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## COMPETENCE DEVELOPMENT FOR INDUSTRY 4.0: QUALIFICATION REQUIREMENTS AND SOLUTIONS\*

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**Abstract.** The article reveals the requirements for the entry of the world economy into the fourth industrial revolution and Industry 4.0 to the competence of personnel. Industry 4.0 promises new digital solutions to optimize the entire flow of value creation in production systems. Existing production systems are often based on a philosophy of continuous improvement and lean management. The increasing digitalisation of production processes is placing new demands on employee competence. The article discusses and analyzes the necessary competences for successful integration of Kazakhstan and Russian enterprises into Industry 4.0. The article provides systematization of company specific competences and skills of employees, as well as the author's roadmap of implementation for competence development in Industry 4.0 and on its basis recommendations and solutions for enterprises are formed.

**Keywords:** Industry 4.0.; Competence; Roadmap; Fourth Industrial Revolution; Digitalization; Companies

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**JEL Classifications:** D21, I26, J24, O30

### 1. Introduction

A successful transition to Industry 4.0 in the coming years will determine the competitiveness and future viability of Russian and Kazakh industry, as well as the creation of added value in Russia and Kazakhstan as a new place to locate business. Technological opportunities for linking facilities, data and processes offer both opportunities to

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improve the efficiency of industrial processes and constructive potential for developing new business models. This will revolutionise not only products and production, but also industrial value creation. It is expected that Industry 4.0 will benefit both large companies and small and medium-sized enterprises (SMEs). At the same time, Industry 4.0 is transforming the world of work in a sustainable way. Increasing networking, flexibility and complexity of processes are placing new demands on the skills of companies and their employees. In addition, Industry 4.0 is also changing the structures and forms of organization within companies and the design of workplaces. However, digital change does not follow a deterministic pattern, but can and should be shaped. There are many different development scenarios that depend on the interaction between technology, people and the organization and are determined by decisions at the level of operational, corporate strategy and work policies, as well as the prevailing framework conditions.

Germany launched the national programs of the "organized" digital economy by adopting the "Industry 4.0" concept in 2012. To date, such strategies have been adopted and provided with regulatory documents in almost two dozen countries from the local "Smart Nation" in Singapore (2015) to the global Chinese concept "Internet +" (2015) and the launch of the Russian digital economy program (2016). The European Union introduces a wide array of financial instruments for supporting of innovative activity of enterprises in years 2021-2027 (Wyrwa, 2020). Issues of economic development, which take into account regional peculiarities, peculiarities of formation of economic and political associations related to development of 4.0, have been repeatedly considered in the works of economists and sociologists (Boronenko, Lavrinenko, 2015; Shevyakova, Petrenko, 2019; Ślusarczyk et al., 2020; Tvaronaviciene, Burinskas, 2020).

**The main problem** of research in the field of digitalization is that it fixes an already established situation and is looking for adaptation to digital technologies. Researchers, providers of training and professional development in the field of E-competencies and digital skills do not take into account that a generation is coming to jobs that already perceive digital reality as part of everyday life. Also, during training, the growing pool of requirements for E-competencies is not always integrated as new content into training materials. The technical and especially the socio-technical aspects, which are the central component of digital processing in the learning process, are often not considered. The focus continues to be on the instrumental level and themes.

**A key challenge** in skills development for Industry 4.0 is to avoid and/or close the dual digital divide: between large companies and small and medium-sized enterprises on the one hand, and between highly and low-skilled workers on the other. Important levers in this regard are the framework conditions for primary and continuing education and training in schools, colleges and universities, as well as in companies.

**The main issue** of this study is the justification of the "gap" between the existing digital reality, the requirements of employers arising under the influence of Industry 4.0 and the possibility of a response or specific changes for educational institutions to form the necessary competencies.

**The purpose of the study** is to systematize company specific competencies and skills of employees based on the analysis of necessary competencies for successful integration of Kazakhstan and Russian enterprises into Industry 4.0, to develop an author's implementation roadmap for competence development in Industry 4.0, and to generate recommendations and solutions for enterprises.

Also, **the objectives of the study** are to predict possible changes under the influence of Industry 4.0 in activities:  
- corporate management at enterprises, if necessary, with the creation of their own Industry 4.0 Competence Centers;

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- Universities, as well as public and private educational institutions;
- government agencies;
- Associations, chambers and unions, including public and professional.

Most of the world's companies see Industry 4.0 as an opportunity. At the same time, there are still many questions concerning its implementation. Small and medium-sized enterprises, in particular, are much more cautious about the possibilities of the fourth industrial revolution than large companies and, compared to them, have a greater need to develop - both to implement Industry 4.0 and to improve the skills of their employees (Dzwigol et al. 2020). Central to the development of competencies for companies of all sizes are the topics of data evaluation and analysis, cross-industry know-how and process management, interdisciplinary thinking and action, as well as customer relationship management and leadership competence. Equally important for companies is the strengthening of IT competencies in terms of comprehensive and interdisciplinary skills on a large scale. Nevertheless, large companies and small and medium-sized enterprises also have different priorities when it comes to qualifications for Industry 4.0. For example, large companies pay more attention to data-centric technologies and skills, such as artificial intelligence. SMEs, on the other hand, pay special attention to client-oriented processes and skills, as well as skills related to infrastructure and organization, such as social and communication skills. Successful qualification for Industry 4.0 cannot be obtained solely through "traditional" learning and development formats, such as full-time education in the classical undergraduate and graduate systems.

## **2. Skills Development for the Industry 4.0**

Industry 4.0 describes an economic paradigm shift that brings both opportunities to improve process efficiency and the potential for the development and transformation of value addition and new business models of (industrial) companies. Digital change is increasingly breaking down tight value chains. Flexible value-added networks, platform markets and innovative intellectual services are replacing them. The real-time networking of products, processes and infrastructures heralds a fourth industrial revolution in which supply, production, service and delivery, as well as customer service, are linked to each other over the Internet. Both the increase in process efficiency in line with Industry 4.0 and the development and implementation of new business models during digitization require new or changed management and workforce skills.

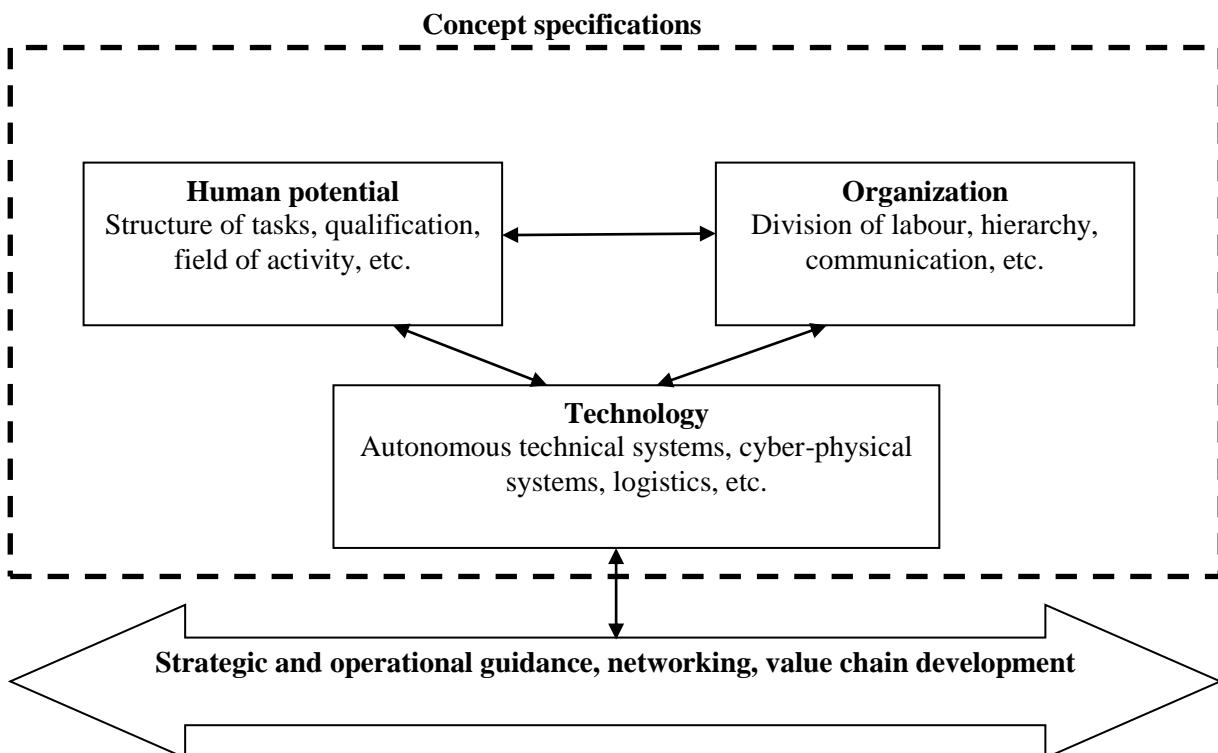
The fourth industrial revolution is also leading to sustainable changes in the world of work. The new degree of flexibility and digital networks require innovative qualification solutions that are available depending on the situation and make the behavior of autonomous cyber-physical systems transparent to humans. Currently, there is still a lack of systematic surveys on the competence requirements of Russian and Kazakh companies. In particular, little is known yet about the needs of small and medium enterprises. In addition, there is a lack of suitable qualification proposals that would prepare both experienced employees and newcomers to the profession specifically for Industry 4.0.

The sector of competence development research for Industry 4.0 is based on the fundamental assumption that:

- there is a significant need for competence development for Industry 4.0 at Russian and Kazakh enterprises,
- small and medium enterprises set different priorities in the development of competencies compared to large enterprises,
- Targeted staff development measures are needed as a key to generating digital change.

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The fourth industrial revolution is not only a long-term change in the existing value-added and industrial production models, but also in the world of work, the forms of organisation in enterprises and the competence and qualification requirements of the workforce. However, the prospects for the future development of work, the competence profiles of employees and the impact on employment are assessed differently by different researchers (Abele et al., 2015, 2017; Monostori et al., 2016; Kagermann et al., 2013; Liker, 2004; Bauernhansl et al., 2016). The debate on competence and qualification development requirements for Industry 4.0 is currently in its infancy. A clear forecast of the expected development as well as a clear definition of competencies is proving to be difficult. For example, estimates of possible future scenarios for the development of job requirements and the resulting qualification requirements vary considerably, but all researchers agree that skills and competence development will play a central role in the implementation of Industry 4.0 and that the requirements for employees will increase (Metternich et al., 2017; Tisch et al. 2013; Enke et al. 2015; Meudt et al. 2017). This article cannot provide a comprehensive analysis, but it does attempt to contribute independently to the overall picture and identify the skills needs for Industry 4.0 based on empirical evidence. Based on this, recommendations for action for companies, policies and education providers will be made, and methodological entry points for qualification solutions will be identified. The starting point is that the digital change and implementation of Industry 4.0 does not follow a deterministic model, but rather that there are various technical and organizational alternatives that can be influenced and shaped by specific company and labour policy decisions. As a social and technical system, Industry 4.0 focuses on the interdependent linkages between all elements of the production system. It takes into account the interactions between technology, people and organization, as well as the operating and policy environment, strategic and regulatory specifications, networking and value chain development (see Figure 1).



**Fig. 1.** Industry 4.0 as a socio-economic system

Source: composed by the authors

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The implementation of Industry 4.0 opens up a wide range of development options. While technology-oriented approaches emphasize the far-reaching replacement of human forms of operation by technical equipment and systems, complementary approaches focus on the complementary distribution of tasks and the interaction between man and machine. Since it can be assumed that the diffusion of digital technologies will not occur simultaneously and that there will be significant challenges at the human, operational and organizational levels, complementary design concepts in particular have great technological and economic potential for the implementation of Industry 4.0.

### **3. Future qualification needs and use of professional development tools**

A decisive component for the successful implementation of Industry 4.0 in enterprises and the expansion of opportunities for the future working world is the qualification of employees. This requires, on the one hand, the determination of future requirements for company competences (company specific competences). A company can meet these needs through technology acquisition, external consulting, recruitment, cooperation with external service providers or training of its own staff. On the other hand, expected skills, which are important for the company's own employees as well as their skills, should be specified.

A change in job descriptions places new demands on the skills needed in companies and on the skills of the workforce. The results of the research made it possible to systematize company specific competences and skills of employees (see Table 1):

- 1) Technology and data-centric competencies and skills, which cover special competences in development, application and mastery of digital technologies.
- 2) Process and customer-centric Competences and Skills describe the understanding of relationships in value-added networks, including the organization and coordination of customer relationships.
- 3) Infrastructure and organization oriented competencies and skills relate to the work with the main technical components in the enterprise and soft skills.

**Table 1.** Systematization of company specific competences and skills of employees

<b>Initiatives focused on</b>	<b>Competencies specific to the company</b>	<b>Employee's Skills</b>
Technology / Databases	Data evaluation and analysis Information Technology Security Cloud architectures Artificial Intelligence User support/service technology	Interdisciplinary thinking and action Mastery of complex content Ability to interact with machines Competence in problem solving and optimization
Processes / customers	Process Management Customer relationship management IT business analysis E-commerce/E-marketing Consulting	Expanding process know-how Participation in innovation processes The ability to coordinate work processes Service orientation Interdisciplinary thinking and action Mastery of complex content Ability to interact with machines Competence in problem solving and optimization
Infrastructure / organization	Processing specific IT systems Administration of network databases IT Architecture Data Protection	Leadership competence Independent solutions Social/communication competence

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The described competencies and skills focus primarily on the opportunities offered by Industry 4.0 to improve process and production efficiency. However, in connection with the development and implementation of innovative business models, new and broad competencies are also needed. This is indicated, for example, by competences in data evaluation and analysis, skills in interdisciplinary thinking or participation in innovative processes, but also include, for example, client experience.

Companies' priorities for targeted development of company specific competences in the future also reflect the identified needs. According to previous studies, less than 25% of companies have special training and professional development programs for Industry 4.0, and naturally large companies are significantly ahead of SMEs. However, interviews with experts from academia and industry suggest that individual modules and building blocks of existing training and development programmes indirectly address selected issues for Industry 4.0.

#### **4. Recommendations for action**

The study confirms that there is a significant need for intensive progress in Russian and Kazakh companies with the development of competencies for Industry 4.0. In addition, there is a need to take into account the specific needs and priorities of small and medium-sized companies. It is also important that the targeted qualification of employees becomes the key to shaping digital change.

A decisive goal for the development of competencies for Industry 4.0 at Russian and Kazakh enterprises and the corresponding qualifications of existing employees is to avoid the so-called "digital divide", as digitalization is the fundamental basis for Industry 4.0. However, the successful application of such modern digital technologies cannot be achieved by delegating such topics only to IT specialists, but requires a comprehensive understanding of methods and concepts by users. However, this knowledge and experience is subject to complex and, depending on the target group, previously unknown relationships.

Due to the importance of digitalization, it is important to counteract the possible gap between the large companies that are pioneers in the implementation of Industry 4.0 and the numerous small and medium-sized enterprises that are still in a catch-up position with Industry 4.0. In order to support small and medium sized enterprises in the implementation of the Industry 4.0 standard and in the professional development of their employees, it is necessary first of all to familiarize companies with the potential and problems of Industry 4.0. This applies to both management and staff.

In order to facilitate the development of competencies for Industry 4.0, the following recommendations should be taken into account by the companies:

##### Developing framework conditions and raising awareness

Although most companies see Industry 4.0 as a breakthrough opportunity, small and medium enterprises have mixed views on this topic. In order to reduce the number of reservations, it is necessary to create an understanding of the causes and a revolutionary idea of Industry 4.0. Dedicated decentralized process management is not an end in itself, but preserves a company's ability to act and respond in future complex and rapidly changing market conditions.

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For companies that are pioneers in Industry 4.0, it may be appropriate to promote themselves as pioneers to achieve competitive and image advantage. For example, implementing software to digitize office and administrative processes can lead to rapid success: increased productivity and data security, better compliance with standards and improved customer satisfaction. Companies should consider the costs incurred in this regard as an investment and evaluate them from a forward-looking perspective.

#### Further develop business models

A critical analysis of the current business model follows directly from an understanding of the destructive nature of Industry 4.0 for established and traditional ways of doing business. This can be changed due to the introduction of new technologies, for example, digitalization facilitates contact with end users and, if necessary, direct sale of products. One-component production technologies - such as 3D printing - will change the supply landscape and raise customer expectations for greater individuality. If the business model and, thus, technological process at the enterprise changes, it is necessary to be convinced that suppliers and other partners also master new requirements.

#### Targeted change management

The digitalization and implementation of Industry 4.0 is usually accompanied by changes in organizational structure (e.g. by reducing the hierarchy in favour of greater personal responsibility) and staffing structure (e.g. in terms of workforce development), and sometimes by a completely different understanding of business. For this reason, change management must be integrated as part of the development of competencies in companies - especially among managers. Small and medium enterprises, in particular, often need external support in implementing change management processes, although it should be borne in mind that it is often economically inexpedient for such companies to seek management consultants. In addition, further training should be anchored as an ongoing strategic objective in management and human resources departments.

#### Digitalization strategy development

The use of new and innovative technologies is an important aspect of Industry 4.0, although concepts for Industry 4.0 can also be implemented on a small scale. The large-scale use of modern technologies - from intelligent mobile devices for the employee through cloud services to offline, driverless transport systems - is usually inevitable. A key benefit (in keeping with the spirit of Industry 4.0) is that it allows the company to remain flexible and adaptive. Digitalization makes data more complete, fast and accurate, providing a transparent overview of the production system and all other areas of the business.

With strategic foresight, opportunities and risks to the company can be identified at an early stage and conclusions drawn to guide corporate strategy. Small and medium-sized enterprises in particular, despite their typically short-term planning horizon, should regularly use this tool to raise awareness of Industry 4.0 and possible strategies for its implementation.

#### Professional development of employees

For the successful implementation of the Industry 4.0, employees must have the appropriate qualifications. This applies to all areas of qualification in enterprises: training in digitalization of content is just as important for dual training and qualified work as for all forms of further training. The most important qualification topics are data evaluation and analysis, process management and customer relationship management. This qualification must be continuous during the gradual implementation of Industry 4.0.

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For this purpose, it is important to make the qualification a management task. It is recommended that digital formats be used for content delivery. They can demonstrate correlations using real, digitally available process data. Smart terminals connected to the cyber level can provide employees with knowledge.

The development of holistic competence for Industry 4.0 requires the interaction of several actors, which takes place at different stages that can usually be divided into implementation, development, consolidation and sustainable linking. The management level plays an important role in this process. Other actors are universities and public educational institutions, private educational institutions, SME competence centres, non-governmental organizations, associations and trade unions. Their respective tasks are outlined in a road map for possible implementation (see table 2), which is one of the main results of the study. In order for the actors to find their role, an integrated information system is needed.

Further research may, in particular, contribute to the successful implementation of digital proposals in practice.

**Table 2.** Implementation roadmap for competence development in Industry 4.0

Indicators	Corporate management	Universities/public education institutions	External private educational institutions	Centres of competence Industry 4.0 in enterprises	State assistance	Associations, Chambers and Unions
<b>Requirements . Creating the foundation and framework conditions for successful implementation of the Sector 4.0</b>	Use of new and innovative technologies Digitization strategy development Increased awareness of new business models, platform economy, digital markets and data sets	Strengthening the dual system Strengthening initial and continuing teacher training Integration of all stakeholders Strengthening scientific support Media integration and digitization of content Adapting academic training	Extension of training and professional development of teaching staff Operational-level orientation Media and digital content integration	Institutionalization of strategic foresight Creating awareness of new business models, platform economy, digital markets and large data sets	Creation of additional education system Strengthening the dual system Strengthening initial and continuing training of teaching staff Integration of all stakeholders Strengthening scientific support	Integration of all stakeholders Creating framework conditions and raising awareness
<b>Introduction Make sense and draw attention to the scale and business relevance of the Industry 4.0</b>	Acquisition of information and composition of the project team Operational-level orientation Integration of all stakeholders Institutionalization of the strategic foresight approach Targeted change management	Survey of Educational Achievement and Competence Implementation of innovative teaching-learning solutions	Education and Competence Survey Initiation of a neutral internet platform for educational offers in Industry 4.0 Mediation of digital transformation requirements Implementation	Creating framework conditions and raising awareness of competence development for the Industry 4.0 Exchanges between enterprises 4.0 Raising awareness by informing about the content and benefits of the	Information campaign Initiation of a neutral brokerage platform for educational offers in the industry 4.0 Incentives through programs and support activities (e.g.	Information campaign Networking and assistance in obtaining information Creation of seminars and special event formats for enterprise managers

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Indicators	Corporate management	Universities/public education institutions	External private educational institutions	Centres of competence Industry 4.0 in enterprises	State assistance	Associations, Chambers and Unions
			of innovative teaching-learning solutions	Industry 4.0 Establishment of demonstration centres, seminars and special formats of events for business leaders	digital implementation or individual transfer projects) Creation of flexible framework conditions for the industry 4.0	
<b>Development</b> <b>Initialize the theme across the company and create a common understanding of the task</b>	Start event with a message of entrepreneurial vision New business model development	Measures to train trainers on the content and requirements of the Industry 4.0	Raising awareness and adapting managers through basic workshops Message about digital transformation requirements	Exchanges between companies Funded consulting workshops to address industry issues	Incentives through programmes and support measures (e.g. advisory measures or awareness campaigns) Support for pilot projects and openness to pilot approaches	Actively contribute to the development and conceptualization of the integration of people into the Industry 4.0
<b>Consolidation</b> <b>Intensive training of specialists and freedom of decision making for project managers</b>	Message about digital conversion requirements Staff development	Seminars and staff training Message about digital conversion requirements	Providing special training programs for individual companies Message about digital transformation requirements	Inter-business exchange Funded consulting workshops to address industry issues	Incentives through programmes and support measures (e.g. for targeted professional development and learning measures).	Creating opportunities to present best practices through networks and sharing experiences
<b>Sustainability</b> <b>Inform about the current status of the project and explain new technological developments</b>	Organization of events within the company Ensuring the transfer of knowledge and skills throughout life Staff development	Ensuring the transfer of knowledge and skills throughout life Adapting academic training	Ensuring the transfer of knowledge and competence throughout life	Regular information on current innovations and technological opportunities	Strengthening framework conditions for lifelong learning	Creating opportunities to present best practices through networks and sharing experiences

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## 5. Conclusion

The areas of data evaluation and analysis, process management and increasing process know-how, as well as interdisciplinary thinking and action, are regarded by enterprises as central elements of staff qualification for Industry 4.0. Information technology competences - above all as extensive knowledge - are also regarded as being of great importance for the fourth industrial revolution. When setting priorities for the future, differences will become apparent: while large companies pay particular attention to technology and data-oriented topics, small and medium-sized enterprises pay particular attention to customer-oriented processes as well as areas of competence related to infrastructure and organization.

The content of Industry 4.0 and digitalization should be integrated into company training and further education, existing offers should be systematically linked to each other and existing programmes should be purposefully developed. In this context, it is essential to strengthen all necessary competences and skills: those that are relevant for the implementation of Industry 4.0 at the production and technological level or in the design of customer relationships, as well as those in management and workforce that are relevant for the development of new business models and for understanding the economics of the Internet and platforms. In addition to traditional competency development tools, participatory learning platforms should also use digital educational offerings as well as learning cases, simulations or learning games (keyword: gamification).

In general, Kazakh companies have significant development potential for further implementation of digital technologies. This is especially true for small and medium-sized enterprises. Both in terms of implementation and intention to develop companies in digital format.

Against this background, it is obvious that it is necessary to raise awareness of digital changes in small and medium-sized businesses and to convey to them not only the benefits of Industry 4.0, but also clear strategies for its implementation. Specific (successful) implementation examples provide important impulses for the introduction of Industry 4.0 to SMEs, on the one hand (to be able to assess digitization opportunities for their business) and, on the other hand, to reduce concerns about high investment costs and uncertainty about depreciation of investments.

In order to facilitate and successfully develop competencies for the Industry, the study has developed the following recommendations for enterprises to act on:

1. Develop and implement strategies for Industry 4.0: Company decision makers must develop an understanding of the disruptive changes caused by Industry 4.0. It is important that companies derive from this understanding the strategies and measures for developing employee competencies and introducing new products, efficient processes, and innovative business models. The leadership competence of management is particularly relevant here (see in particular the implementation roadmap in Table 2).
2. Strengthen qualification and change management: Initial and continuing vocational training in enterprises should be adapted to Industry 4.0 and qualifications should be a priority. New digital methods offer effective entry points for this. In addition, it is important to adapt the work organisation and process as well as the framework conditions. Change management must be taken into account from the outset.

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