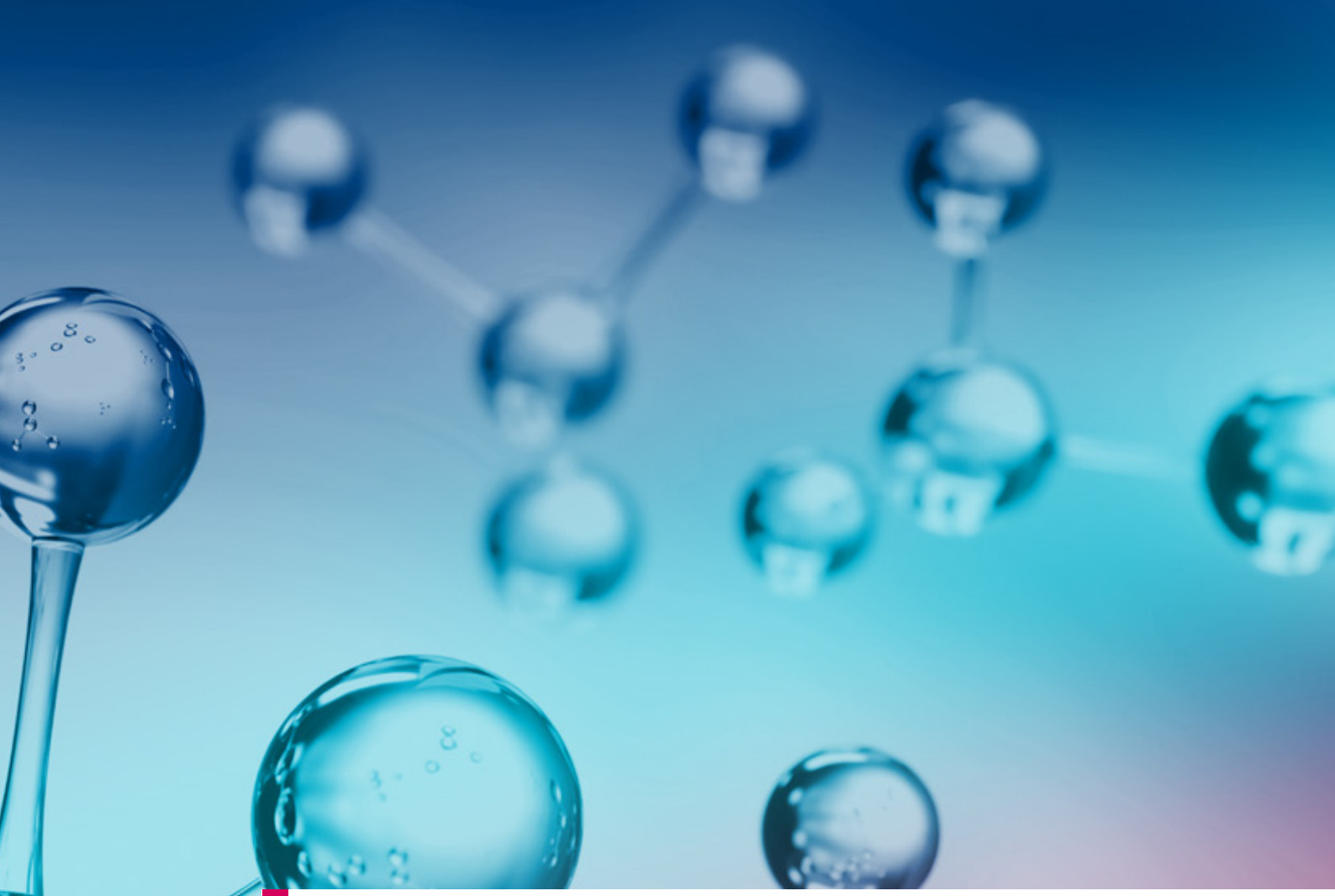


SURVEY

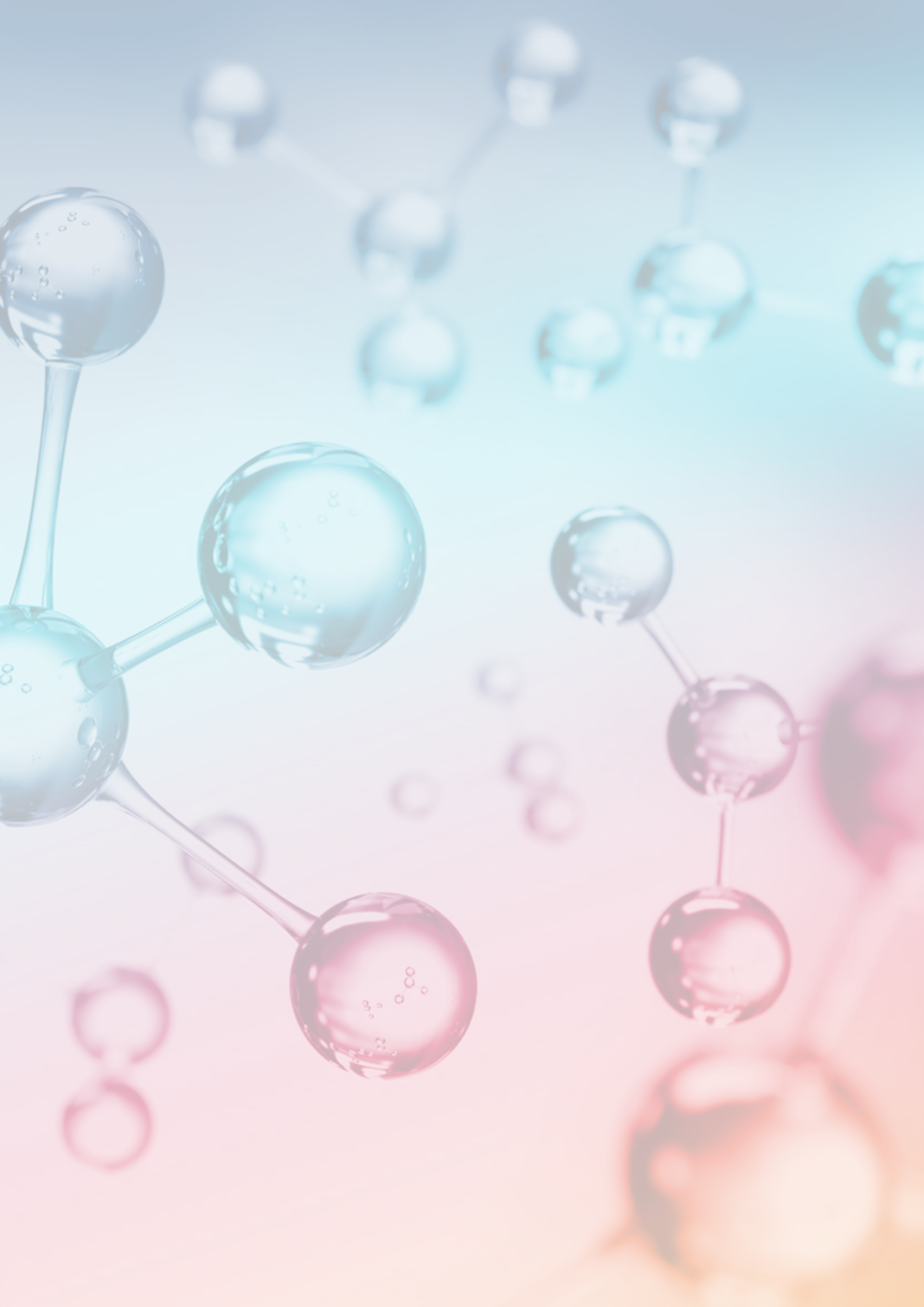
Digital Skills Needs in the European chemical, pharmaceutical, rubber, and plastics industry

FECCIA CEC EUROPEAN MANAGERS

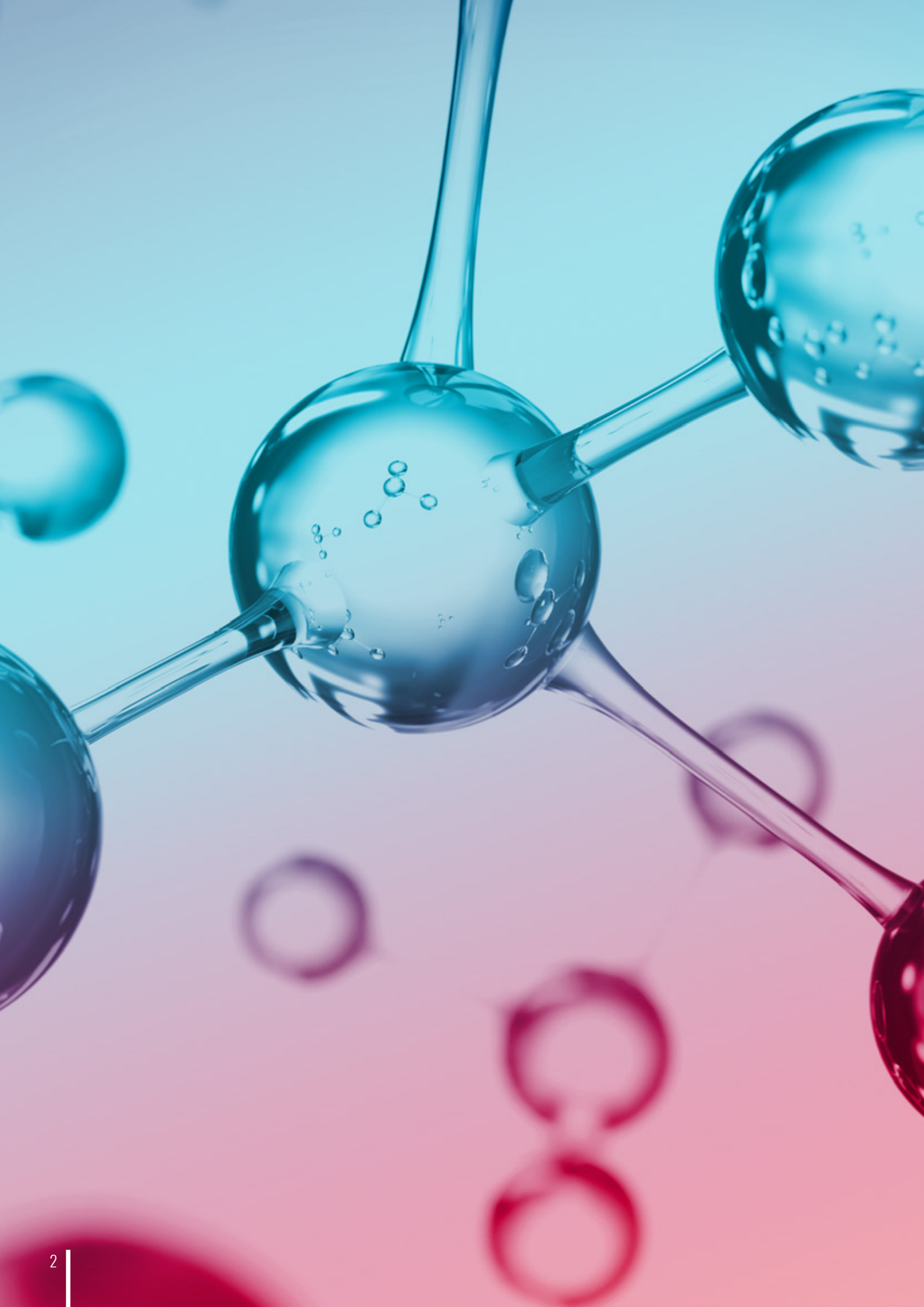
ECEG European Chemical Employers Group

ledarna SVERIGES CHEFSORGANISATION

With the financial support of the European Union



Agenda



1 INTRODUCTION

Introduction

The digital transformation induces disruptive change in the chemical industry, bringing forth an ever-increasing number of digital innovations, while demands on employees' knowledge and skills are growing at the same time. The central question therefore is: which specific digital skills are crucial today and in future and how well-prepared are employees and employers for the challenges of that transformation?

In order to find answers, FECCIA, ECEG and Ledarna commissioned the Institute for Employment and Employability IBE of Ludwigshafen University to conducted in-depth research on 'Identifying and Meeting Digital Skills Needs in the European Chemical, Pharmaceutical, Rubber and Plastics Industry' as part of their social partner project with the same name.

With the aim of identifying the digital skills needs today and in the future, an online survey was conducted at the start, in which carefully selected experts, representing blue-collar workers, managers and company leaders from the relevant sectors participated.

This survey revealed potential gaps and development needs regarding direct and indirect digital skills in seven competence areas. Subsequently, the experts took part in guided interviews in which the identified gaps and needs were examined in greater detail and transferred into specific requirements for the development of digital skills.

On the one hand, the interviews confirmed that the constant transformation of production processes calls for action in all competence areas. On the other hand, however, it became obvious that there was a strong awareness and understanding of the various challenges this transformation entails. In some cases, specific concepts have already been developed and implemented to meet the needs for digital skills.

The results of the analysis are presented here in detail and put into their respective contexts and formed the basis for the four dedicated digital skills workshops on the development of digital skills curricula frameworks for workers, mangers, employers and academic institutions.

Project context and objectives

The attempt to assess the digital skills needed today and in the future for different job profiles in the chemical, pharmaceutical, rubber, and plastics industry, comes with three significant challenges:

- Reducing complexity regarding job profiles
- Addressing different workforce levels
- Reducing the complexity of digital skills

Challenge 1: How to reduce the complexity of job profiles?

The European chemical, pharmaceutical, rubber, and plastics industries are diversified, developing, manufacturing, and supplying various products and services. Therefore, there is also a wide range of different job profiles. Most people might associate the industries primarily with jobs such as chemical lab assistants working with test tubes and microscopes. However, beyond that large numbers of other technical, research, commercial and administrative types of jobs exist, which can be found in all operational areas of organisations, such as R&D, production, logistics, marketing or administration. Given this complexity it

Fig. 1: Jobs in the European chemical, pharmaceutical, rubber, and plastics industry

would be impossible and unfeasible to assess each individual job profile with regard to the digital skills they may require. (fig. 1)

There is a need for a reduction of complexity, which can be achieved by creating job clusters. It is like a procedure used in strategic workforce planning. All jobs are clustered according to their job specifications. It doesn't matter which operational area a specific job is assigned to. Instead, it is about the similarity of competencies of the relevant job. (fig. 2)

The following example illustrates the procedure:

Production controller vs financial controller

Controlling jobs can be found in both production and finance in the industries in question. A production controller will deal with the analysis of production costs and their optimisation to enhance efficiency. For a financial controller, the overall analysis of the economic situation of the company and future developments is a principal task. To that effect, a production controller deals with technical matters. In contrast, a financial controller is responsible for general and strategic questions in finance.

However, regardless of their different focuses, functional areas, and career paths, both jobs can be assigned to the same job cluster (finance/administration/controlling) because the basic skills required are somewhat similar. The production and financial controller need a mindset related to operational figures.[1] Moreover, it can be assumed that it would be possible, after a somewhat brief adaption training (e.g., one year), for the respective jobholders to replace one another.

By creating job clusters, the innumerable variety of jobs becomes manageable. It is recommended to base job clusters on the significant departments of a company, e.g., R&D, production, finance, sales, et cetera. as these provide a reliable initial outline. However, it should be emphasised that the generation of job clusters is primarily based on similar skill requirements, not on organisational charts or hierarchy levels. For this project, nine job clusters are considered particularly relevant for the European chemical, pharmaceutical, rubber, and plastics Industries. (fig. 3)

For each job cluster, there are specific skills requirements. Therefore, job clusters provide a framework for what skills are attributed to, and thus expected of, a group through assignment to a specific cluster. Job groupings also make it possible to identify structural needs and the requirements of different functional areas. It is a solid basis for the planning of human resources development.[2]

1 Von Kettler 2017.

2 Hans Böckler Stiftung 2019, pp. 35.

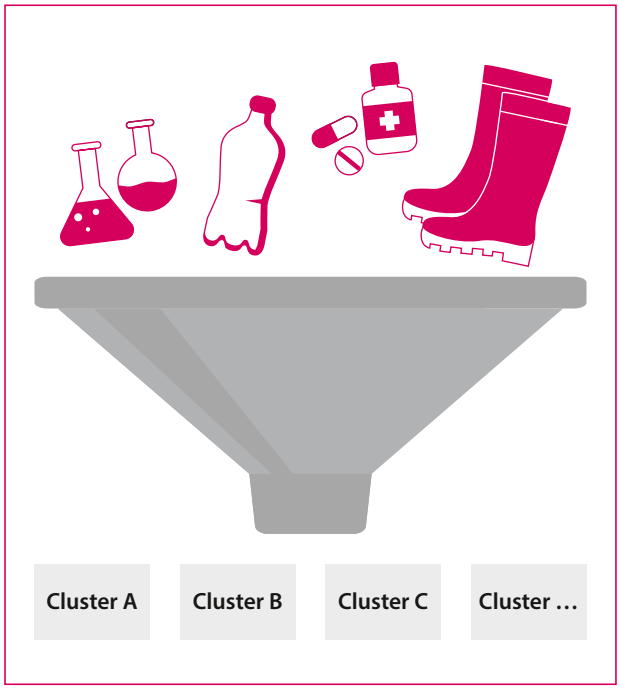


Fig. 2: Generating job clusters

Fig. 3: Identified job clusters

Challenge 2: How to address different levels of the workforce?

However, since mere assignment to job clusters is not sufficient to create a requirements profile adapted for employees, the next step is to address the level of the workforce. The workforce is divided into workers, managers, and employers, and the different requirements of each job cluster are matched against these three groups. Among employers, however, there is the distinction that management skills are primarily attributed instead to job cluster requirements, as these are often difficult to assign to a job cluster due to the holistic skill requirements. For workers and managers, on the other hand, needs are assigned to the respective job cluster and their workforce level.

Challenge 3: How to reduce complexity regarding digital skills required now and in the future?

Once the classification into job clusters and employment levels has been made, it is vital to address the individual needs of the employees regarding digital skills.

The term 'Digital Skills' describes many skills and is subject to various interpretations. A matrix of so-called direct and indirect skills has been developed to identify the skills relevant to this approach. This matrix is mainly based on three studies: The DIGCOMP Framework for Developing and Understanding Digital Competence in Europe[3] and Skills Shift – Automation and the future of the workforce[4]. While the DIGCOMP studies, focusing on digital competencies, can be used to evaluate digital skills, the MGI study offers a wide range of indirect digital skills (cognitive/social/emotional skills). Further studies (e.g., Vodafone Stiftung/Fraunhofer ISI 2016, Acatech 2016, van Laar et al. 2019, Ehlers 2019, IFTF 2011, Rump et al. 2019; Prognos 2019) have also been analysed and additional relevant skills and competences have been integrated. (tab. 1)

To assess the importance of these skills for the present and the near future in personal interviews, considering the identified job clusters in the given industries and the work levels, it soon became apparent that complexity needed to be reduced. Therefore, only the competence areas were addressed, with exemplary skills helping to describe the areas.

3 Ferrari 2013; Carretero et al. 2017.

4 McKinsey Global Institute MGI 2018.

Competence areas	Competences
Direct digital skills	
Information	Digital literacy Browsing, searching, and filtering information Analysing digital information Evaluating digital information Storing and retrieving digital information Computational thinking
Communication	Communicating through digital channels Interacting with machines Sharing information and content Networking and collaborating through digital channels Interacting with and participating in communities and networks Netiquette New media literacy Virtual collaboration Tech translation
Content creation	Creating and editing content (different formats, e.g., word processing, photos, videos) Integrating and re-elaborating existing resources of knowledge and content Developing creative formats, including multimedia, and programming Understanding and applying regulations regarding copyright and licenses Programming
Safety and ethics	Protecting self from online fraud, threats, cyberbullying, et cetera Protecting personal data Protecting digital identities Protecting health Protecting the environment Sustainability Ethical awareness
Problem-solving	Analysing technical problems Identifying needs and technological responses Innovating and creatively using technology Prioritising problems and responses Identifying competence gaps Implementation of digital solutions

Competence areas	Competences
Indirect digital skills	
Cognitive skills	Critical thinking Complexity management Insecurity and risk management Systemically thinking Readiness for change Decision-making Learning aptitude Adaptability Flexibility Teaching Project management Process thinking Transdisciplinarity Cognitive load management
Social and emotional skills	Empathy Resilience Conflict management Leadership Skills Motivating oneself Motivating others Entrepreneurial thinking Self-organisation Self-initiative Self-efficacy Autonomy Curiosity Perseverance Interpersonal relation management

Tab. 1.: Direct digital skills and Indirect digital skills

Using a brief survey and in several personal interviews, representatives of the above industries, job clusters, and workforce levels were then asked to assess the importance of the chosen competence areas now and in the future using a four-level point system:

A = Foundation level

B = Intermediate level

C = Advanced level

D = Highly specialised level

The interview process was supplemented by a literature analysis to achieve a higher level of representativeness and substantiate the outcomes.

During the interviews, the experts often used different terms for 'digitisation' to describe specific skill requirements. These terms were like the digital techniques defined by the Chemical Industries Association (CIA), as shown below.[5] Therefore, in this report, 'digitisation' is the generic term used to cover these as well:

- Artificial intelligence
- Virtual/Augmented reality
- Digital twin
- Cyber-physical systems
- Big data/Smart algorithms
- Internet-of-Things
- Advanced robotics & cobotics
- Cloud technology
- 3D printing/Additive manufacturing
- Cyber-security

5 Chemical Industries Association (CIA) 2021, p. 3.

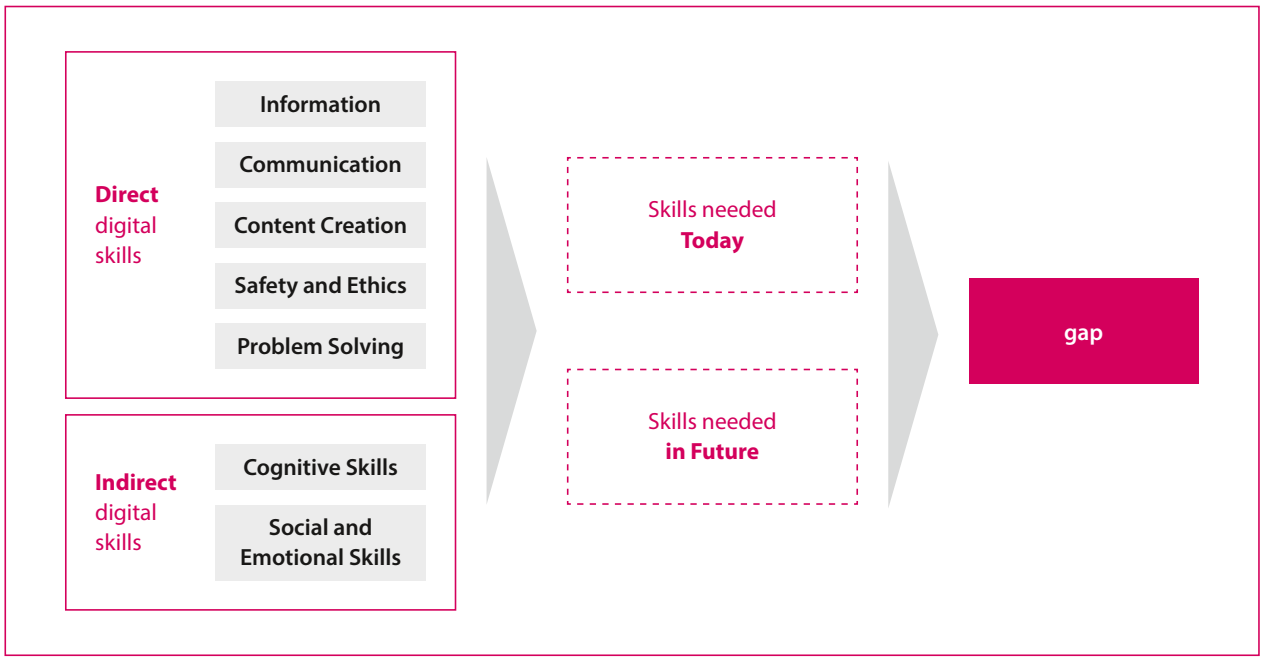


Fig. 4: Gap analysis model

2 FINDINGS

The following chapters give an overview of the above-mentioned competence areas of digital skills such as information, communication, content creation, safety/ethics, and problem-solving, as well as indirect digital skills such as cognitive skills and social/emotional skills. The findings are based on the interview series and literature analysis. In the light of the given fact that it was impossible to talk to representatives of all defined job clusters, the key findings are structured by the underlying seven competence areas.

Direct Digital Skills

> We must ensure that we provide the correct information and have good data management. Suppose there is an accident under working conditions. How can you ensure that this kind of experience does not happen elsewhere? Because we already know how to manage it and how we can provide a solution to this issue, we must target the right people with the information and that managers simplify this part of communication.

Laurent Selles, *Corporate HR & Communication Director, Bostik, France*

Information

Exemplary skills: digital literacy, browsing, searching, and filtering information, analysing digital information, evaluating digital information, storing and retrieving digital information, computational thinking, …

The competence area of information indicates the extent to which people can utilise digital means to find, analyse, and further use information. This is particularly important in the context of employees since, in the future, employees will have to deal with large quantities of data and information. In addition, the internet enables access to a large amount of information when searching for information, which must, however, be critically and analytically examined.

- In most cases, the first contact with a new customer is made via the internet. Therefore, employees must be able to provide all vital information customers require during this first contact (e.g., website content). Another critical aspect in this context is sharing information, e.g., decent examples for dealing with problems or accidents to prevent similar events in the future. It has always been vital, but digital tools and the know-how to use them will enhance and facilitate this process. People need advanced or highly specialised skills to create and set up these tools. If they only use these tools, they will need skills in translating all the information and using it for their actions. Due to the development of smart factories [working with robots, cobots, Articificial Intelligence (AI), and Extended Reality (XR)], the need to process and analyse digital information increases, and the job roles of machine operators, for example, face a considerable change.

- It will become even more vital in the future to use apps on mobile devices. They are increasingly used to manage production processes and monitor damages and failures, et cetera, but also for administrative matters such as time recording. Sometimes, private mobile devices must be used as well.

- Moreover, it will be necessary to handle process control systems. Regarding maintenance, it is essential to combine and compare actual data with information from the past to assess the expected operating life of devices and components.

- Another essential skill is the ability to carry out simulations which will be used more and more in the future. For example, flow or pressure losses can be predicted with computational fluid dynamics.

- Nowadays, more and more data are collected. There might be too much data, which does not necessarily help. Thus, it is not just important that people know how to find the information they need to do a specific task. It becomes more crucial for

them to filter the information regularly by themselves because the system does not necessarily do it automatically. However, applications and inventions are helping to understand and filter data so correct decisions can be made.

- Skills such as collecting, storing, contextualising, visualising, and integrating data will increasingly be connected. They are required in production more and more, often using specific information systems that help workers collect and analyse the necessary information.

- In the past, information was passed on via telephone to a large extent. In addition to stationary phones, people started to use smartphones. Nowadays, people are connected via telephone, smartphone, and video conferencing, often extending to various chat and collaboration tools. All these devices and sources of information must be handled simultaneously. This requires specific skills which need to be enhanced.

Fig. 5 shows shows skill gaps assessed by the interviewees between digital skills needed today and in the future regarding competence area 'information'. As can be seen, the skill requirements vary according to the workforce level for employers, managers, and workers:

> "The increasing use of digital devices is constantly opening new channels of communication. Thus, on the one hand the employees can very easily obtain information, on the other hand this can prove to be an increasing source of pressure for them because at the same time they are also expected to provide ever more information."
>
> ***Melf Singer,*** *Foreman Sulphuric Acid plant, Aurubis, Germany*

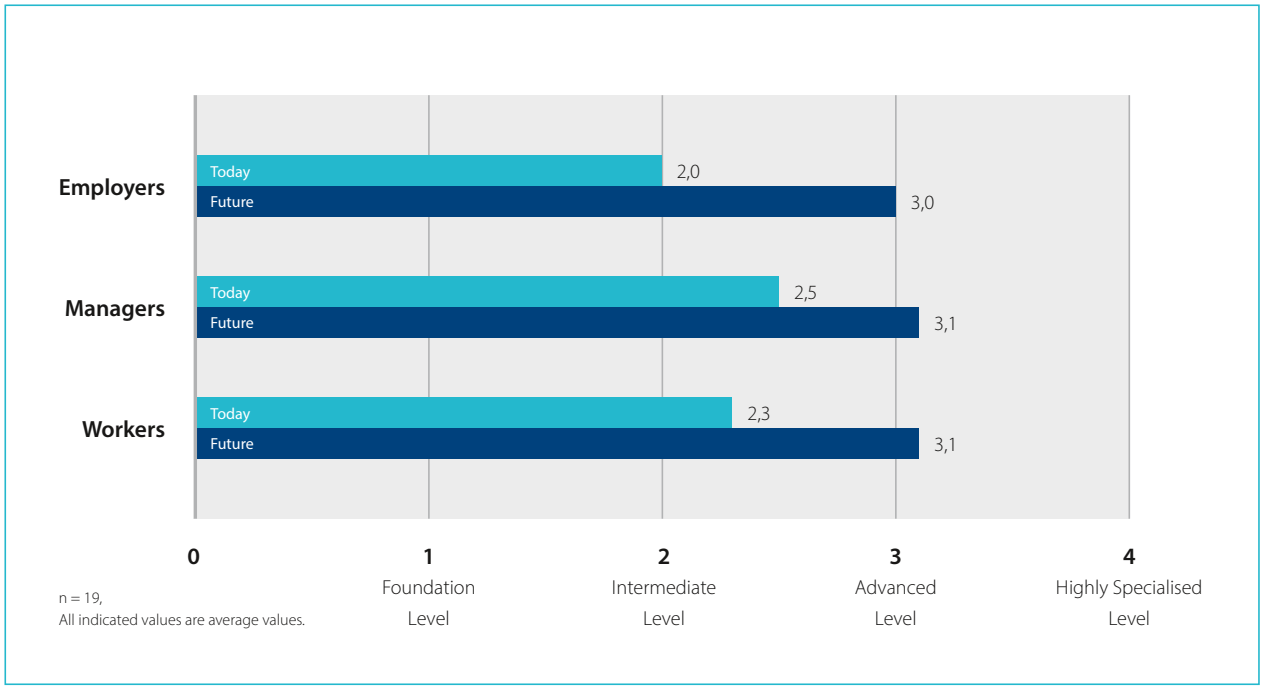


Fig. 5: Information

> We use a lot of different communication channels for various purposes. Sharing information, for example, but also communicating with other groups on different levels at different speeds, depending on the channel. This applies to internal and external communication.

Dr. Martina Seiler, *R&D Laundry & Home Care, Henkel AG & Co KGaA, Germany*

Communication

Exemplary skills: communicating through digital channels, interacting with machines, sharing information and content, networking and collaborating through digital channels, interacting with and participating in communities and networks, netiquette, new media literacy, virtual collaboration, tech translation, …

Another competence area is communication in the digital context. It includes using digital means of communication, data, information and content sharing with colleagues, and networking within organisations on a digital basis. Of particular importance is the digital way of communicating, where relationships between colleagues are also maintained in the digital workspace, while at the same time observing certain netiquettes. Since problems can arise in the context of these new and complex ways of communicating, there is a solid link to the competence area of problem-solving (see below).

- In recent years, the number of possible ways of communicating with colleagues has increased considerably. Often, different tools are used for various purposes (e.g., chat groups for a fast exchange, e-mails for more official use, team working tools for sharing information, and internal social media platforms). This offers many possibilities and, at the same time, requires specific skills to protect oneself from being overwhelmed.

- A megatrend that has been on the agenda for several years but has been pushed forward considerably by the Covid-19 crisis is the rise in mobile work, leading to an increase in the importance of communication skills. After the pandemic, part of the communication will most likely continue to be via digital tools or in a hybrid way. This proved to be a challenge for many people who were not familiar with mobile work and virtual or mixed communication before the pandemic struck.

- The Covid-19-Pandemic has also accelerated the development of new tools to communicate and interact with people from all over the world, e.g., AR for maintenance or training purposes or even for sales and marketing (people wearing goggles to show the audience how a production line works, or which problems occur on a machine). People will need advanced skills in interacting and communicating with machines because the latter will take over more and more tasks (e.g., DCS-Systems).

- One of the most vital aspects of communicative skills is that people need to be aware of the damage digital communication might do. If the wrong kind of information is shared or the way they talk about their company in public and on social media gives a negative impression, considerable harm can be done. In this context, they also need to realise there is a connection between company life and private life, e.g., when posting photos.

- To learn more about potential errors in production and how to solve them, workers need to improve their communication skills, so they can communicate with and learn from engineers and managers. With the rise in tasks related to digitisation, all staff members must be able to communicate with each other, regardless of seniority matters. Therefore, skills in identifying intrapersonal knowledge of other people need to be developed.
- Every department within a company should ensure contact persons who have a proper command of relevant new technologies and are willing to pass their knowledge on to others, helping them with their questions.

For the competence area 'Communication', potential skills gaps were identified by the interviewees as shown in fig. 6.

> "Because of relatively rigid guidelines, communicating through digital channels and interacting with and participating in communities and networks is only possible to a minimal extent."
>
> ***Peter Oberle,*** *Country Representative Iberia, LANXESS Chemicals S.E., Spain*

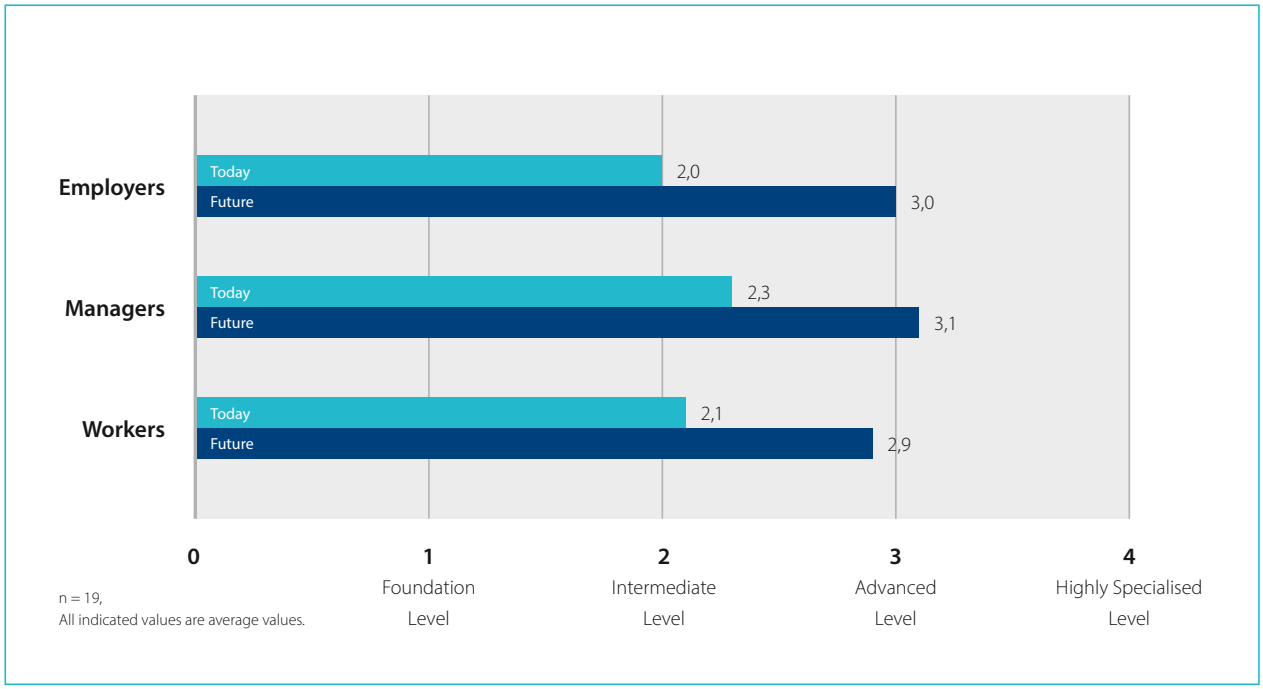
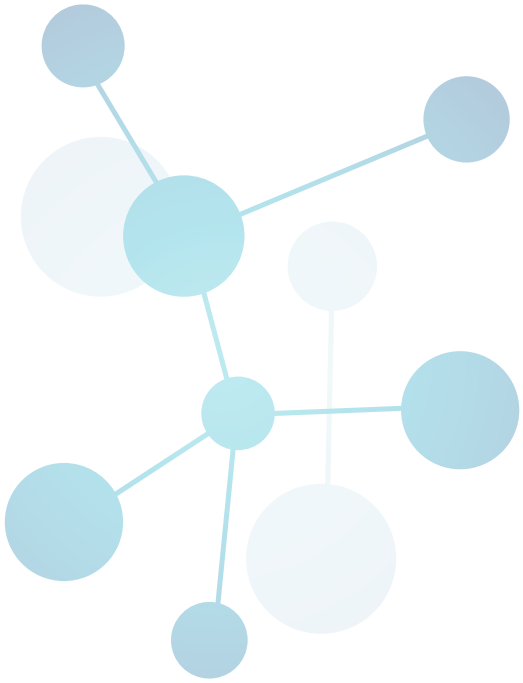


Fig. 6: Communication



> We have a big project where we renew all our websites. It is easy to add some content, but it is not so easy to decide how the customer journey is managed. You must ensure that you get the right people and stakeholders. This is a big challenge because you can create a lot of communication, information, and content. Still, if you lose your final customer, it's not worth it.

Laurent Selles, *Corporate HR & Communication Director, Bostik, France*

Content creation

Exemplary skills: creating and editing content (different formats, e.g., word processing, photos, videos), integrating and re-elaborating existing resources of knowledge and content, developing creative formats (including multimedia and programming), understanding and applying regulations about copyright and licenses, programming, …

When it comes to the competence area of content creation, skills in the presentation of results are required in many areas. This applies both within the company and to the outside world. Examples include the development of a specific brand for a product, for which content must be developed, planned, created, and lastly, edited. This requires photo and video editing skills, possibly in conjunction with social media management. When creating communication tools, such as websites, skills in programming are often required as well.

- Creating the appropriate content for different groups of recipients has always required much information and knowledge. However, with developments happening faster and recipient groups becoming more and more heterogenous, content must be created and updated regularly. In this context, all content must align with the company's values and culture. Moreover, in a fast-changing world, it is no longer sufficient to work with content development and creation experts on a global or freelance basis. Companies need those skills locally and within the company to save time.

- People will need more skills in creating E-learning content using third-party tools (e.g., Street View maps or 3D learning environments). Teaching and learning content should be innovative and easily accessible for the learner and of high standards. This requires very creative formats. In some cases, the same content needs to be available in different forms (e.g., VR, AR, videos, PowerPoint) to include and attract other groups of learners. Besides that, the learning content will have to be more diversified. Creating such content requires highly skilled experts.

- Workers will need skills in tuning machines to improve their performance. Sometimes this will require highly specialised skills as well. However, this doesn't apply to all workers alike. So far, not much has changed for some of them since they receive the content they work with from other departments.

- For many applications, hard coding skills are no longer needed (e.g., creating websites). Many applications will get more accessible, and people will have to do things they would not have been able to do some years ago.

- Being able to use process control systems will become more and more important, e.g., to create evaluations or visualisations regarding machines or systems and at the same time to analyse them. This is necessary to adapt to process requirements at short notice. In addition, certain skills will be needed to provide data for colleagues in a way that is easy to understand by different people.
- Even in routine jobs, it will not be enough anymore to operate the provided programs for a specific task as an ordinary user. Due to the rise in digital tasks, people need to be willing to understand the tools they are using on an intermediate level. Therefore, it would be helpful if more people were interested in basic programming skills to understand how different components like valves and pumps communicate and relate to each other, especially in the chemical industry.
- The tools used offer innumerable possibilities to process data. Seizing all those possibilities requires creativity, e.g., creating a customised dashboard that may help improve performance and efficiency.

> We have other people working with computing and programming. I'm just using the things they give me. But I think it will be more and more demanding to understand how everything works in the future."
>
> ***Andreas Höckersten,*** *Operations Technician, St1 Refinery AB, Sweden*

Fig. 7 relates to. the interviewees' assessment of potential skills gaps in the competence area 'Content creation':

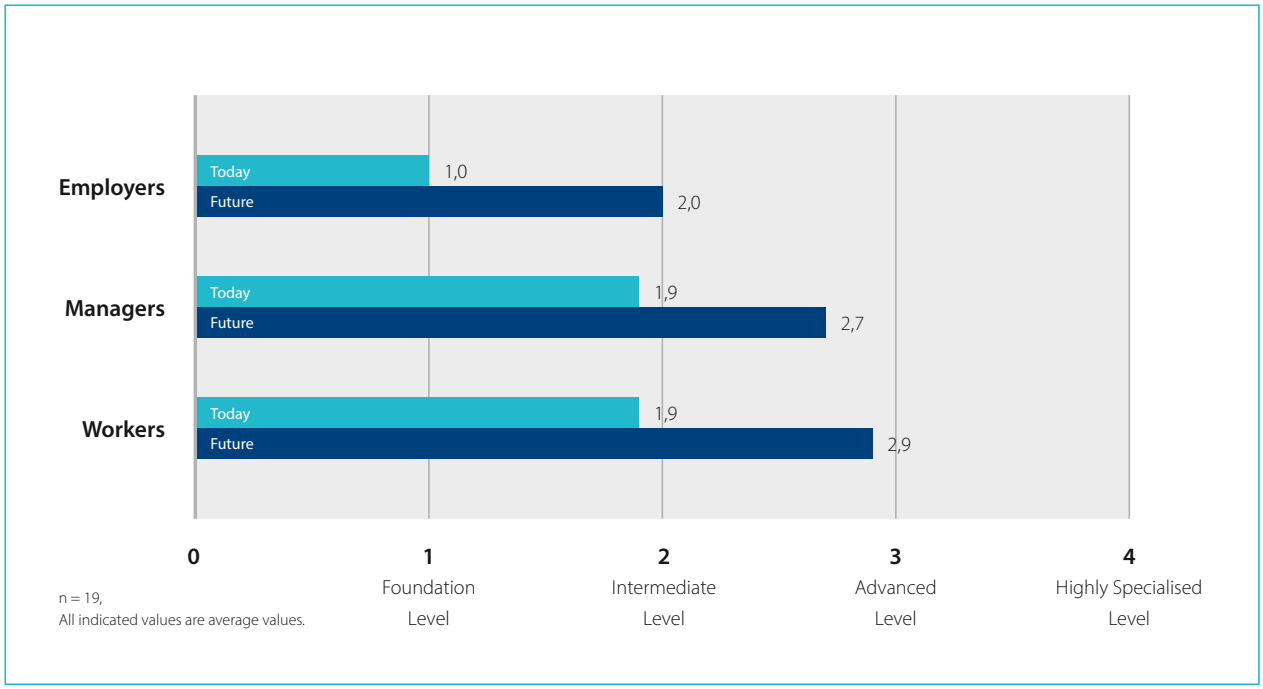


Fig. 7: Content creation

> There is plenty of training on cyber security. Sometimes, we even invite external speakers, e.g., the police, to demonstrate possible types of fraud such as identity theft.

Dr. Martina Seiler, *R&D Laundry & Home Care, Henkel AG & Co KGaA, Germany*

Safety and ethics

Exemplary skills: protecting oneself from online threats such as fraud, identity theft, cyberbullying, etc.; protecting personal data, digital identities; being aware of health, environment, sustainability, ethical codes, …

Safety is essential for chemical plants and processes. Therefore, skills to ensure security will gain importance. This includes safety for both workers and customers (patients in the case of the pharmaceutical industry) as well. When a company is presented in the digital space, it is also important to maintain ethical standards, including a clear position on issues such as environmental protection and sustainability.

More and more, safety matters do not only refer to safe handling of chemical substances to avoid damage but also to safely handling data, machines, systems, and digital processes. For example, an increase in mobile working raises new questions regarding cybersecurity (e.g., working in a public place, working with sensible data at home, using private Wi-Fi), which must be considered.

> We have specific tasks in our production process that we can't make any mistakes in. In a septic area, if we make a mistake, the whole batch, the entire product will be ruined, and we can't afford that. So that's why we have taken the training in VR or AR so that our employees can learn by making mistakes because making mistakes is an excellent way of learning. So, we want to make sure that it's perfect for people to try and make mistakes to understand and see what's happening.

Maria Wandelstam, *Site Learning & Development Lead Sweden Operations, AstraZeneca, Sweden*

> Ethical awareness is vital for us. This also applies to our sales team. There is compulsory yearly training with a test you must pass at the end. One of the topics is cybercrime. [...] Among the cautious organisations, ours is one of the most prudent.

Peter Oberle, *Country Representative Iberia, LANXESS Chemicals S.E., Spain*

- There will also be a higher need to protect the company's IT infrastructure because of more potential frauds (e.g., via smartphones and other personal devices). Several companies already work with closed loops for their production processes to prevent them from cyber-attacks or environmental damage.
- In this context, employees also need to have a high level of awareness of potential risks when making changes to the digital tools they are using.
- Skills regarding safe data management are required, for example, to ensure that sensitive data are only available to a particular authorised group of people for specific purposes and a defined period.

Potential skills gaps in the competence area 'Safety and ethics' have been assessed as shown in fig. 8.

> "Safety in the chemical industry must be at the highest level, not just in handling chemicals but also in digital security, ransomware, for instance. You must be very careful. We must train people how to work with digital technology in this chemical world, and we really must step up."

Frans van den Akker, *Business Developer Energy & Industry BL Digital, Royal HaskoningDHV, The Netherlands*

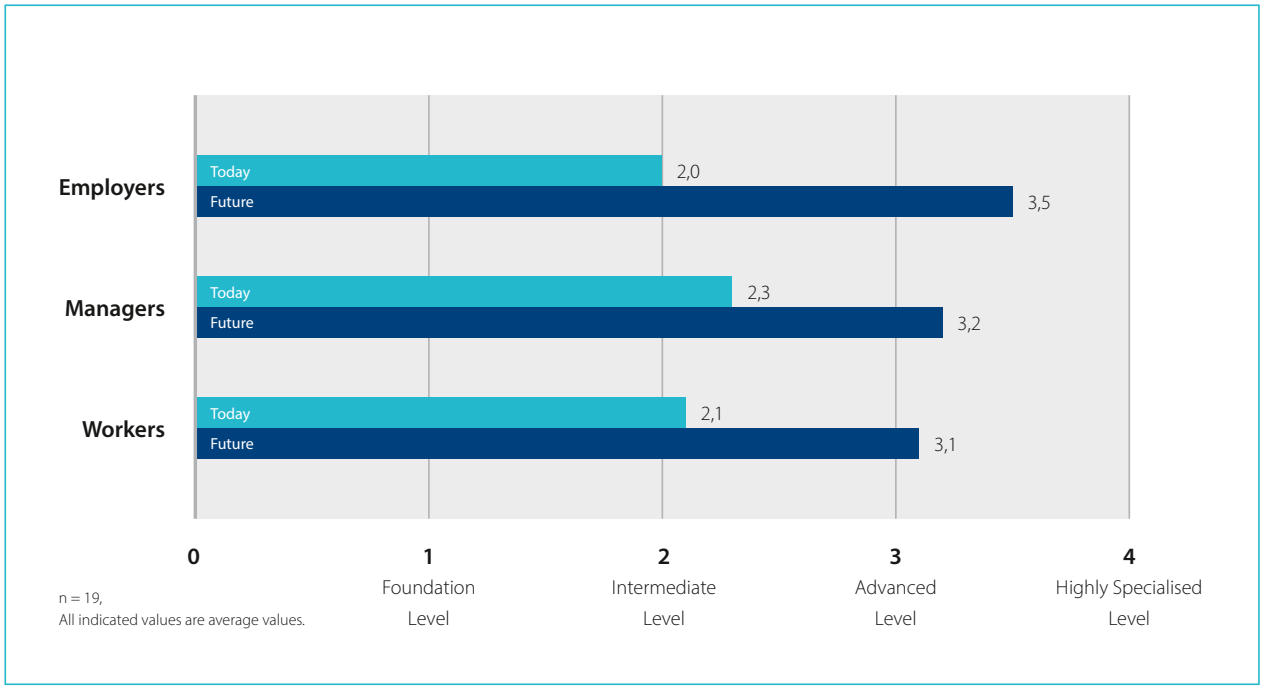


Fig. 8: Safety and ethics

> If you want to improve yourself further, you have to learn to perceive problems as a chance. Particularly in a digital context it is vital to understand what the exact cause of a certain problem was in order to be able to draw the correct conclusions for the future. This mindset must therefore be encouraged by all means.

Zeinab Abdallah, *Process Operator, Nouryon, Sweden*

Problem-solving

Exemplary skills: analysing technical problems, innovating and creatively using technology, prioritising problems and responses, identifying tchnological needs and competence gaps, implementing digital solutions, …

Problem-solving is something that machines will not be able to take over entirely in the foreseeable future. Therefore, these personal skills will remain crucial. At the same time, the amount and types of problems related to digital matters will rise. Complex connections between different components (employees, processes, divisions, et cetera) will require advanced problem-solving skills. It includes recognising problems and taking the necessary steps to solve these problems. In some cases, this can also mean identifying one's competence gaps and either seeking support or closing these competence gaps.

- Skills concerning working in a team, analysing problems, and communicating about possible causes and solutions are crucial when it comes to problem-solving. Today, there is often just one IT specialist in a team to solve complex problems. When the number of issues related to digital matters rises in the future, this might not be enough.

- People need to be able to rely on data more than before. Data will tell them when and what to do. Machines, for example, assess their components' conditions (e.g., by noticing vibrations) and will notify their users or even the suppliers of spare parts when something needs replacing. These improved control systems can also lead to a higher demand for maintenance plans and actions because notification about problems happens faster and more often due to the data. Moreover, people will need a higher ability to solve more problems at a time, also remotely (e.g., from a control room).

- However, problem-solving will get easier because condition models will tell workers when there is a problem. Instead of having to go through a written manual to find a solution to a machine-related problem, advanced AR skills will be needed to find the cause of the problem a lot faster and more easily. More and more information on solving certain problems can also be found Online. In this context, it is essential to have the ability to assess what kind of information is reliable critically.

- With a higher demand for self-initiative, the demand for problem-solving skills will also rise. For example, people will need to be able to read complex charts and anticipate future events. Furthermore, they will need to be able to explain more digital-related problems to colleagues to understand and solve them together.

- People will also have to understand that in the digital surrounding, minor problems they notice today can become much more prominent in the future. This is why they need to be more sensitive in identifying and evaluating issues.
- In a production environment, there are 'troubleshooters' on duty most of the time. Their tasks are becoming increasingly complex, and they will need more organisational skills in the future.
- A higher level of self-initiative and ad-creativity will be required for problem-solving in the future. Employees need to be able to use the technical possibilities they have (e.g., research on the internet) before asking other departments or colleagues for help.
- On the one hand, relying on digital devices is essential. However, it is equally important to continue checking those devices for possible misfunctions. There must be smooth and reliable interfaces between machines and humans.

Regarding the competence area 'Problem-solving', skills gaps are expected, as shown in fig. 9.

> "People are increasingly looking on the internet for information on how to solve or manage problems. That's why I think today you can have decent or poor information online. You need to have a more professional vision of what information you can trust. So, a critical mindset is vital to problem-solving."
>
> ***Laurent Selles,*** *Corporate HR & Communication Director, Bostik, France*

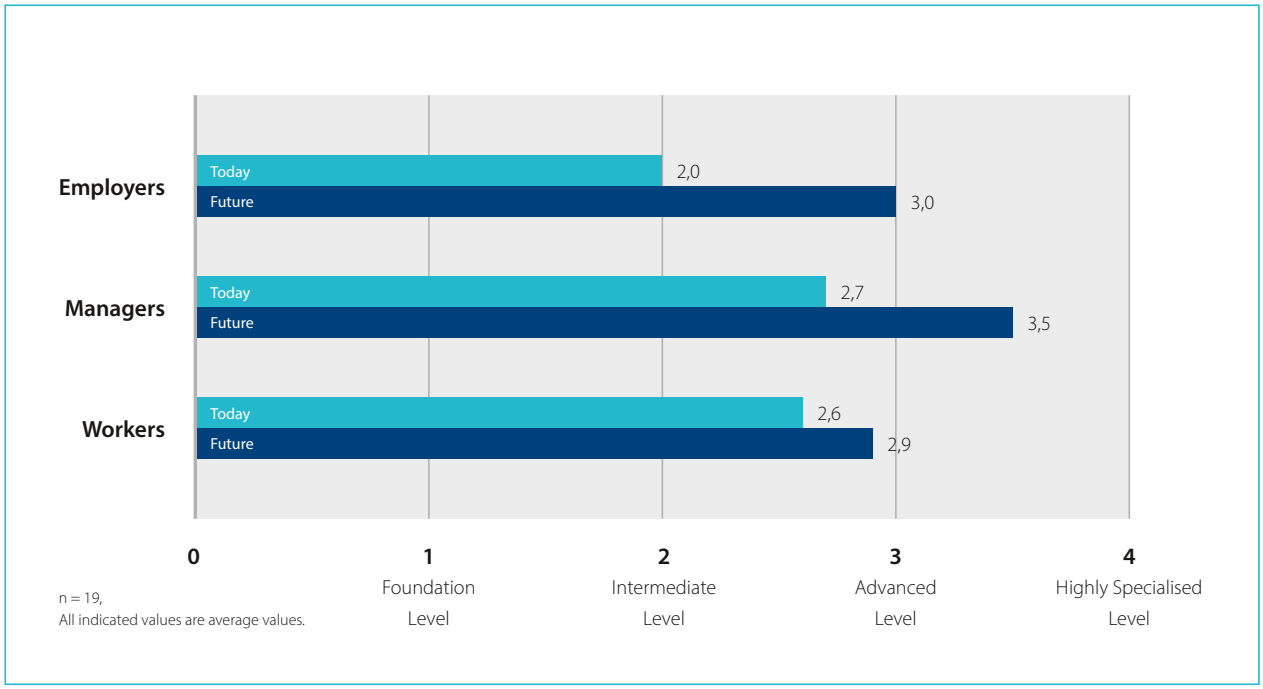


Fig. 9: Problem-solving

Indirect Digital Skills

> The increase in complexity and the immense amount of data everyone must deal with does not only require suitable tools but also the ability to organise oneself and the own data management.

Dr. Martina Seiler, *R&D Laundry & Home Care, Henkel AG & Co KGaA, Germany*

> Digitisation makes it more important to think about processes. We are well organised in that respect now and define our work based on procedures. This makes it a lot easier for our production colleagues to schedule and complete their tasks successfully.

Marcel Stotzka, *Foreman IH EMR North/South, Aurubis, Germany*

Cognitive skills

Exemplary skills: critical thinking, complexity management, insecurity and risk management, systemically thinking, readiness for change, decision-making, learning aptitude, adaptability, flexibility, teaching, project management, process thinking, transdisciplinary, cognitive load management, …

In addition to direct digital skills, indirect digital skills must also be considered. These include cognitive skills that enable people to learn and master direct digital skills. Thus, the competence area of cognitive skills covers abilities such as critical thinking and decision-making ability, but also skills in adapting to new circumstances, such as adaptability, flexibility, and openness to change.

- Cognitive skills will gain importance because, due to digitisation, employees' technical skills and expertise can become outdated rapidly in some areas. They need the ability and willingness to adapt to changing circumstances throughout their working lives.
- One of the vital skills in this context is learning agility. Many people need to upskill or reskill every two or three years. Employees therefore need to be able and willing to work with different digital learning tools like Street View maps or 3D models, which might be challenging for some people who are not used to this application. Some workers in production have mainly done repetitive manual work for a long time; they may face challenges in developing their learning abilities with regard to working with digital tools.
- Furthermore, new digital processes and tools mean people will have to make more decisions or assess risks independently without discussing them in a team meeting. Within an automated process, it is crucial to explain decisions concisely to ensure those next in line or those who must sign off get all the information they require. Decision-making is also becoming more critical because new choices must be made when interacting with machines instead of people.
- Readiness for change will get more challenging because changes happen more often and simultaneously. This can cause problems because people are not always fully ready for changes.
- The different ways of communicating skills, such as complexity management, are essential to handle the increasing amount of information.
- People will need to learn to appreciate digital-related problems in some ways. Understanding them and knowing what to do will help them improve their cognitive skills like critical thinking and decision making.

> If tools become more and more advanced, this might lead to a gap between employees who know precisely how they work and those who are only able to use them to complete their tasks."

Dr. Bernd Ederer, *Controlling RD, Research and Development, SCHOTT AG, Germany*

> The level of creativity you need depends on your function. People in maintenance, for example, must fix problems. So, they need a more advanced level of creativity than an operator behind a 24/7 desk."

Frans van den Akker, *Business Developer Energy & Industry BL Digital, Royal HaskoningDHV, The Netherlands*

Process thinking will become increasingly important in production. Today a team frequently changes, e.g., during shift work. In that case, everyone must have the same information and knowledge so that team members can discuss work-related issues and improve their performance.

Fig. 10 shows to what extent the interviewees see potential skill gaps in the competence area 'Cognitive skills':

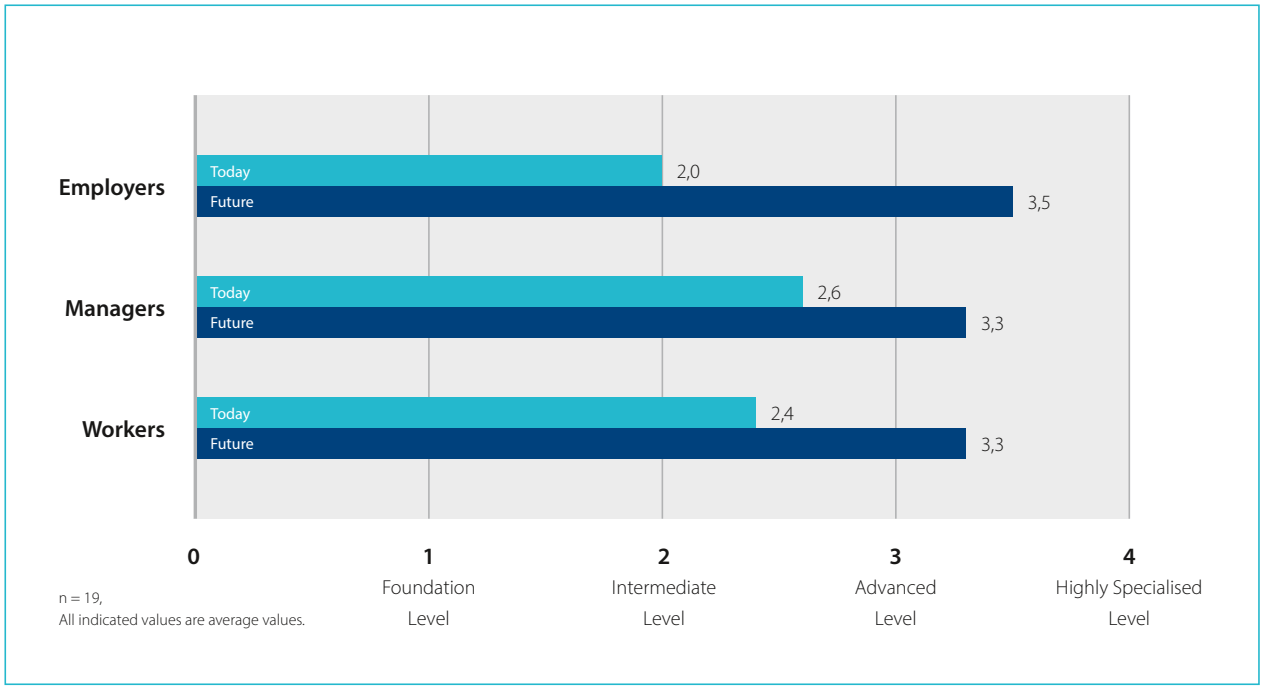


Fig. 10: Cognitive skills

> It might sound trivial, but in production it is especially important to be able to cooperate with your colleagues. This mutual support does not only contribute to the success of the company but also helps develop your digital knowledge."

Zeinab Abdallah, *Process Operator, Nouryon, Sweden*

> Social skills will be more critical when everything gets more digitised so you can talk to each other. Today, much work is done behind screens, sending e-mails, and using web conferences. I think that skill might get lost."

Andreas Höckersten, *Operations Technician, St1 Refinery AB, Sweden*

Social and emotional skills

Exemplary skills: empathy, resilience, conflict management, leadership skills, motivating oneself, motivating others, entrepreneurial thinking, self-organisation, self-initiative, self-efficacy, autonomy, curiosity, perseverance, interpersonal relation management, …

In addition to cognitive skills, the competence area of indirect digital skills also includes social and emotional skills. These are particularly necessary for digital work and communication. In contact with others, for example, empathy and interpersonal relationship management, as well as motivating others, are among the skills required. In self-management, self-organisation and self-initiative are vital in coping with problems, as independent work is increasingly in demand.

- People are proven to be social creatures. Consequently, the Covid-19-Pandemic has left people increasingly isolated through lockdowns or mandatory home offices – the psychological consequences of Covid-19 present people with new challenges. For this reason, emotional skills occupy an essential position in the future work style. Thereby, emotional abilities are closely related to emotional intelligence. Psychologist Daniel Goleman describes emotional intelligence as the ability to recognise one's feelings and those of others, to motivate ourselves, and to deal well with emotions in ourselves and in our relationships.[6] Thus, both aspects of emotions must be considered – one's own and those of others. Regarding one's own feelings, given the new working conditions, it is crucial to recognise signals of those emotions, for example, concerning physical and mental overload. Furthermore, it is vital to respond to these signals. On the other hand, it is also important to be even more attentive to other people than under ordinary circumstances.

- Since increased digital collaboration means that situations such as a quick chat in the hallway are no longer possible, communication must be actively encouraged. Regular meetings can therefore be a valuable way of promoting interaction and communication, which can help identify and solve problems of all kinds. They also show that people are there for each other despite the physical distance.

- As already discussed, more and more communication will be through digital tools. This entails a higher risk of misunderstandings and can lead to a lack of social interaction. Therefore, people will need different empathy for communicating through digital tools or virtual meetings compared to communicating in person.

- For managers, skills regarding remote leadership will become increasingly important with a high number of employees working remotely.

6 Goleman 2000.

7 Smonik 2021.

- Whether it's Covid or technological progress, employees face many new challenges that require resilience and the willingness to address new problems. Resilience is defined as the ability to cope with challenges, especially from the point of view of being able to overcome setbacks.[7]
- Increased digital communication via various channels and the enormous flow of information also require a lot of resilience and boundary management.
- One essential skill that affects nearly every competence area is self-initiative and self-organisation. In the future, people need to be willing to develop themselves to improve their performance and that of their company.
- People who work behind screens and in with machines in manufacturing plants are still the key to a company's success. People in the chemical and related industries often work together very closely with each other. Solving digital problems in the future together will need significant social and emotional skills.

For the competence area 'Social and emotional skills', potential skills gaps have been assessed as shown in fig. 11.

> "It's essential when working together that we feel empathy for each other. We are always solving things as a team. We cannot have seven individualists on a shift. We must work together to solve our problems, and we shall do that."
>
> ***Niklas Jakobsson,*** *Production Team Leader, Borealis AB, Sweden*

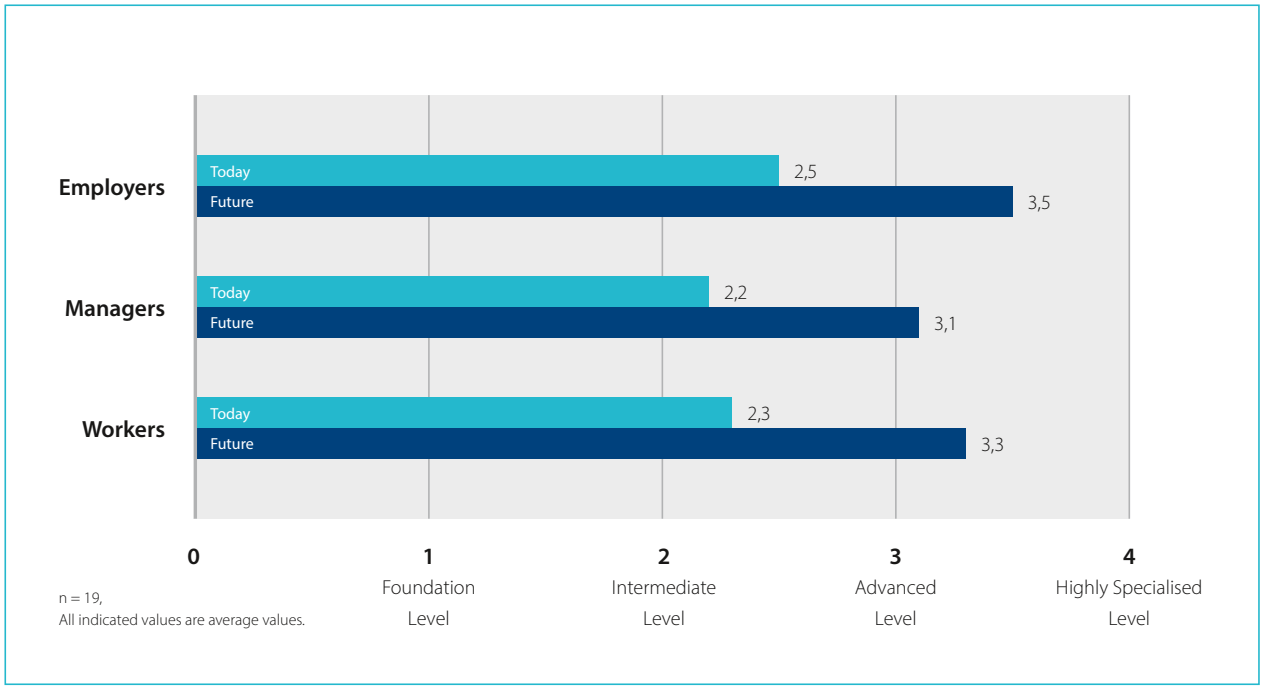


Fig. 11: Social and emotional skills

Summarised key findings

During the interviews, the following competence requirements were particularly mentioned:

- Self-organised work in a networked environment
- Use of occupation-specific/subject-specific software
- Use of digital communication and collaboration tools
- Operation of digital equipment and machines
- Participation in virtual, interdisciplinary, and agile teams
- Researching and evaluating digital data
- Digitally capture, check, interpret and save data
- Identify and correct errors during the data exchange of digital systems
- Understanding and using simulations and data analysis for process optimisation and maintenance
- Use of mobile and stationary software apps
- Create and use digital learning media
- Creating simple digital programmes and apps
- Knowledge of legal and operational data security and data protection requirements

These competencies will be of particular importance in the future. According to the interviewees, they are still being taught with various intensities. Here it is essential to check to what extent these competencies are already part of internal company training programmes and in which areas the offers need to be expanded.

In summary, industries and job clusters under consideration are increasingly focusing on digitisation and networking. In particular, the connection of IT systems and production facilities across locations, the use of mobile devices and apps, the advance of artificial intelligence and the increasing relevance of comprehensive data analyses and simulations are leading to changed digital competence requirements. In particular, employees must be flexible with digital technologies and the work and process flows that go with them. As a result, digital know-how and specific self-learning competence that enables flexible adaptation to company-specific requirements and developments are increasingly in demand. During the interviews, three main, overarching fields of action were highlighted: 1.) Plant planning and expansion, 2.) commissioning and monitoring, and 3.)management and

8 Bundesinstitut für Berufsbildung (BIBB) 2019, pp. 60.

maintenance. It is a more frequently encountered three-way division, employed, e.g., by the German Federal Institute for Vocational Education and Training (BIBB).[8]

The area of plant planning and expansion primarily concerns engineers. In the future, there will be an increasing need for virtual reality skills to design automated chemical plants or expand them. In particular, process engineering sequences and upstream and downstream processes must be simulated and experienced interactively. Thus, employees should also be able to work together in mixed, interdisciplinary teams following agile principles to work together on an optimal solution. It requires not only the ability to plan the plant but also to think about the competence development of the employees who will later work there. It requires the ability to create customised learning documents and operating instructions (for example, using VR and learning apps), with the help of which employees can acquire the necessary competencies for operation before the system is commissioned.

In the area of commissioning and plant monitoring, the safe handling of digital process control systems is required now and later because the operation and monitoring of an individual or networked chemical plants are based primarily on the collection, use, and interpretation of real-time data. Thus, employees must be further encouraged to understand these processes to recognise, identify, and rectify faults safely. Skills in statistical models, monitoring systems, and extensive data analyses should be developed in a way that employees can correctly classify evaluation results and actively control the work process. However, to use the digital methods correctly, additional analogue diagnostic knowledge, as well as sensory perceptions, are still a crucial element.

The third field of action, which played a significant role in the interviews, is plant management and maintenance. The main aim here is to promote the ability to collect relevant real-time information on the condition of plants or their parts. Employees must be enabled to determine maintenance requirements and narrow down the causes of faults using digital tools. Thus, it is crucial to promote the use of fault diagnosis and digital instructions apps, such as tablets or data glasses. In addition to this, skills in using mobile communication tools are essential, as they are used to carry out and document the work and assignments digitally. These skills are integral to preventive maintenance, which is the collection, processing, and visualisation of operational and production data. Thus, workers need in-depth knowledge to help interpret all data and initiate proactive measures to ensure the facility's functionality.

Further challenges to be addressed

> When it comes to digitisation, it's not so much about the investment or the money. It's more about the maturity of people. Are we ready to do this? Are we confident enough to move from something that we know is working and go to more digitisation?"

Maria Wandelstam, *Site Learning & Development Lead Sweden Operations, AstraZeneca, Sweden*

> When you run a factory, you do it by sitting in front of a computer. Yes, it's like playing a computer game."

Niklas Jakobsson, *Production Team Leader, Borealis AB, Sweden*

> Digitisation offers such a wide variety of possibilities that it is imperative to draw a distinctive line. Being able to digitise all sorts of things doesn't mean it is always beneficiary. Of course, you can go and digitise as much as possible. However, you might end up creating more effort without wanting to."

Marcel Stotzka, *Foreman IH EMR North/South, Aurubis, Germany*

The interviews also revealed a range of challenges that go beyond the reference framework of the project. Even though they open an additional perspective, they are no less relevant for the big picture:

Learning to deal with the challenges of digitisation

Reservations towards digitisation are often caused by fear of what might happen to familiar working conditions, tasks, and roles. However, having experienced some digital processes, many people understand that their role might change. However, their job is still not at risk. They might even enjoy handling digital tools and learning about digital technologies.

Being forced to adapt to many digital tools and processes within a short period (e.g., due to Covid) can boost people's self-esteem and trust in new technologies if they experience adequate support throughout the change process.

For blue-collar workers, adapting to digital technologies is often more challenging because they are not as used to working with laptops, control panels, mobile terminals and other digital devices as most white-collar workers are.

> In future, experimental knowledge alone will not be enough. In the past, it was possible to operate entire industrial plants based on experimental knowledge. Today, it is unthinkable to do this without digital applications such as computational fluid dynamics. It is important to be aware of that and to ensure the necessary skills are developed long-term."

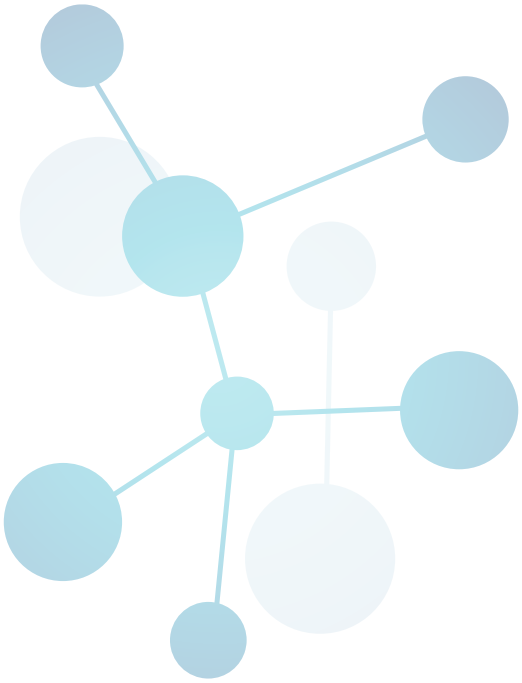
Melf Singer, *Foreman Sulphuric Acid plant, Aurubis, Germany*

Using adaptive technology, gamification, etc. cetera for learning

Adaptive technology offers opportunities to meet the requirements of different groups of learners with just one course. Courses start with several questions assessing the learner's level of expertise regarding the respective topics. Depending on the answers, the learner is automatically transferred to an adequate training level.

During the course, there are further questions to ensure the learning content is understood. If so, the learner moves on. If not, they are redirected to the previous topic.

Creative learning formats such as gamification need to be developed to address all groups of learners.



Addressing the needs of different generations

Assuming that the younger generation (the so-called 'digital natives') is automatically more apt in handling digital technologies is wrong.

Indeed, younger employees are usually more used to social networks, social media, gamification, and VR/AR. However, many of them are not at a high skill level when it comes to programming, coding, etc. There is not necessarily an age effect regarding those skills, e.g., creating a pivot table is more likely to be a skill more mature employees have.

Since the younger generation has specific expectations regarding the freedom of choice regarding working time, working place, and working arrangements, it will become increasingly important to find ways of being an attractive employer to all age groups.

Furthermore, there should be more activities to motivate the new generation to work in the chemical industry. Using digital tools to let them experience the sector (e.g., VR journeys in the classroom) could be effective. The industry should ask itself what it offers to new generations and if it is enough.

> "Younger people are more open to digitisation. That's my experience. So, I think what is on an advanced level today will maybe be foundation level in ten years."

Andreas Höckersten, *Operations Technician, St1 Refinery AB, Sweden*

> "We talked about the skills the industry needs to be successful. But if you turn it around, does the chemical industry give you the environment to use and deploy all your competencies? In that case, you will be motivated. It would be interesting to know if we offer enough to people to match what they want."

Frans van den Akker, *Business Developer Energy & Industry BL Digital, Royal HaskoningDHV, The Netherlands*

Using new/other ways of education

Some companies in Europe increasingly make use of the education systems of other European countries. Some of them are trying to establish a type of dual vocational training like it is common in Germany, for example.

Working students are also not ordinary in every European country. Thus, exploring at what other countries do could be beneficial.

> "It isn't common practice in Spain to train your own junior staff within the organisation. German companies have established that over the years because they missed the dual education system. Those young people get a high-quality degree in German and Spanish, and they are also fluent in English."

Peter Oberle, *Country Representative Iberia, LANXESS Chemicals S.E., Spain*

Appreciating the importance of soft skills

Due to living and working in a so-called VUCA world characterised by volatility, uncertainty, complexity and ambiguity, the importance of soft skills like adaptability, resilience or complexity management is growing fast. While some hard skills may quickly become obsolete due to technological developments, soft skills are usually part of people's personalities.

If a person lacks specific hard skills, it is comparably easy to improve them by training. It is much harder to change if they do not have the necessary soft skills. Therefore, more stress should be put on recruiting employees with the appropriate soft skills.

> "Digital skills can be learned, but soft skills are not so easy to obtain. You must empower that in the people you have. I have worked for many years in the engineering department. Initially, when I had to contract a new engineer, I focused mainly on the technical skills, not the soft skills, which is a gross oversight. Now, I'm more focused on soft skills. The capacity of these people to communicate and empathise with their colleagues etc."

Arturo García Forcada, *Innovation Manager, Standard Profil, Spain*

> The problem usually is at entry level. Today the new technology requires more knowledge and digital abilities that we don't have in all cases. In the mid-level people, we have significantly increased the digital skill knowledge. At the top level, we don't have any problems, because we have had excellent training for years."

Arturo García Forcada, *Innovation Manager, Standard Profil, Spain*

> I do believe that digitalisation will help us. Still, I hope that everyone will understand that it is not only easy. [...] Sometimes you get the feeling that we go into digitalisation, and everything will be fine, but it comes with a cost in that sense. You must have the personnel to create these applications and handle digitalisation. In this case it is particularly important that the digital tools and training tools are user-friendly and easy to access. And when it comes to training tools it is a value if it can be monitored by the manager, and maybe also a drive for the learner if it comes with some part of gamification. However, it's not always easy to cope with that."

Mathias Ottosson, *Specialist – Digitalisation, Borealis AB, Sweden*

> We are on a cultural journey. Without our employees, we can't achieve anything. For some people, the speed of change is natural and easy to handle. For others, it is an enormous challenge. We must make sure nobody is left behind."

Dr. Bernd Ederer*, Controlling RD, Research and Development, SCHOTT AG, Germany*

3 OUTLOOK

Outlook

This study shows that the change in processes and products will require numerous future digital competencies, just like the emergence of new business models in the four sectors. As a result, the employees' competence profiles will change in the coming years. Companies are in the process of adjusting more and more to the demands for continuous and needs-based training in digital competencies. It affects not only initial but also further education and training in the sense of lifelong learning. Training concepts for the specific acquisition of digital competencies need to be developed.

Exchange with experts showed that in many companies in the chemical industry, the networking of plants, as well as development and production processes, is increasing at high speed and that numerous new digitisation-related requirements are arising for all kinds of employees. The interviewees always saw human labour as the central element since the interaction between humans and machines will be of even greater and more complex importance in the future. Steering and control tasks will increasingly have to be managed cooperatively and interdisciplinary. As a result, the number of work steps that cannot be planned well will increase significantly. The flexibility of processes and ability to react to changes at short notice and in an agile manner will also become increasingly important. For example, for production employees, product development skills will be increasingly necessary, as they will also be involved increasingly in the entire development process on an interdisciplinary basis.

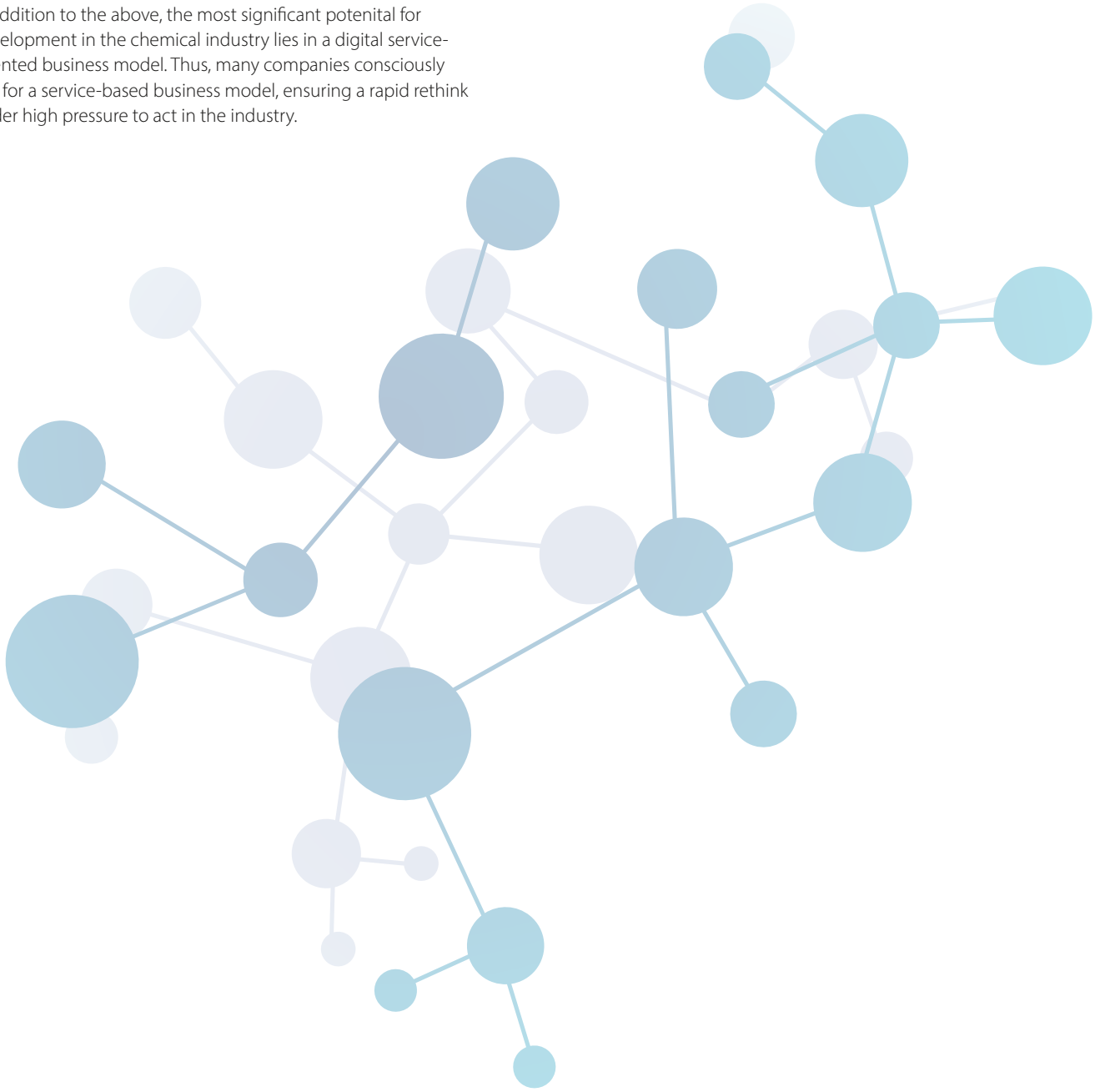
The ability to think and work in a network, paired with strong problem-solving skills, will also play a central role. Because of flexible deployment conditions, employees will need to learn demandoriented, creatively, and on their initiative quickly. In addition to motivating employees to continue education, new forms of delivery and contemporary teaching methods such as blended learning or training simulators are required. The contemporary and rigid educational concepts and curricula must also become more flexible regarding content. Academic education and further training must be more focused on professional needs. Competence, qualification level-related, individualised training options and fast tracks must be offered to consider the different abilities of employees, especially when it comes to digital requirements.

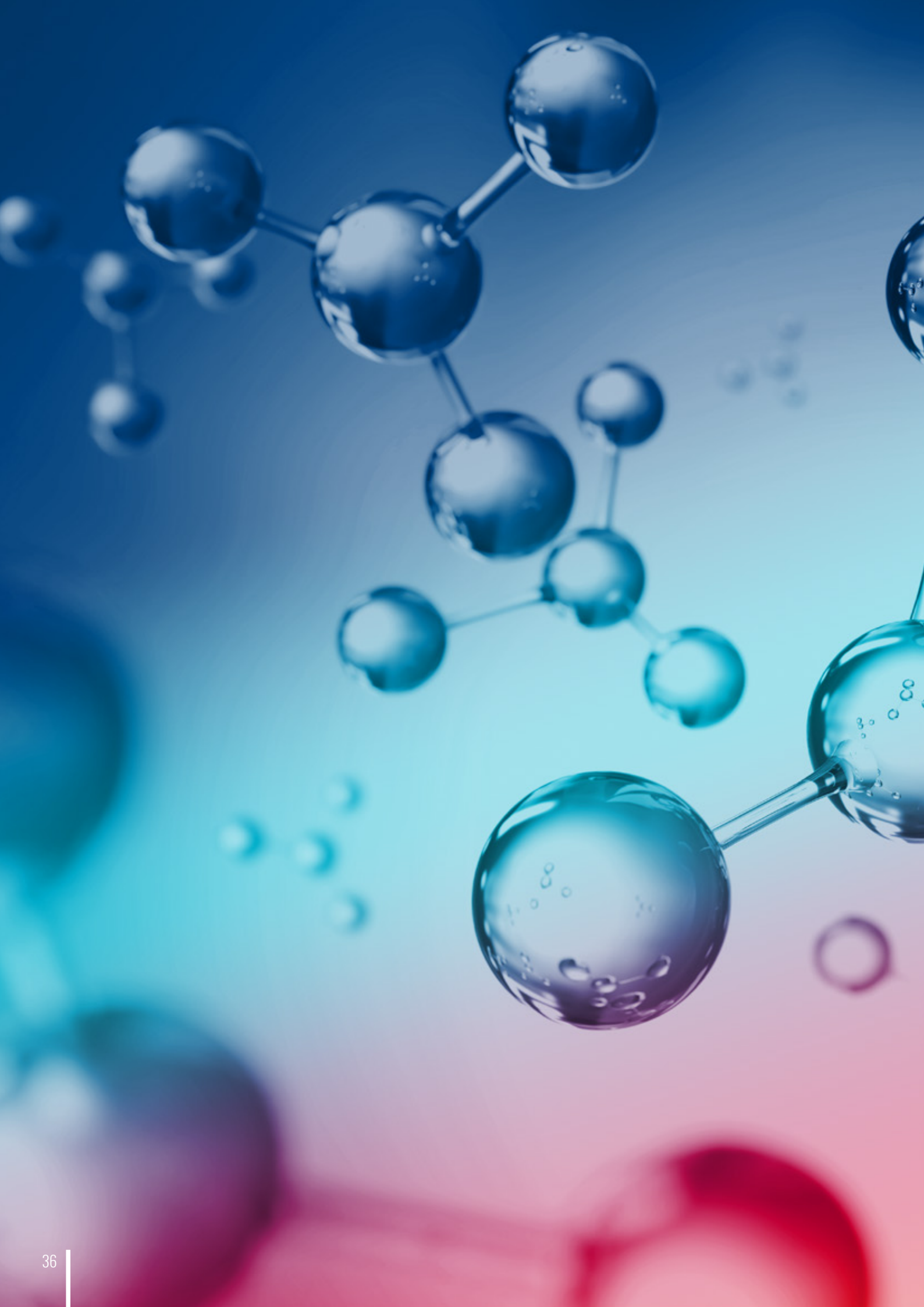
Most of the sectors explored here, however, are already 'digitalised', though further changes caused by large amounts of data, high computer capacities, or new algorithms have just started or will arrive in the near future. The industry needs suitable algorithms and qualified specialists to analyse these data volumes. The increasing use of cross-location systems and the development of disruptive product innovations based on acquired data also increasingly require the ability to link internal and external data.

9 DECHEMA e.V. 2016, pp. 6.

In the immediate future the digital transformation will also require increased capabilities in modular production. Because modular production plants are mainly used where different reaction steps are required, and small quantities of a high-quality product are produced. On the production side, for years, a trend toward modular and continuous production has been evident in the fine and speciality chemicals industry. Here, skills are needed to operate standardised modules and data interfaces used in plug-and-produce procedures to enable digital communication between the modules. Hand in hand with this development comes the continuous need to operate new types of digital control elements and software to produce minimal quantities economically.[9]

In addition to the above, the most significant potenital for development in the chemical industry lies in a digital service-oriented business model. Thus, many companies consciously opt for a service-based business model, ensuring a rapid rethink under high pressure to act in the industry.





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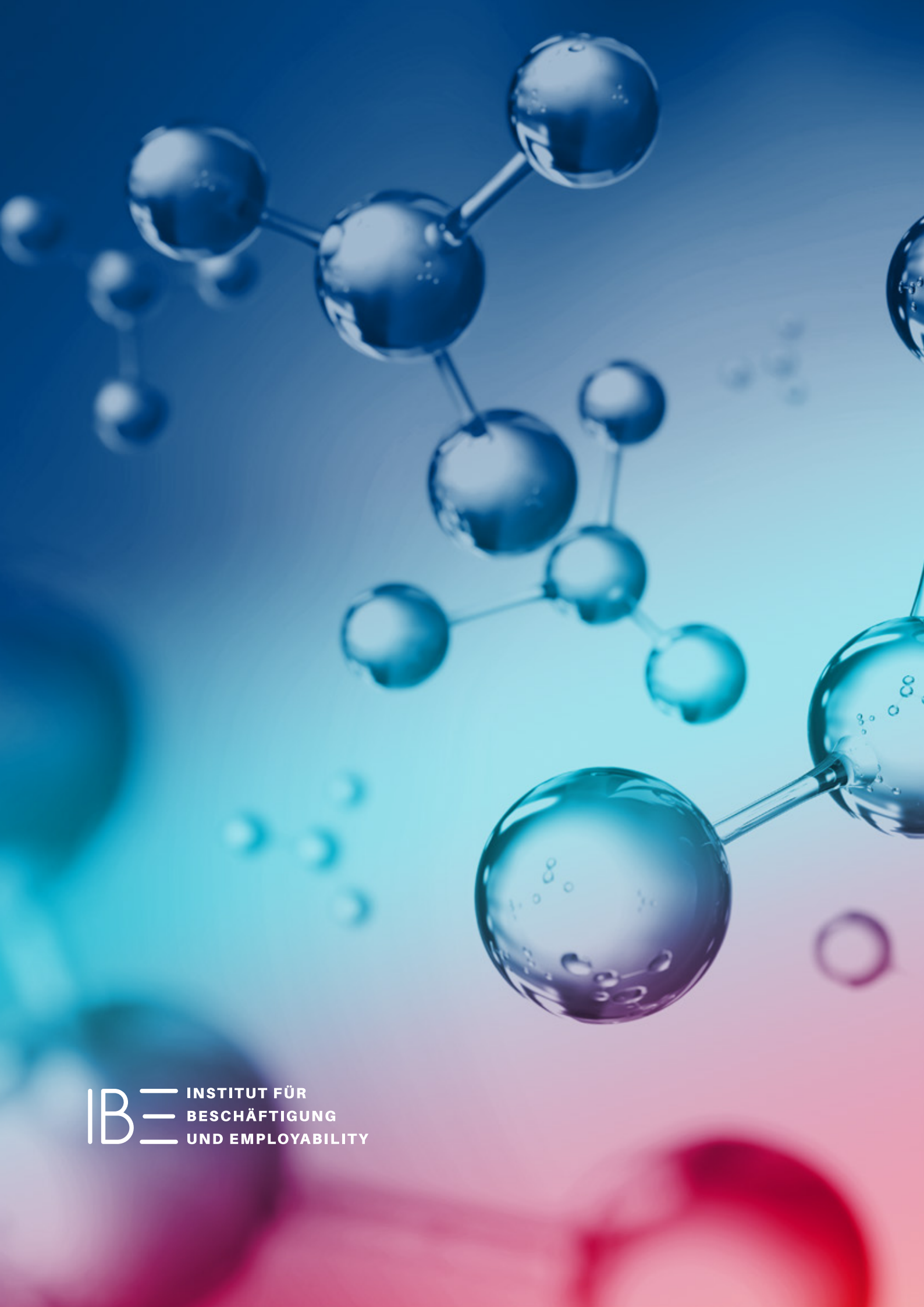

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