering industry (n=518);
- four qualitative and explorative company case studies, carried out in summer and autumn 2015 (35 individual interviews, five group discussions and three site visits, generating a total of 42 hours of transcribed audio material);
- a quantitative online survey of professionals in the industry who are responsible for qualification and training. Just over 2208 people were contacted by email via the VDMA, of whom 210 took part in the survey, with 198 answering the whole questionnaire. The survey took place in February 2016.

\(^1\) This Management Summary sums up the most important findings of the full study which was published in German: Pfeiffer, Sabine; Lee, Horan; Zirnig, Christopher; Suphan, Anne (2016). Industrie 4.0 – Qualifizierung 2025. Frankfurt/M.: VDMA.

→ References point to the original chapter in the German study.
Throughout the sector and in the companies surveyed, the occupations with the highest numbers are industrial mechanic (Industriemechaniker/-in), mechatronics engineer, and machinist (Zerspaner/-in). The hybrid occupation of the mechatronics engineer is the second most important training occupation in this sector (→ 6.2).

The occupational profile of the production technologist is relatively new, and partly targets content that can readily be adapted to the requirements of Industrie 4.0. As yet, however, the total number of trainees in Germany has not risen above the low hundreds. Nearly 90 % of the companies surveyed do not offer training for this occupational profile (or no longer offer it); 55 % justify this with the lack of demand, and for 28 % the subject has never arisen or the occupational profile is unknown. One great difficulty lies in the assessment of its level (→ 6.3).

In quantitative terms, industrial and technical training occupations play a central role. The classical metalworking and machining occupations predominate, along with the hybrid occupation of the mechatronics engineer (Mechatroniker). As yet few have chosen the new occupational profile of the production technologist (Produktionstechnologe/-in), as most people are unfamiliar with the content of this role.

Nearly 30 % of employees in this sector can be classed as belonging to the mechanical and automotive engineering occupations, 63 % to the industrial/technical area or the STEM fields. Thus the significance of these occupations in this industry is considerably above the federal average for all employees (in the German long version of the study see chapter (→ 6.1).

New VET profile: Production Technologist

![Graph showing the numbers of VET starters, graduates, and currently in training for the years 2011 to 2014.]

Qualification and attitudes to continuing training

The employees in the sector are very well qualified: 59 % state that their highest qualification was a course of VET, 24 % have a university degree, and 14 % have completed advanced training to become Meister or Techniker (official qualifications, roughly translatable as 'master craftsman' and 'technician'). Less than 4 % of employees have no vocational qualification at all. Their attitude to continuing education and training is also impressive: 41 % of those employed in this sector have more than one qualification. Of those who obtain a second vocational qualification, 28 % choose a second course of training in the dual system, 34 % an advanced vocational qualification such as Techniker or Meister, and 26 % an academic pathway. Those who enter the industry with an academic qualification also often continue their education and training: 38 % of university-educated employees with more than one qualification choose a second course of academic study, while 25 % undertake further vocational training, i.e. they choose a non-academic qualification as their second step (→ 5.1).

Labouring capacity and experience

Alongside formal qualifications, informal abilities and experiential knowledge also play a major role — especially when it comes to dealing with unpredictability and complexity, and successfully coping with change in the workplace. The higher the degree of automation and digitalization, the greater the importance of this labouring capacity (LC) — especially for the avoidance of disruptions. The extent of these implicit abilities can be roughly assessed by means of the LC index, constructed from 18 items in the BiBB/BaAuA Employment Survey. The index yields a value between 0 and 1, and does not measure a purely individual capacity, but the complexity employees are required to cope with in the workplace.

By conservative calculations, only LC values of at least 0.5 are regarded as high. In mechanical engineering, the LC index values in all three levels of qualification (low, medium and high) lie well over the values for all sectors in Germany. While 71 % of employees throughout Germany show a high LC index value, this rate is considerably higher in the mechanical engineering industry, at 80 %. In this industry, the majority of employees are already dealing successfully with complexity, unpredictability and change in the workplace. This is particularly true of those employees trained in the vocational system; in some cases they attain higher values than people with academic qualifications (→ 5.2).

Labouring capacity by level of qualification

<table>
<thead>
<tr>
<th>Qualification</th>
<th>LC mean</th>
<th>%</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>0.423</td>
<td>4%</td>
<td>0.335</td>
</tr>
<tr>
<td>medium</td>
<td>0.625</td>
<td>69%</td>
<td>0.242</td>
</tr>
<tr>
<td>high</td>
<td>0.673</td>
<td>27%</td>
<td>0.217</td>
</tr>
<tr>
<td>all</td>
<td>0.630</td>
<td>100%</td>
<td>0.244</td>
</tr>
</tbody>
</table>

LC-Index (Pfeifer/Suphan 2015); Database BiBB/BaAuA 2012; Germany n=16,450; mechanical engineering n=398.
How companies deal with qualification and training

In some respects the companies in the industry prove to be flexible and open to change when it comes to training and development structures. They support employees in their continuing vocational and academic training, and usually reward further training with corresponding employment opportunities.

Around two thirds of the companies use the freedom which the VET system offers in terms of content and methods. In the last five years 39 % had made actual changes in the content of their training programmes, and 44 % in the methods.

A high proportion, around 80 %, collaborate with vocational schools and other VET institutions or bodies. When it comes to continuing education and training, technical content (offered by 77 % of companies) predominates over non-technical content (63 %). A large majority state that their companies support skilled workers training to become Meister or Techniker (84 % of respondents), or those undertaking university study (68 %). Moreover, further education and training seems to be worthwhile: 80 % of respondents state that this usually leads to employment commensurate with the qualification (+ 7.1).

Different ways of organizing VET in the workplace

By company size

- Proactive/innovative: 11.1%
- Moderate/innovative: 27.8%
- Pragmatic, wait-and-see attitude: 61.1%
- > 500: 21.4%
- 100 bis 499: 40.4%
- < 99: 36.4%

39.8% Proactive/innovative
55.2% Pragmatic, wait-and-see attitude
5.0% Moderate/innovative
Overall, however, the dominant attitude towards the innovative use of the scope and structures of the VET system is pragmatic and cautious. There is considerable variation in the level of collaboration between training departments and research and development (R&D) departments when it comes to innovation processes: some work together closely from an early stage, in other cases the areas remain separate, taking a wait-and-see or catch-up-later attitude.

The individual questions about approaches to VET reveal various different ways of organizing qualification and training in the workplace. 45 % of companies take a proactive/innovative or moderate/innovative stance; 55 % have a pragmatic, wait-and-see attitude. Larger companies with more than 500 employees are most likely to be proactive/innovative in their organization of training in the workplace. This means that in most companies the opportunities for organizing training in the workplace that are available within the system are being used less than they conceivably could be. To some extent this finding points to a more traditional attitude on the part of those responsible for qualification and training, to some extent it also reflects the flexibility of the given structures (→ 7.2).

With regard to potentially disruptive changes in the context of Industrie 4.0, the collaboration between training departments and R&D departments could become more relevant in the future. In the online survey, questions were asked about the intensity and timing of the current forms of this collaboration. Four typical forms can be deduced from the data: in 50 % of the companies, the training side is already closely involved in R&D measures from an early stage (types: strategic-creative innovation and co-creative interaction), in 41 % of companies, collaboration does not occur until the implementation phase (type: traditional integration), and 9 % rely more on stimuli from outside than on their own innovative capacity (type: separate spheres/catch-up-later) (→ 7.3).
Industrie 4.0 today

Change and complexity

The mechanical engineering industry already offers highly complex products in extremely small batch sizes, and engineering services. Employees in this industry are experiencing a more digital and more diverse technological transformation than in other industries. Those responsible for qualification and training, however, are much less affected by digital and technological changes.

Batch size 1 and customer-specific products are topics that play a major role in Industrie 4.0. For mechanical engineering, both these concepts are already familiar. This is also apparent in the companies surveyed online: the majority of these (84%) offer complex products and services, with 73% providing one-off and small-batch production, and 75% also selling engineering services (→ 8.1).

The industry is already strongly shaped by the digital transformation: 52% of employees had been confronted with new computer programs in the two years preceding the survey. The change in mechanical engineering is thus not only more IT-driven, but also more diverse than for employees in most other sectors: in all the technology-driven fields covered by the BIBB/BAuA survey, the values in this sector are well above those for all employees in Germany. For the respondents in our online survey, most of whom come from the area of qualification and training, newer forms of digitalization hardly feature (2.1%). Thus the experience of digital and technological change seems to be much more dramatic in the industry as a whole than among those responsible for qualification and training (→ 8.2).

Implementation status and variations of Industrie 4.0

While the companies surveyed are well advanced in the implementation of Industrie 4.0, the respondents themselves appear to have comparatively little knowledge about it. In the case study companies, cyber-physical systems (CPSs) are viewed as by far the most relevant technologies at present, and in the online survey the topics of Web 2.0 and robotics are currently predominant. Different strategies for dealing with Industrie 4.0 can also be observed among the companies playing a leading role in this area.

In terms of Industrie 4.0, the respondents offer differing views of their companies: 19% see them as leaders, and 34% as followers; 27% report intensive implementation in several areas, 33% report that implementation has begun in some areas.

The respondents thus see their companies as further advanced than comparable studies of the sector with regard to Industrie 4.0 suggest. At the same time, the knowledge deficits are greater: 19% assess Industrie 4.0 as irrelevant or unknown, and 28% do not yet see any implementation of Industrie 4.0, or cannot make any statements about it (→ 8.3).
Assessments of the development of Industrie 4.0 vary even between and within the pioneering companies in the qualitative study. Three different innovation strategies are identified: the disruptive business model, progressive process innovation, and forward-looking/expanded product innovation. These strategies do not represent the degree of implementation, but illustrate how diverse Industrie 4.0 is and will be, and how much it needs to be shaped and managed creative input it requires. Equally varied are the consequences that can be deduced from this for the areas of work organization, qualification and training, and employment (→ 9).
Qualification and training for Industrie 4.0 today

Today Industrie 4.0 already plays a part in the majority of the companies surveyed – in both initial and continuing training. The more innovative companies are in qualification and training, and the greater the extent to which they have implemented Industrie 4.0, the more we can learn from their training practices.

The majority of respondents currently see the topic of Industrie 4.0 as having a firm place in qualification and training: 62% affirm this for continuing development, and 71% for initial training. Companies that are proactive/innovative in qualification and training, and those that are pioneers in the area of Industrie 4.0, integrate the topic to an equal extent in initial and continuing training. Those companies with a more wait-and-see attitude in both fields – qualification/training and Industrie 4.0 – currently incorporate this topic more in continuing development than in initial training. Even among respondents who do not so far regard Industrie 4.0 as relevant for their company, 40% see the topic as belonging to initial training (→ 10).

Industrie 4.0 and VET

- 62,0% is of relevance today in initial training.
- 70,9% is of relevance today in continuing qualification.
- 29,1% is of no relevance today in initial training.
- 38,0% is of no relevance today in continuing qualification.

Q2025, n= [197]
Qualification and training up to 2025

Dual courses of study (duales Studium, i.e. courses combining tertiary study and vocational training or work experience) and systems of continuing VET will become more significant. The qualification expected to experience the greatest loss in importance is that of Meister – a negative development for most respondents. Opinions differ on whether or not training times will become shorter, but respondents are unanimously opposed to such a reduction.

Before embarking on the topic of digitalization and Industrie 4.0, both the online and qualitative surveys included questions about general education policy issues, asking respondents to think about the year 2025. Most assume – with agreement levels of well over 90% – that both dual courses of study and systems of continuing vocational training will become more important (→ 11.1).

Advanced training to become a Meister is expected to become less significant, with 42% holding this view. At the same time, this development is seen as particularly negative. Respondents are equally critical of the reductions in training periods, which 70% of them expect to see. In contrast, 30% do not expect such reductions. Regardless of which development is expected, respondents are clearly opposed to a shortening of training times (→ 11.1).

Respondents welcome web-based learning modules as a digital supplement to existing forms of training. Dual courses of study are regarded positively, but their weaknesses are nonetheless discussed. The qualitative case studies show how different and how nuanced the viewpoints behind the numbers are. Thus, the increasing use of supplementary digital learning modules within training is expected and desired. Instead of a shortening of training times, the emphasis is on the need for faster integration of new content in qualification and training. Despite positive attitudes to the growing importance of dual courses of study, there are also critical voices: these stress a lack of technical skills and practical workplace experience, as well as deficits in conceptual and academic abilities (→ 11.2.2).
Industrie 4.0 up to 2025

Robotics and Web 2.0/mobile devices are currently seen as the biggest technology topics in the companies – with a tendency for their importance to decrease by 2025. Cyber-physical systems are also already present in the surveyed companies, with their significance expected to grow substantially by 2025. Wearables are barely an issue so far, but this is where the greatest increase in importance by 2025 is expected.

The online questionnaire asked about five technological facets of Industrie 4.0. Web 2.0/mobile devices and robotics are already relevant today in 50 % and 44 % of companies respectively. Both these topics are expected to become less important by 2025. CPSs and additive processes are currently in use in around 30 % of companies; 55 % of respondents expect their importance to increase by 2025. The greatest leap and the most contradictory assessment is found in the case of the Wearables: today these are only found in 9 % of companies, yet 55 % expect them to become more significant by 2025. 36 % of companies see this topic as having no relevance either now or in the future (→ 12).
Qualification and training for Industrie 4.0 up to 2025

Different scenarios

Assessments of the development of qualification and training in the context of Industrie 4.0 differ, with three variations emerging. Some assume a polarization will occur, others expect a general rise in the need for qualification and training, and a third group sees a dual (academic and vocational) professionalism as an increasingly important link between different levels of qualification.

The qualitative interviews show that assessments on qualification and training are linked with expectations about what technological and work-organization solutions will become established. Three types of future scenario can be identified. In the “growing gap” scenario, the gulf between highly-skilled and low-skilled workers becomes ever wider. Another group expects a “general upgrade”, i.e. the need to raise the skill levels of all employees. A third group stresses the special and, in its view, rising importance of training and qualification for skilled workers, and of the specific professionalism associated with this. These respondents see this as a “central link”: the connecting point between qualification levels, specialist fields, and abstract and concrete requirements (→13).

The need for innovation in VET

The existing vocational profiles are regarded as well equipped, and incremental changes are largely viewed as sufficient. Substantial changes are also expected, but it is assumed that the system of vocational training and development will cope with these. Somewhat more need for change is apparent in methods than in content. A clear need for change is seen in VET structures. This, however, is primarily incremental in nature and can be coped with in the existing systems. The greatest need for substantial change is expected in continuing training (47 %). For initial education and training, 58 % expect that no change or only incremental change will be needed. Only 9 % think that no changes will be needed in methods and only 11 % see no need for changes in the content of training and development programmes (→15.1).

Learning venues and learning pathways

Qualification and training for Industrie 4.0 is mainly seen as taking place in higher education institutions, in digital forms of learning, and in the responsibility of the individual. A considerably smaller role is attributed to initial education and training in vocational schools and in the workplace, and continuing training in the workplace. This tendency towards the academic and the digital manifests itself somewhat more strongly in relation to subject-specific requirements than to generic skills.
Digital learning pathways are viewed as important: 44% stress their relevance for the communication of subject-specific requirements, and 40% for that of generic skills such as interdisciplinary collaboration. One in five respondents believe that learning is mainly the responsibility of the individual. Institutions of higher education are mentioned as an important learning venue: 20% declare that their role is to teach subject-specific skills, 25% expect them to impart generic skills. In contrast, the respondents see their own institution – the workplace – as having surprisingly little obligation in this respect: 22% mention workplace activities (initial and continuing training, and in-house e-learning programmes) for subject-specific skills and 18% for generic skills (→15.2).

**Requirements in initial and continuing training**

Those who regard the workplace as an important learning venue for Industrie 4.0 topics are already engaging with qualification and training for Industrie 4.0. Big data is viewed as highly significant in VET today and in 2025. Technological issues are seen as less important for workplace qualification and training today than in the future. Social skills, on the other hand, are perceived as being more significant for initial and continuing training today than in 2025.
Those who see initial and continuing training in the workplace as an important venue for Industrie 4.0-related learning regard VET training as significant for all technical/subject-specific skills as well as for generic skills. Some view this importance as a transitional phenomenon; others see it as generally rising (→ 14).

Data protection and privacy already feature in initial training in 79% of cases, and big data in 53%. Thus data-related generic skills are already a more prominent feature of training than the more narrowly defined technical/subject-specific requirements.

The only generic skill expected to retain its importance over time is the ability to deal with big data: 45.6% think this will still be important in initial training in 2025.

Web 2.0, additive processes, CPSs and robotics are also already being taught today – with substantial growth expected by 2025. Interdisciplinary collaboration and the ability to create innovations are seen as especially important topics in initial and continuing training today (→ 15.3).
Imprint

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